APPENDIX E SURFACE WATER IMAPCT ASSESSMENT

Angus Place Amended Project

Centennial Angus Place Pty Ltd

Surface Water Impact Assessment

IA161511-RPT-0013 | Final

31 October 2019

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Appendices

Appendix A. Surface Water Users

Appendix B. Flow and Water Quality Plots

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Appendix E. Springvale Angus Place Swamp Water Balance Model Report

Appendix F. Stream Geomorphology Assessment

Executive Summary

Centennial Angus Place Pty Limited (Centennial) operates the Angus Place Colliery and propose to recommence longwall mining operations with the proposed LW1001 to LW1015 longwalls.

In April 2014 a State significant development application (SSD 5602) and the supporting Environmental Impact Statement for the Angus Place Mine Extension Project was submitted to the then NSW Department of Planning and Infrastructure. In response to a prolonged downturn in international coal markets, Centennial made the decision in March 2015 to move Angus Place Colliery to care and maintenance following the completion of secondary extraction within Longwall 900W. At this time, the assessment of the Angus Place Mine Extension Project was placed on hold and the Project did not progress to determination.

A revised mine plan is proposed for the Project. An Amended Project Report assessing the impacts of the revised mine plan will be submitted for SSD 5602. This surface water impact assessment has been prepared to support the Amended Project Report.

The life of mine will be extended to 2053. Dewatering of the mine will occur throughout the mine life, in conjunction with neighbouring Springvale Mine, and will continue to be transferred to the Springvale Water Treatment Project until 2053. Post mining no dewatering will occur and both Angus Place and Springvale underground mining areas will be flooded.

From 2020, there will be no discharge of mine water (treated or raw) from the project and all mine water not used on site will be transferred to the Springvale Water Treatment Project. Site water management at the Angus Place Pit Top will remain unchanged.

Extensive baseline monitoring of swamp and creek, flow and quality have been undertaken for the Project, including data for neighbouring Springvale Mine. A detailed numerical groundwater model has been built on the MODFLOW Unstructured Grid (MODFLOW USG) platform for the purposes of assessing mine dewatering requirements and informing a groundwater impact assessment for the Project, as has a swamp water balance model. The swamp water balance model is a combined GoldSIM/Australian Water Balance Model and incorporates outputs from seepage faces and baseflow contribution generated from the groundwater model.

Geomorphological characterisation of the streams overlying the longwall extraction area has been undertaken and the influence of the predicted subsidence on surface flows has been hydraulically modelled. In some areas subsidence is predicted to result in increased stream power, however the increased stream power does not present a significant additional risk of erosion due to the dense riparian vegetation and intact nature of the existing channels.

Groundwater drawdown and reduced baseflow contribution are expected to impact on Temperate Highland Peat Swamps on Sandstone that exist above the proposed mining area. Temperate Highland Peat Swamps on Sandstone are listed as matters of national environmental significance under the EPBC Act and are registered as high priority groundwater dependent ecosystems under the relevant water sharing plan (discussed in the Groundwater Impact Assessment). The reduced groundwater contribution to baseflow will also have a corresponding reduction in predicted surface flow. The reduced flows have the potential to have cascading impacts for aquatic ecology and swamp flora and fauna; however, they are not of sufficient magnitude to impact on downstream surface water users.

Mine dewatering take has been partitioned between the applicable groundwater and surface water sources, including allowance for incidental surface water take through baseflow reduction (ground water licencing requirements are addressed in the Groundwater Impact Assessment). The maximum predicted take from each of the applicable management zones, and therefore the volume of share components for each of the water sources required to be held during mining, are as follows.

- Water take from the Wywandy Management Zone only occurs in the 2029/2030 and 2030/2031 water years with a maximum take of 13 ML/year.
- Water take from the Colo River Management Zone peaks at 26ML/year during mining in 2030 to 2031. Post mining water take then increases, peaking at 84ML/year in 2041 to 2042 and 2042 to 2043.

Important note about your report

The purpose of this report is to present the findings of a surface water impact assessment investigation carried out by Jacobs for Centennial Angus Place Pty Limited (the Client) in connection with the Angus Place Amended Project environmental impact statement. This report was produced in accordance with, and is limited to the scope of, services set out in the contract between Jacobs and the Client.

The findings presented in this report are professional opinions based solely on information and data provided or made available by the Client or otherwise available in the public domain documentation made available by the Client and its contractors.

Jacobs has relied on and presumed that documentation made available by the Client and its contractors is accurate and representative of the environmental conditions within the Project Application Area. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete, or if site conditions change, then it is possible that the conclusions as expressed in this report may not be relevant.

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1. Introduction

1.1 Background

Centennial Angus Place Pty Limited operates the Angus Place Colliery under State significant development consent MP06_0021. The key components of this consent are:

- extraction of up to 4 Mtpa of run of mine (ROM) coal from longwalls within the 900 Panel Area
- employment of 300 full time equivalent (FTE) workforce
- transfer of up to 13.4 ML/year of mine inflows from the existing workings (800 and 900 Panel Areas) water storage areas to the Springvale Water Treatment Project (SSD 7592)
- transfer of up to 4 Mtpa of run-of-mine (ROM) coal to the Western Coal Services Project (SSD 5579)
- utilisation of the existing infrastructure at the Angus Place Colliery pit top and Newnes Plateau.

The development consent will expire in August 2024 and a new consent is required to ensure Angus Place Colliery is operational beyond this date.

1.1.1 Angus Place Mine Extension Project

A State significant development application (SSD 5602) and the supporting Environmental Impact Statement for the Angus Place Mine Extension Project (APMEP) was submitted to the then NSW Department of Planning and Infrastructure (DP&I) in April 2014. The APMEP sought to extend the life of the Angus Place Colliery, and to extend the life of mine workings into the new extension area (1000 Panel Area) to the east of the existing workings. The APMEP (refer Figure 1.1) also sought to continue to utilise existing infrastructure approved under PA06_0021 as modified, and to construct and operate additional surface infrastructure on the Newnes Plateau to support the underground mining operations.

The exhibition period for the EIS commenced on 12 April 2014 and ended on 26 May 2014. A Response to Submissions (RTS) report was lodged with the then DP&I on 1 October 2014 to respond to submissions received during the public exhibition period. A supplementary RTS was lodged with NSW Department of Planning and Infrastructure (DP&I) in December 2014 to responses to additional government agency submissions on the RTS. The EIS and associated RTS reports are available on the Department's Major Project website.

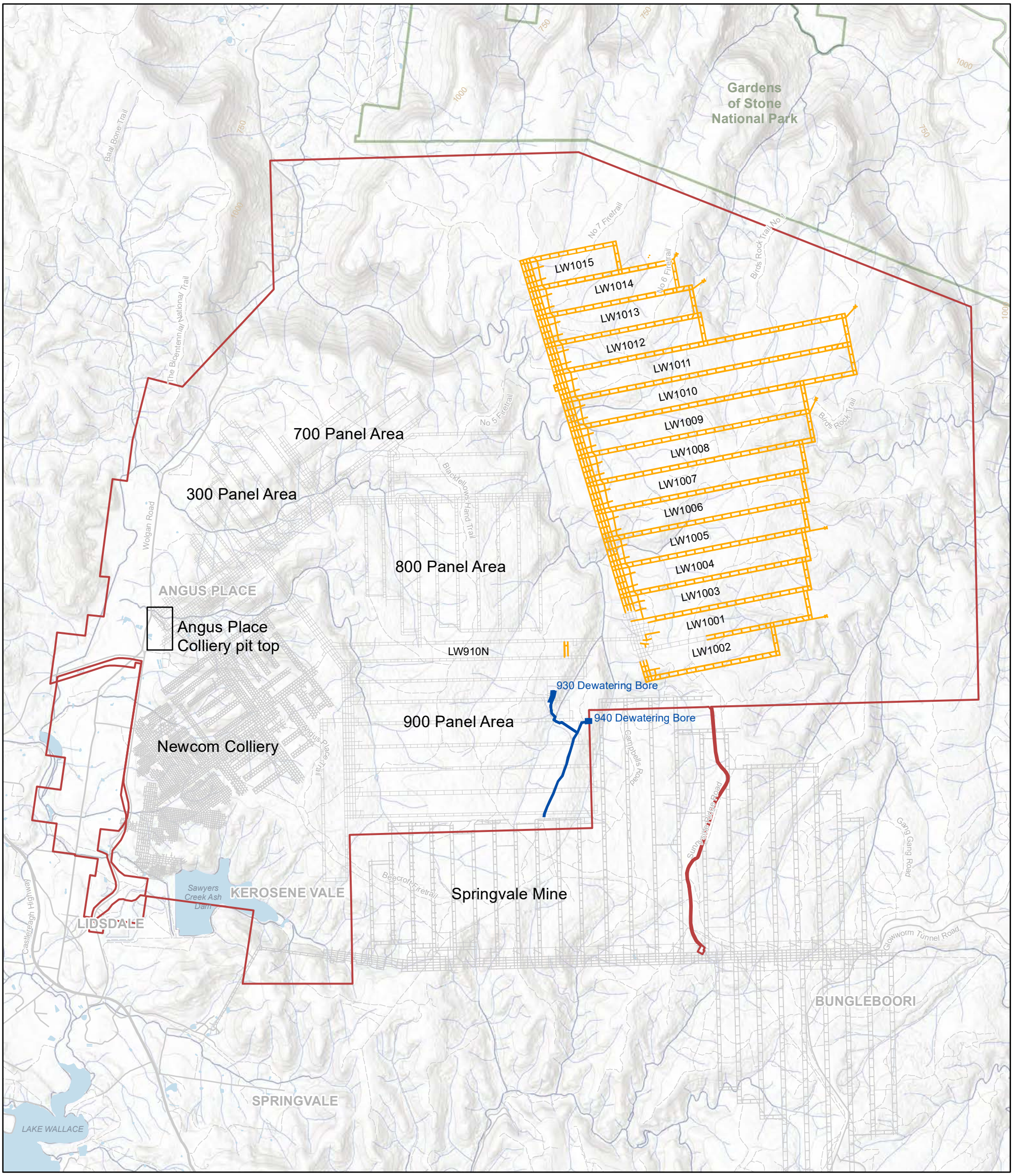
In response to a prolonged downturn in international coal markets, Centennial made the decision in March 2015 to move Angus Place Colliery to care and maintenance following the completion of secondary extraction within Longwall 900W. Concurrently, the assessment of the APMEP was placed on hold.

1.1.2 EPBC Referral

Due to the potential for the APMEP to impact matters of national environmental significance (MNES) under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act), an EPBC referral (EPBC 2013/6889) was submitted to the then Department of Sustainability, Environment, Water, Population and Communities (now Department of Environment and Energy [DEE]) on 20 May 2013. The APMEP was subsequently declared a controlled action on 7th July 2013 and supplementary Director General's Requirements (DGRs) were issued on 30th August 2013.

The APMEP will be assessed by accredited assessment under the Environmental Planning and Assessment Act 1979 (EP&A Act).

Figure 1.1: Angus Place Amended Project Overview



Infrastructure
- Proposed Workings
- Existing Workings

Project Area
- Project Area

Contours
- 50 Metre

Hydrology
- Water Areas
- Stream Order 1 - 2
- Stream Order 3 - 6

Tenures
- National Parks



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Angus Place Amended Project

Data Sources - Centennial Angus Place Pty Ltd: Project Area, Infrastructure (2019); NSW Government Public Data: Roads, Hydrology, Placenames; Geosciences Australia (ELVIS): 50m Contours; Office of Environment and Heritage NSW: Tenures; ESRI ArcGIS Image Service: World Elevation Terrain, World Topographic Map

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1.1.3 Secretary's Environmental Assessment Requirements

All mining projects in NSW must be assessed under the EP&A Act. The APMEP is classified as a State Significant Development (SSD) in accordance with the State Environmental Planning Policy 2011 (State and Regional Development). An EIS must be prepared in response to requirements set out by the Secretary of the NSW Department of Planning, Industry and Environment (DPIE). These requirements are known as the Secretary's Environmental Assessment Requirements (SEARs) and were formerly known as (DGRs).

The 2014 EIS for the APMEP was prepared in accordance with the DGRs issued on 6 November 2012, by the then DP&I NSW Department of Primary Industries (DPI) and supplementary DGRs were issued on 30 August 2013 in relation to referral EPBC 2013/6889.

The DGRs (SEARs) for the APMEP remain valid. A summary of the DGRs relating to surface water are provided in Table 2.2, Section 2.3.

1.1.4 Project Review

Since the submission of the APMEP EIS and subsequent RTS documents, a review of APMEP has been completed to take into consideration the up to date monitoring data obtained from the adjacent Springvale Mine. The data is in relation to observed swamp impacts, as well as recent changes in operational requirements. This review has resulted in proposed changes to the APMEP when compared to that presented in the 2014 EIS.

Three major changes have occurred in relation to the current approved operations at the Angus Place Colliery:

- Angus Place MOD 4 was approved allowing three gateroads to be developed in the 1000 Panel Area;
- Angus Place MOD 5 was approved that has altered the mine water management at the mine. The principal change to the site water management is that from 2020 all mine inflows from the existing workings will be transferred to the Springvale Water Treatment Project (SSD 7592); and
- Springvale Water Treatment Project (SSD 7592) has been developed to address Condition 12 under Schedule 4 of Springvale Mine's consent SSD 5594.

1.1.5 IESC Comments on the Angus Place Mine Extension Project

The APMEP EIS received a series of comments from the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mine Development (IESC).

Comments received from the IESC relevant to surface water were as follows. Additional comments are addressed in the Groundwater Impact Assessment.

- Relevant data and information:
  - Requirement to characterise existing surface water, groundwater and ecological conditions for the majority of Temperate Highland Peat Swamps on Sandstone (THPSS) (IESC01).
  - Seasonal surface water flow and an assessment, or estimation, of the baseflow component of the Coxs River (IESC02).
- Application of appropriate methods:
  - Finer scaled, site specific models, informed by a conceptualisation of the hydrology and hydrogeology, would be needed to have confidence in the predictions of groundwater impacts to individual swamps (IESC04).
  - Water quality impact estimations for the Coxs River need to consider the increased discharge volumes to Coxs River resulting from reduced demand from the Wallerawang Power Station (IESC05).

A response to the comments received from the IESC was provided in RPS (2014b). An updated response to matters raised by the IESC is provided in Section 5.5.

1.2 Amended Project Overview

The APMEP Amended Project will, in general, include all currently approved operations, facilities and infrastructure of the Angus Place Colliery, except as otherwise indicated below:

- Extend the life of the mine to 31 December 2053;
- Increase in Project Application Area from 10,460 ha to 10,551 ha;
- Increase in full time equivalent (FTE) personnel from 300 to 450;
- Increase the extraction up to 4.5 million tonnes per annum of ROM coal from the Lithgow Seam within the Project Application Area;
- Continued development of new roadways to enable access to the proposed 1000 panel longwall mining area;
- Extraction of existing approved longwall 910N;
- Development and extraction of 15 longwall panels (LW1001 to LW1015) with void widths of 360m;
- Development of underground roadway connections between the Angus Place Colliery underground mine workings and the Springvale Mine underground mine workings;
- Transfer up to 4 Mtpa of ROM coal to the Angus Place pit top for processing and handling before being transported off site in accordance with the Western Coal Services Project development consent (SSD 5579);
- Transfer up to 4.5 Mtpa of ROM coal by underground conveyor to the Springvale Mine pit top via proposed new underground connection roadways for handling and processing in accordance with the Springvale Mine Extension Project development consent (SSD 5594);
- Enlargement of the ROM coal stockpile at the Angus Place Colliery pit top from 90,000 t to 110,000 t capacity;
- Construction of the approved 4.5 m wide shaft at the Angus Place Ventilation Facility (APC-VS2) on the Newnes Plateau;
- Installation and operation of the ventilation fan at the Angus Place Ventilation Facility (APC-VS2) on the Newnes Plateau;
- Construction and operation of one additional downcast shaft and mine services boreholes within the proposed Angus Place Ventilation Facility (APC-VS3) on the Newnes Plateau to support mining in the 1000 panel area;
- Construction and operation of additional dewatering facilities and associated infrastructure on the Newnes Plateau to support mining in the 1000 panel area to facilitate the transfer of mine water into the Springvale Water Treatment Project;
- Transfer of mine inflows from the existing and proposed workings at Angus Place Colliery to the Springvale Water Treatment Project (SSD 7972) for treatment and beneficial reuse at the Mount Piper Power Station. Water will be transferred via the Springvale Water Treatment Project Transfer pipeline and the Angus Place Haul Road Pipeline;
- Operation of the Angus Place Colliery 930 Bore and associated infrastructure for raw mine water transfer from the surface infrastructure back to the underground mining area when required; and
- Connection to the Lithgow City Council main sewer line prior to the commencement of longwall extraction (subject to a separate development application through Lithgow City Council).

1.3 Existing Water Management and Proposed Changes

1.3.1 Existing Water Management

The existing surface and groundwater management at Angus Place Colliery is described in detail in the Environmental Assessment supporting the Angus Place MOD 5, available from the Department of Planning's

Major Project's site (https://www.planningportal.nsw.gov.au/major-projects/project/12941). The key points in relation to the existing mine water management are described below.

- Mine inflows from the existing workings are managed as follows:
  - Mine water is treated in a temporary water treatment plant (reverse osmosis) located at the Angus Place Colliery pit top, and up to 10 ML/day of the treated water is discharged via Angus Place Licensed Discharge Point (LDP) LDP001 to Kangaroo Creek in the Coxs River catchment (refer Figure 1.1). This discharge will cease in 2020 and mine inflows will be transferred to the Springvale Water Treatment Project via the Angus Place Pipeline, currently under construction.
  - Mine inflows (untreated) are transferred to the Springvale Delta Water Transfer Scheme (SDWTS) via the dewatering bore facility 940 Bore, located above the mining area on Newnes Plateau. The SDWTS also manages Springvale Mine's mine inflow contributions. Mine water transferred to the SDWTS will be transferred to the Springvale Water Treatment Project via the Springvale Water Treatment Project Water Transfer Pipeline.
- The pit top surface water management system manages clean and dirty water separation, as well managing grey water and sewage from the administration and bath house buildings.

1.4 Proposed Changes to Water Management

Mine water discharge from Angus Place Colliery LDP001 will cease from 2020. From 2020, all mine inflows from existing and proposed workings will be transferred to the Springvale Water Treatment Project, via either the Springvale Water Treatment Project Water Transfer Pipeline or the Angus Place Haul Road Pipeline.

Changes to water management infrastructure required to support the Amended Project are detailed below.

1.4.1 Pit Top

From 2020, the pit top water management infrastructure will only manage stormwater runoff from the pit top and surrounding areas. Those works have been assessed in the EIS and found to be consistent with relevant guidelines. No significant change to Pit Top site water management is proposed. Minor civil works associated with a change of the ROM coal stockpile will not significantly change Pit Top water management.

The existing sewage system comprises treatment of grey water and sewage in an onsite sewage treatment plant prior to being directed to maturation ponds and disposed via spray irrigation at LDP005. In the future, a pipeline system is proposed to be constructed and connected to Lithgow City Council's mains. The upgrade works will be implemented prior to the commencement of longwall extraction and when the workforce will exceed the current 300 FTE personnel and the existing sewage system will become inadequate.

1.4.2 Newnes Plateau Infrastructure

Mine inflows, comprising groundwater intercepted during mining are required to be managed to ensure a safe work environment underground. New dewatering facilities will be required to be constructed on the Newnes Plateau, which will dewater the existing and proposed workings (refer Figure 1.1). Additional infrastructure, such as associated trenched pipelines and booster pump stations and power kiosks, will also be required. Pipelines will follow existing access tracks, albeit widened for installation of the pipeline and power cables. The pipelines from the Angus Place dewatering facilities will connect to the existing Springvale Water Treatment Project pipeline.

It should be noted that no infrastructure will be sited in the vicinity of any waterway and pipelines will not be trenched through any waterway.

1.4.3 Study Areas

In addition to the greater Project Application Area, for the purposes of assessing subsidence related impacts, two refined study areas relating to the location of the proposed longwalls are defined.

MSEC (2019) have defined the Study Area as the surface area that could be affected by the extraction of the proposed LW1001 to LW1015. Two areas have been considered in this report, these being the Study Area based on the 26.5° angle of draw of longwall subsidence, and a Study Area based on a 600m offset from the proposed longwalls.

The Study Area based on the 26.5° angle of draw represents the minimum extent for the assessments of the conventional ground movements (i.e. vertical subsidence and its associated effects). However, it is noted that low level conventional ground movements can extend beyond the 26.5° angle of draw.

The Study Area based on the 600m offset boundary represents the minimum extent of the assessments of the valley related effects. This distance is based on the recommendations from the Southern Coalfield Inquiry (DPIE, 2008) for the risk management zones.

The Study Areas are presented on Figure 1.1 and other figures as relevant. Further discussion regarding the development of the Study Areas is provided in MSEC (2019).

2. Relevant Legislation, Policy and Guidelines

Commonwealth and State legislation, policies and guidelines relevant to groundwater management are outlined below.

2.1 Commonwealth Legislation, Policies and Guidelines

2.1.1 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act prescribes the Commonwealth Government's role in environmental assessment, biodiversity conservation and the management of protected areas and species, population and communities and heritage items.

Approval from the Commonwealth Minister for the Environment is required for:

- An action which has, would have, or is likely to have a significant impact on 'Matters of National Environmental Significance' (MNES) such as wetlands, ecological communities, or water resources;
- An action by the Commonwealth or a Commonwealth agency which has, would have, or is likely to have a significant impact on the environment;
- An action on Commonwealth land which has, would have, or is likely to have a significant impact on the environment; or
- An action which has, would have, or is likely to have a significant impact on the environment of Commonwealth land, no matter where it is to be carried out.

Of most relevance to the APMEP, MNES include the Temperate Highland Peat Swamps on Sandstone which are federally listed Endangered Ecological Communities under the EPBC Act and occur within the Project Application Area. Water resources in relation to coal seam gas and large coal mining developments are also considered to be MNES.

Impacts on MNES are assessed through a referral process to the Commonwealth Department of the Environment Energy and the EPBC Act Significant Impact Guidelines. If the Commonwealth Minister for the Environment determines that a project is likely to have a significant impact on a MNES, then the project becomes a controlled action. In the case of the Project, approval of the Commonwealth Minister for the Environment would be required.

2.1.1.1 Significant Impact Guidelines: Coal Seam Gas and Large Coal Mining Developments – Impacts on Water Resources 2013

The Significant Impact Guidelines include general criteria for whether there is a real, or "not remote" chance, or possibility that an action will have a significant impact on a matter protected under national environment law, which may directly or indirectly result in changes to the hydrology of a water resource, or the water quality of a water resource, that is of sufficient scale or intensity as to reduce the current or future utility of the water resource for third party users, including environmental and other public benefit outcomes, or to create a material risk of such reduction in utility occurring.

Under the Significant Impact Guidelines, the value of the water resource needs to be confirmed such that impacts from actions can be evaluated on their significance. Key factors for determining the value of a water resource is its utility for all third party users, including environmental and other public benefit outcomes. Outcomes relevant to the Project include:

- Provisioning services (e.g. use by other industries and use as drinking water);
- Cultural services (e.g. recreation and tourism, science and education); and
- Supporting services (e.g. maintenance of ecosystem function).

If there is evidence, based on data, modelling and stakeholder engagement, that the action would not materially affect the availability and quality of water for all third party users, then that would reduce the likelihood of the action having a significant impact.

2.1.1.2 Independent Expert Scientific Committee - Information guidelines for proponents preparing coal seam gas and large coal mining development proposals

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) is a statutory body under the EPBC Act. The IESC's key legislative functions are to:

- Provide scientific advice to the Commonwealth Environment Minister and relevant state ministers on coal seam gas (CSG) and large coal mining development proposals that are likely to have a significant impact on water resources;
- Provide scientific advice to the Commonwealth Environment Minister on bioregional assessments (CoA 2015a) of areas of CSG and large coal mining development;
- Provide scientific advice to the Commonwealth Environment Minister on research priorities and projects;
- Collect, analyse, interpret and publish scientific information about the impacts of CSG and large coal mining activities on water resources; and
- Provide scientific advice on other matters in response to a request from the Commonwealth or relevant state ministers.

The Information Guidelines outline what types of information a proposal should include for a CSG or large coal mining project. This information is needed to enable the IESC to provide robust scientific advice to government regulators on the potential water-related impacts of such proposals.

The guidelines were first published in February 2013. The guidelines were reviewed and amended in April 2014, June 2015 and May 2018 to update reference material, cover developments in leading practice and knowledge, take account of the IESC's recent experience and incorporate comments from users.

2.1.2 National Water Quality Management Strategy

The National Water Quality Management Strategy (NWQMS) is the adopted national framework to protect and improve water quality in Australia. The main policy objective of the NWQMS is to achieve sustainable use of the nation's water resources, protecting and enhancing their quality, while maintaining economic and social development. The framework consists of a number of guideline documents, of which certain documents relate to protection of surface water resources and others relate to the protection of groundwater resources.

The framework refers to other NWQMS guidelines documents for specific water quality objective values. Where the resource requiring protection is a surface water resource with a component of groundwater discharge, the water quality objectives should be applied at the point of discharge. Other NWQMS guideline documents containing specific water quality objectives guideline values that are relevant to the project include:

- Guidelines for Managing Risks in Recreational Water (National Health and Medical Research Council (NHMRC) 2008):
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, (2000/2018)); and
- Australian Drinking Water Guidelines (NHMRC/NRMMC, (2011)).

Where these specific water quality objectives are identified, the groundwater and surface water component of the water source should meet the guideline values. For the APMEP, this means that the current uses of groundwater or surface water must not be degraded as a result of the construction and operation of the APMEP.

2.2 State Legislation and Policies

2.2.1 Water Management Act 2000

Water resources in NSW are administered under the Water Act 1912 and the Water Management Act 2000 by the NSW Office of Water, within the DPI. The Water Management Act 2000 governs the issue of water access licences and approvals for those water sources (rivers, lakes, estuaries and groundwater) in New South Wales where Water Sharing Plans (WSPs) have been established. The WSPs relevant to the Application Area have been established and the area is therefore governed under the Water Management Act 2000.

Part 2 of the Water Management Act 2000 establishes access licences for the take of water within a particular water management area. The Water Management (General) Regulation 2011 is the primary regulation instrument under the Water Management Act 2000. In general, the Water Management Act 2000 requires a:

- water access licence to take water;
- water supply works approval to construct a work; and
- water use approval to use the water.

2.2.1.1 Water Sharing Plans

WSPs establish rules for sharing water between the environmental needs of the river or aquifer and water users, and also between different types of water use such as town supply, rural domestic supply, stock watering, industry and irrigation. There are WSPs for regulated and unregulated river catchments and groundwater sources in water management areas. The Water Act 1912 governs the issue of water licences for water sources in areas where Water Management Act 2000 WSP have not been established.

For surface water, the Project Application Area lies on the boundary of the Upper Nepean and Upstream Warragamba Water Source (Wywandy Management Zone) (southwest) and the Hawkesbury and Lower Nepean Rivers Water Source (Colo River Management Zone) (northeast) of the Water Sharing Plan for Greater Metropolitan Region Unregulated River Water Sources 2011 (NSW). Surface water source boundaries are shown on Figure 2.1.

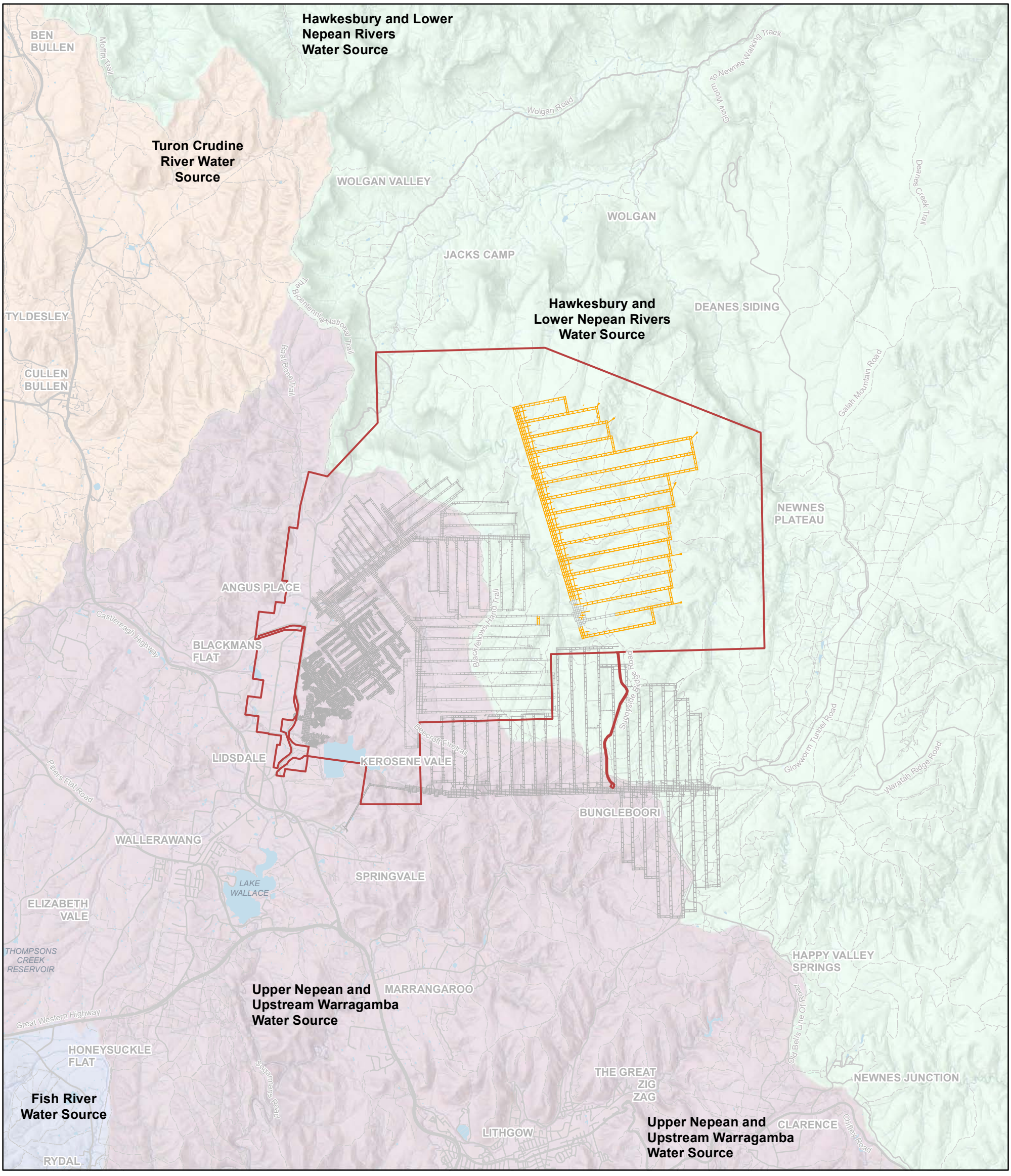
2.2.1.2 Maximum Harvestable Right Dam Capacity (2006)

Licences are not required for harvestable rights dams built on minor streams that capture 10 per cent of the average regional rainfall run-off on land in the Central and Eastern Divisions of New South Wales, and up to 100 per cent on land in the Western Division. The total capacity of all dams on a property allowed under the harvestable right is called the Maximum Harvestable Right Dam Capacity (MHRDC). If a dam that is larger than the MHRDC is constructed, then a licence will be needed for the volume of water that exceeds the MHRDC, unless it is taken under a basic landholder right. An approval for a dam which exceeds the MHRDC is also needed.

Minor watercourses, under the Water Management (General) Regulation 2011 (NSW), are defined by the Strahler stream ordering method as first-order and second-order watercourses that do not permanently flow. Watercourses shown as broken or continuous on topographic maps listed in the Water Management (General) Regulation 2018 (NSW) are deemed to be continuous, even if they lose definition and then reappear.

Dams solely for the capture, containment and recirculation of drainage and/or effluent, consistent with best management practice or Local Government Council to prevent the contamination of a water source, are exempt from the MHRDC.

Figure 2.1: Surface Water Sources



Water Sharing Plan Surface Water Sources

- Fish River Water Source
- Hawkesbury and Lower Nepean Rivers Water Source
- Turon Crudine River Water Source
- Upper Nepean and Upstream Warragamba Water Source

Infrastructure

- Proposed Workings
- Existing Workings

Project Area

- Project Area

Roads

- Primary Road
- Arterial Road
- Sub-Arterial Road
- Local Road
- Track-Vehicular

Hydrology

- Waterareas



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Angus Place Amended Project

Data Sources - Centennial Angus Place Pty Ltd: Project Area, Infrastructure (2019); NSW Government Public Data: Roads, Hydrology, Placenames; Geosciences Australia (ELVIS): 50m Contours; Department of Primary Industries: Water Sharing Plan Surface Water Sources; ESRI ArcGIS Image Service: World Elevation Terrain, World Topographic Map

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2.2.2 Protection of the Environment Operations Act (1997)

The Protection of the Environment Operations Act 1997 (POEO Act) is administered by the NSW Environment Protection Authority (NSW EPA). The objectives of the POEO Act are to protect, restore and enhance the quality of the environment.

The POEO Act regulates and requires licensing for environmental protection, including for waste generation and disposal and for water, air, land and noise pollution. Relevant features of the POEO Act include:

- protection of the environment policies (PEPs);
- integrated environment protection licensing; and
- regulation of scheduled and non-scheduled activities.

Under the POEO Act, an Environment Protection Licence (EPL) is required for premises at which a 'scheduled activity' is conducted. Schedule 1 of the POEO Act lists activities that are scheduled activities for the purpose of the act.

Centennial holds an EPL for mining for coal and associated works at the Angus Place Colliery (EPL467), which covers the mining operation, surface facilities and overland conveyors at Angus Place Colliery. The provisions of EPL467 prescribe water quality and volumetric discharge limits of various surface water pollutants to designated LDPs. The location of LDPs under EPL467 (latest revision, 9 April 2019), and details of limits to quality and volumetric discharge are summarised in Table 2.1.

Table 2.1: Summary of Licensed Discharge Points - EPL467

Discharge Point	Location and function	Volumetric Limit (kL/day)	Oil and Grease (mg/L)	pH	TSS (mg/L) / Turbidity (NTU)	Electrical Conductivity (µS/cm)
LDP001	Discharge of mine water make and runoff into Kangaroo Creek through wetlands.	10,000	10	6.5 – 9.0	30 / 40	350
LDP002[1]	Discharge of surface water from the Angus Place Colliery surface facilities into the Coxs River through settling ponds.	N/A	10	6.5 – 9.0	30 / 40	N/A
LDP003	Discharge from the Kerosene Vale sediment dam west of the Haul Road	N/A	10	6.5 – 8.5	30 / 40	
LDP005	Discharge of treated sewage effluent from Angus Place Colliery via a spray irrigation network to a designated utilisation area. (Irrigation area (2.5-3 ha) located adjacent to aeration ponds).	N/A	N/A	N/A	N/A	N/A

Notes – 1. Clause L2.5 of EPL467 notes that L2.4 conditions do not apply to LDP002 (and LPD003) when discharge occurs from those LDPs within 5 days of a rainfall event exceeding 44mm over any consecutive 5-day period.

In addition to the physio-chemical parameters outlined on Table 2.1, discharge at LDP001 is also subject to the following pollutant concentration limits:

- Aluminium (0.45mg/L)
- Arsenic (0.024mg/L)
- Boron (0.37mg/L)
- Copper (0.007mg/L)
- Fluoride (1.8mg/L)
- Iron (0.4mg/L)
- Manganese (1.7mg/L)
- Nickel (0.047mg/L)
- Zin (0.05mg/L)

2.2.3 NSW Water Quality and River Flow Objectives

For each catchment in NSW, the state government has endorsed the community's environmental values for water, known as 'Water Quality Objectives'. The NSW Water Quality Objectives are the environmental values and long-term goals for consideration when assessing and managing the likely impact of activities on waterways (DEC, 2006).

The guiding principles of the Water Quality Objectives are that:

- where the environmental values are being achieved in a waterway, they should be protected, and
- where the environmental values are not being achieved in a waterway, all activities should work towards their achievement over time.

The River Flow Objectives are the agreed high-level goals for surface water flow management. They identify the key elements of the flow regime that protect river health and water quality for ecosystems and human uses.

There are no specific environmental values set for the Hawkesbury-Nepean catchment due to the transition at that time from the Healthy Rivers Commission to the Natural Resources Commission. However, catchments in the vicinity have identified water quality and river flow objectives that are appropriate for the purpose of assessing the impact of the APMEP.

Applicable Water Quality and River Flow Objectives for the Wywandy and Colo River Management Zones are presented below.

- Water Quality Objectives
  - Aquatic ecosystems
  - Drinking water
  - Livestock water supply
  - Secondary contact recreation
  - Visual amenity; and
- River Flow Objectives
  - protect natural pools in dry times
  - protect natural low flows
  - maintain wetland and floodplain inundation
  - maintain natural flow variability
  - minimise effects of weirs and other structures.

Given that the APMEP will not be discharging mine water to the Coxs River Catchment and no water quality impacts are anticipated, the APMEP meets with the NSW Water Quality Objectives.

An assessment of the project against the NSW River Flow Objectives is provided in Section 5.6.

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

The State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 (NSW) is an environmental planning instrument under the Environmental Planning and Assessment Act 1979 (NSW).

Surface water catchments within the Upper Nepean and Upstream Warragamba Water Source, of which Kangaroo Creek and the Coxs River are tributaries, are declared by the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 (NSW) to be within the Sydney Drinking Water Catchment.

Part 2 of the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 (NSW) requires that:

Clause 10 – Development consent cannot be granted unless neutral or beneficial effect on water quality

A consent authority must not grant consent to the carrying out of development under Part 4 of the Act on land in the Sydney drinking water catchment unless it is satisfied that the carrying out of the proposed development would have a neutral or beneficial effect on water quality.

For the purposes of determining whether the carrying out of the proposed development on land in the Sydney drinking water catchment would have a neutral or beneficial effect on water quality, the consent authority must, if the proposed development is one to which the NorBE Tool applies, undertake an assessment using that Tool.

Following an amendment to the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 (NSW), Part 2, Clause 11A now requires that:

Clause 11A Neutral or beneficial effect on water quality—continuing development

(1) This clause applies for the purposes of determining under this Policy whether the carrying out of continuing development on land in the Sydney drinking water catchment would have a neutral or beneficial effect on water quality.

(2) ***Continuing development*** *is any development (such as mining) for which development consent was limited to the carrying out of the development for a particular time or to a particular area or intensity, but which was likely to be the subject of future applications for consent for its extension or expansion.*

(3) If:

(a) development consent was granted for continuing development ("the existing development consent"), and

(b) a development application is made for consent to extend or expand the carrying out of the development ("the proposed development"), and

(c) the development application is made before the authority conferred by the existing development consent expires or is exhausted, the carrying out of the proposed development will have a neutral or beneficial effect on water quality if it will have the same or a lesser adverse impact on water quality when compared to the adverse impact that the continuing development would have if it were extended or expanded under similar conditions as the existing development consent.

(4) Subclause (3) extends to an existing development consent that is to be surrendered if consent is granted on the determination of the development application.

(5) In this clause, a reference to an existing development consent includes a reference to a project approved under Part 3A of the Act before its repeal (or granted after its repeal pursuant to Schedule 6A to the Act).

2.2.5 NSW National Parks and Wildlife Act 1974

In NSW, Wild Rivers may be declared within national parks and other reserves that are protected under the NSW *National Parks and Wildlife Act* (*NP&W) 1974*.

Wild Rivers are rivers that are in near-pristine condition in terms of animal and plant life and water flow, and are free of the unnatural rates of siltation or bank erosion that affect many of Australia's waterways. The declaration of 'wild rivers' ensures that their high conservation values are maintained, and that Aboriginal objects and places associated with them are identified, conserved and protected. The Colo River and its four sub-catchments (Wolgan, Capertee, Colo, and Wollemi) is one of the river systems declared a Wild River in 2008.

The Colo Wild River Assessment, however, recommended that only the section of the Wolgan River to its intersection with (and including) Rocky Creek and their tributaries be declared a Wild River. This section of the river is downstream of the Project Application Area. The confluence of Rocky Creek and the Wolgan River is approximately 20km to the northeast of the Project Application Area, and no impacts from APMEP are anticipated, as such Wild Rivers protected areas are not relevant to the APMEP.

2.3 Summary of Requirements

A summary of the Project DGRs (SEARs) and other requirements, and where they are addressed in this report is provided in Table 2.2.

Table 2.2: Summary of DGRs/SEARs

DGRs Specific to Water Resources (Issued on 6 November 2012)	Report Reference
Detailed assessment of potential impacts on the quality and quantity of existing surface water and ground water resources in accordance with the NSW Aquifer Interference Policy, including: • impacts on affected licensed water users and basic landholder rights. • impacts on riparian, ecological, geo-morphological and hydrological values of watercourses, including groundwater dependent ecosystems and environmental flows. • whether the development can operate to achieve a neutral or beneficial effect on water quality in the drinking water catchment, consistent with the provisions of State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011.	Impacts to other surface water users – Section 5.3.5 Impacts to GDEs – Groundwater impact Assessment Impacts to surface flow – Section 5.3.4.1 and Appendix E Impacts to watercourses – Section 5.3.4.2 and Appendix E Neutral or beneficial effect – Section 5.7
A detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply infrastructure and water storage structures;	Section 5.2 and Appendix D
Identification of any licensing requirements, including existing or future Environment Protection Licences (EPLs) or Pollution Reduction Programs (PRPs), and approvals under the Water Act 1912 and/or Water Management Act 2000;	Water Access Licence – Section 6.1 EPLs – Section 6.2
Demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP);	The Project operates a water surplus with current mine dewatering for care and maintenance.
A description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo;	Section 2.2.1
A detailed description of the proposed water management system (including sewerage), water monitoring program and all other proposed measures to mitigate surface water and groundwater impacts	Section 1.4 and Section 6.3
Supplementary DGRs Specific to Groundwater (Issued on 30 August 2013)	**Where addressed in Report**
An assessment of all relevant impacts on water resources and water related values, including: • detailed information addressing the Independent Expert Scientific Committee Information Guidelines for Proposals Relating to the Development of Coal Seam Gas and Large Coal Mines where there is a Significant Impact on Water Resources. • detailed information addressing the department's Water Resources Terms of Reference, currently in preparation.	Water and Salt Balance – Appendix D Impact Assessment including Risk Assessment – Section 5.5 and Appendix H of the Groundwater Impact Assessment Monitoring and Management – Section 7

DGRs Specific to Water Resources (Issued on 6 November 2012)	Report Reference
IESC Comments on the APMEP EIS (Issued 25 August 2014)	
Relevant data and information: • Requirement to characterise existing surface water, groundwater and ecological conditions for the majority of Temperate Highland Peat Swamps on Sandstone (THPSS) (IESC01). • Seasonal surface water flow and an assessment, or estimation, of the baseflow component of the Coxs River (IESC02).	Section 5.5 Existing surface water conditions Section 4. Existing groundwater and ecological conditions are discussed under the relevant impact assessments. Coxs River flows and baseflow are no longer an issue for APMEP as no mine water will be discharged and no impacts to baseflow are anticipated (Section 5.3.4.2).
Application of appropriate methods: • Finer scaled, site specific models, informed by a conceptualisation of the hydrology and hydrogeology, would be needed to have confidence in the predictions of groundwater impacts to individual swamps (IESC04). • Water quality impact estimations for the Coxs River need to consider the increased discharge volumes to Coxs River resulting from reduced demand from the Wallerawang Power Station (IESC05).	Section 5.3.4 and Appendix E. Coxs River water quality is no longer an issue with the implementation of the Springvale water Treatment Project.
NSW River Flow Objectives	
River Flow Objectives	Section 5.6
State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011	
Neutral or Beneficial Impact	Section 5.7

3. Existing Environment

3.1 Climate

The Newnes State Forest is described as being of a warm temperate climate with an annual rainfall of 1,091 mm (Lithgow (Newnes State Forest); Bureau of Meteorology (BoM) Station No. 63062). Summers are mild with average temperatures of 23.5˚ C and winters are cold with average minimum temperatures of -1.0˚ C. Rainfall and temperature are highest in summer and lowest during winter.

Angus Place Colliery pit top facilities are located on the footslopes below the Newnes Plateau, about 150 m lower in elevation than the plateau. Climatological characteristics at the Angus Place Colliery pit top are different to that encountered on the Newnes Plateau, with average annual rainfall at pit top of 758 mm (Lidsdale (Maddox Lane); BoM Station No. 63132).

3.1.1 Rainfall

BoM Station No. 63062 (Newnes Forest Centre) located on Newnes Plateau has rainfall data record from 1938 to 1999. Centennial also operate a weather station on the Newnes Plateau (SVNEWPFR) with data from 1998 to present. A compilation of data from these two stations are provided on Figure 3.1.

Rainfall at the Angus Place Colliery pit top is provided by BoM Station No. 63132 (Maddox Lane) in Lidsdale. The Maddox Lane gauge has data from 1959 to present. Data is presented along with Newnes Plateau data on Table 3.1.

Table 3.1: Average Monthly Rainfall Statistics

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
BoM Station No. 63132 (Maddox Lane) - 1959 to present													
Mean	85.8	75.9	66.6	42.4	47.9	50.3	50.0	63.2	53.0	68.0	72.4	73.9	758.3
Lowest	8.0	5.6	3.8	1.0	2.6	2.6	2.7	1.8	3.4	2.4	7.6	0.0	329.8
Median	76.7	68.2	51.4	31.6	40.6	39.8	42.6	50.0	49.9	71.4	62.5	66.1	761.8
Highest	213.6	270.4	270.4	202.6	131.2	228.3	214.0	363.8	123.0	228.4	164.7	217.0	1260.3
BoM Station No. 63062 (Newnes Forest Centre) - 1938 to 1999													
Mean	121.0	114.1	102.9	79.9	81.3	83.0	68.3	83.5	67.9	91.5	89.0	90.4	1091.9
Lowest	18.8	5.6	5.1	6.2	11.0	0.0	2.0	4.6	0.0	6.4	4.7	2.6	495.5
Median	132.9	90.8	78.7	60.0	63.2	62.8	53.9	67.2	64.3	80.8	78.6	67.1	1136.8
Highest	280.8	338.6	519.4	299.1	286.9	320.0	240.7	412.4	207.2	267.2	209.3	303.2	1889.1
Centennial Newnes Prison Farm													
Mean	93.7	119.6	105.3	54.5	41.1	79.2	49.9	52.7	54.5	83.6	100.4	84.2	924.6
Lowest	19.5	15.2	29.5	10.0	13.0	9.0	8.5	13.5	0.4	8.0	31.5	37.5	595.5
Median	79.3	99.5	89.5	49.3	35.4	54.1	39.0	46.6	52.0	77.9	80.8	75.6	979.9
Highest	196.8	285.0	244.5	206.4	94.0	255.5	114.5	108.5	137.6	272.5	196.0	207.0	1286.0

Key rainfall statistics are provided on Table 3.1. Mean annual rainfall on the Newnes Plateau at Newnes Forrest Centre is typically of the order of 44% higher than that at Lidsdale. Average annual rainfall at Newnes Prison Farm is also lower than that for Newnes Forrest Centre, reflecting the predominantly below average rainfall of the past 18 years.

Figure 3.1 also presents the cumulative rainfall deviation (CRD) of rainfall trends from the long-term average rainfall for the combined Newnes Forrest Centre and Newnes Prison Farm rainfall record. From the CRD trend, it is apparent that there was a long period of predominantly above average rainfall (upwards trending plot) from 1947 through to 1990. Subsequently, the rainfall has been predominantly below average (downwards trending plot). Shorter term cycles of above and below average rainfall are over printed on the longer-term trends.

As well as reduced average rainfalls, rainfall intensities are also shown to be decreasing, that is:

- in the 43 years of data to 1990, there were 43 occasions when monthly rainfall totals met or exceeded 200 mm and 23 occasions when monthly rainfall totals met or exceeded 250mm.
- in the 28 years of data from 1990, there were 19 occasions when monthly rainfall totals met or exceeded 200mm and 3 occasions when monthly rainfall totals met or exceeded 250mm.

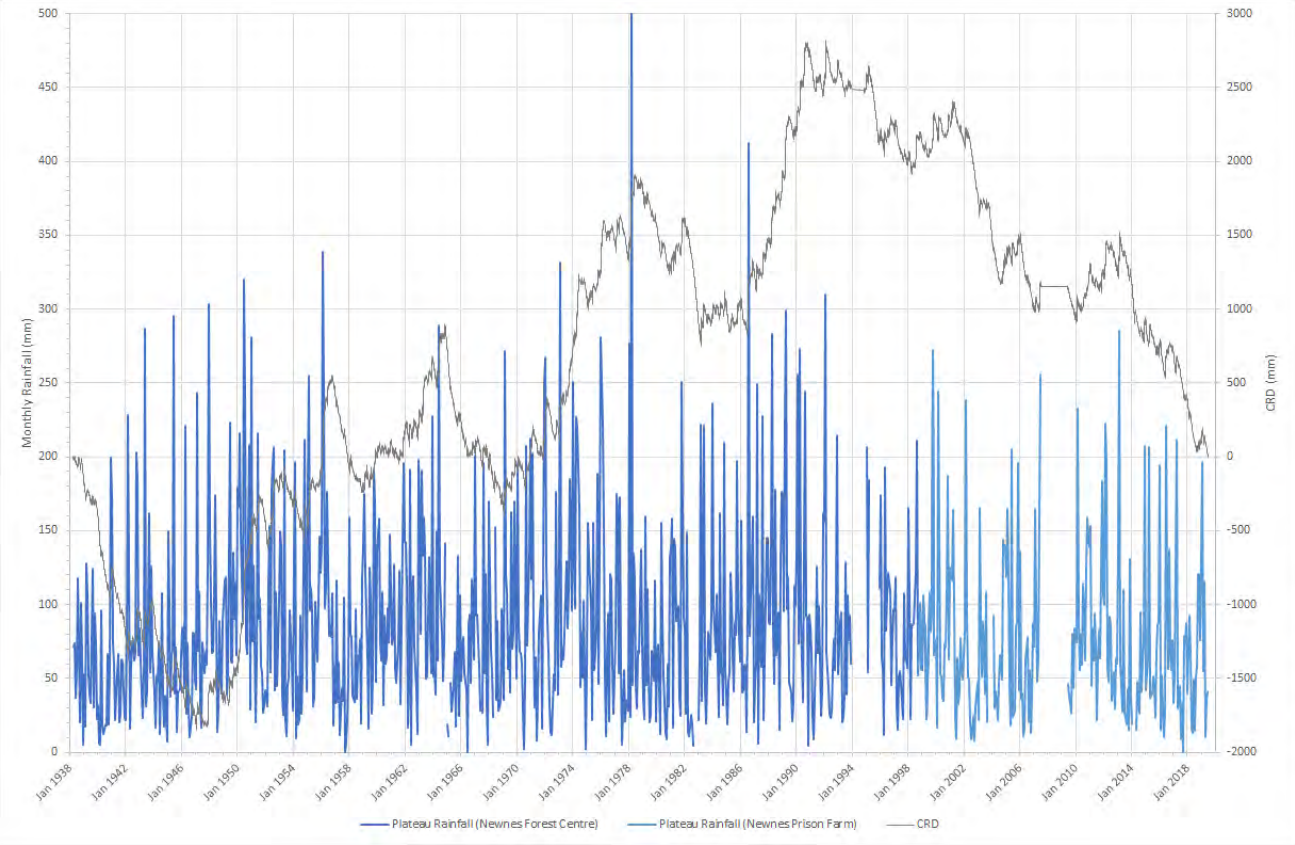


Figure 3.1: Newnes Plateau Rainfall (1938 to 2019)

3.1.2 Evaporation

Daily Pan A evaporation was recorded at the Bathurst Agricultural Station (BoM Station 63005) from 1966 to 2018. The average monthly evaporation rate is presented in Table 3.2. The annual average daily Pan A evaporation rate is 3.7 mm/day. The Bathurst Agricultural Station is the closest monitoring station to Angus Place and is approximately 60 km to the west. Mean monthly rainfall for Bathurst Agricultural Station is also provided on Table 3.2 for comparison, with average annual rainfall approximately 120 mm lower than Lidsdale.

Table 3.2: Evaporation - BOM Station 63005 (Bathurst Agricultural Station)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Monthly Rainfall (mm)	68.4	57.7	52.1	41.4	41.1	44.2	48.3	49.4	46.9	59.0	61.2	66.2	636.8
Mean Daily Evaporation (mm)	6.8	5.8	4.5	2.9	1.7	1.1	1.2	1.9	2.8	4.1	5.3	6.5	3.7

3.1.3 SILO Data

Supporting studies for this Surface Water Assessment (JBS&G, 2019a, JBS&G, 2019b) incorporate the use of Scientific Information for Land Owners (SILO) climate data. SILO is a database of Australian climate data from 1889 to the present, hosted by the Queensland Department of Environment and Science (DES).

Data can be acquired for individual weather stations (station point datasets are available at approximately 8,000 station locations around Australia), or as point or grid data sets, which are defined as:

- Station point datasets are a time series of data at a weather station location, consisting of weather station records which have been supplemented by interpolated estimates when observed data are missing;
- Point datasets are temporal datasets at a single grid location. They provide a time-series of data (usually daily time-step) at either a single grid cell or a single station. Point datasets at grid locations consist entirely of interpolated data; or
- Gridded datasets are spatial datasets for a given date. SILO grids cover all of Australia with resolution 0.05° longitude by 0.05° latitude (approximately 5 km × 5 km).

Rainfall and evapotranspiration data for the region was obtained from the SILO climatic dataset for use in the numerical groundwater model (JBS&G, 2019a) and the swamp water balance model (JBS&G, 2019b). Point data was obtained for SILO grid point Latitude -33.40 and Longitude 150.20, and the gridded dataset (0.05 degrees, equivalent to 5km x 5km cells) was also used in the Swamp Water Balance Model and Hydrogeological Model.

3.2 Drainage and Catchments

The Project Application Area is located in the catchments of the Coxs River and Wolgan River (Figure 3.2). The Angus Place Colliery pit top is located in the Coxs River Valley. Kangaroo Creek drains off the Newnes Plateau and joins the Coxs River in the vicinity of the pit top.

Proposed longwalls, LW1001 to LW1015, of the Amended Project are located beneath the catchment of the Wolgan River. The longwalls are bounded by the Wolgan River to the west and Carne Creek to the east. In the vicinity of the project, the Wolgan River flows generally to the north and then to the north east in the Wolgan Valley. Carne Creek also drains in a generally northwards direction, flowing to the Wolgan Valley. Numerous drainage lines on the plateau flow westward and contribute to the Wolgan River and Carne Creek, including the drainages of Tri Star Swamp and Twin Gully Swamp that are located above the proposed longwalls.

Catchment areas above the proposed longwalls typically comprise open eucalypt woodland on the ridges and valley flanks, with dry rocky heath along exposed ridges and cliff lines. Valley floors in the upper catchment area comprise a combination of open woodland, and wet heath and sedge shrubs swamps (refer Section 3.6.1).

The Coxs River Valley is largely cleared and modified with the predominant land use being dryland grazing. Topography and slope gradient are presented on Figure 3.2. Drainages off the plateau are often deeply incised in their lower reaches, incorporating numerous cliff lines and pagodas bordering the valley flanks. In the upper catchment areas, drainage lines are typically poorly defined to non-existent with overland sheet flow being the typical mode of discharge during high rainfall events.

The Angus Place Colliery pit top sits at an elevation of approximately 915 mAHD in the Coxs River Valley. Ridgeline elevations of the Newnes Plateau above the proposed longwalls are at elevations of the order of 1100 mAHD to 1160 mAHD, with valleys incised down to approximately 1000 mAHD above the proposed longwalls.

3.2.1 Stream Order

Stream order in the Project Application Area is shown on **Error! Reference source not found.**. The stream order assignment has been undertaken in accordance with the NSW Department of Industry Fact Sheet – Determining Stream Order (NSW DoI, 2018) and the Water Management (General) Regulation 2018 Hydro Line spatial data set.

Drainage lines above the proposed longwalls and with the 26.5° angle of draw Study Area are predominantly either first or second order streams, often with no defined drainage channel. Third order streams are associated with the drainages of Twin Gully and Tri Star Swamps, with the Twin Gully drainage becoming fourth order below the confluence of the two branches of the swamp and within the 600m Study Area. The Wolgan River, on the Newnes Plateau, ranges from third order to fifth order adjacent to the proposed longwalls.

In the vicinity of the pit top, Kangaroo Creek has reached third order and joins the fifth order Coxs River.

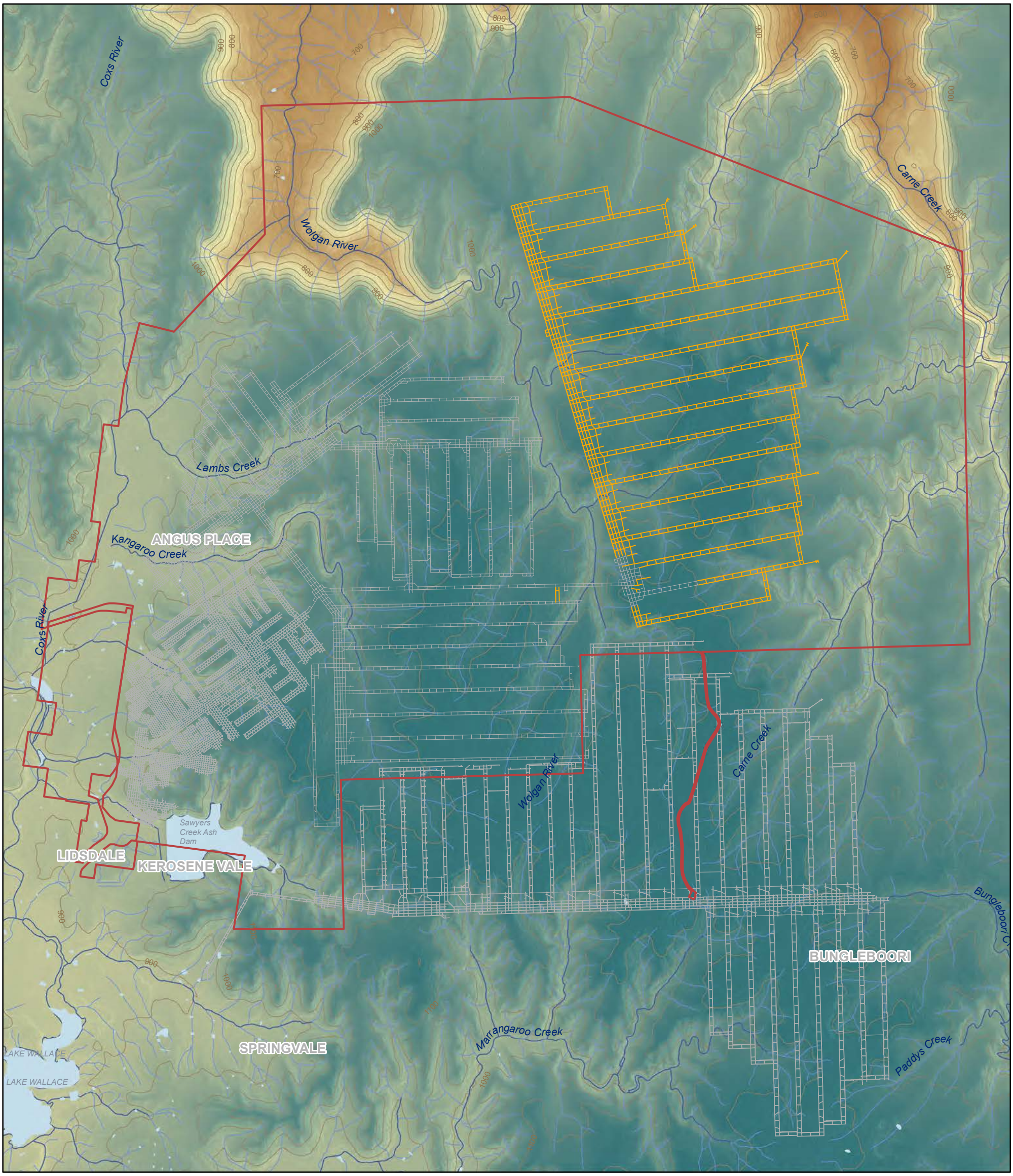
3.3 Soils

The soil landscape units within the Project Application Area have been mapped by the former NSW Department of Land and Water Conservation, incorporating the NSW Soil Conservation Service (now part of the DPI), at the scale of 1:100,000 (King, 1993). A detailed soil and land capability assessment was undertaken for the 2014 Angus Place Extension Project EIS (GSS, 2014). A summary of the soil landscapes present in the Project Application Area is provided on Table 3.3 and presented on Figure 3.3.

The dominant soil landscape units in the Project Application Area are the Wollangambe landscape, which is an erosional landscape comprised of rounded convex crests and moderately to steeply inclined side slopes on sandstone, and Newnes Plateau landscape, which is a residual landscape comprised of level to gently undulating wide crests and ridges on plateau surfaces of sandstone.

Other substantial soil landscapes include Warragamba, Hassans Walls and Medlow Bath. Soil types associated with swamps include Deanes Creek soil types on the Newnes Plateau and Long Swamp soil types in the Coxs River valley. Soils in the vicinity of the Angus Place Colliery pit top are dominated by Lithgow Soils. Other minor soil landscapes in the Project Application Area include Mt Sinai, Cullen Bullen and Glen Alice.

Figure 3.2: Topography and Drainage



Infrastructure
- Proposed Workings
- Existing Workings

Project Area
- Project Area

Contours [mAHD]
- 50 m interval

Hydrology
- Water Areas
- Stream Order 1 - 2
- Stream Order 3 - 6

Elevation [mAHD]
High : 1150
Low : 500



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Data Sources - Centennial Angus Place Pty Ltd: Project Area, Infrastructure (2019); NSW Government Public Data: Roads, Hydrology, Placenames; Geosciences Australia (ELVIS): Elevation, 50m Contours; Office of Environment and Heritage NSW: Tenures; ESRI ArcGIS Image Service: World Elevation Terrain, World Topographic Map

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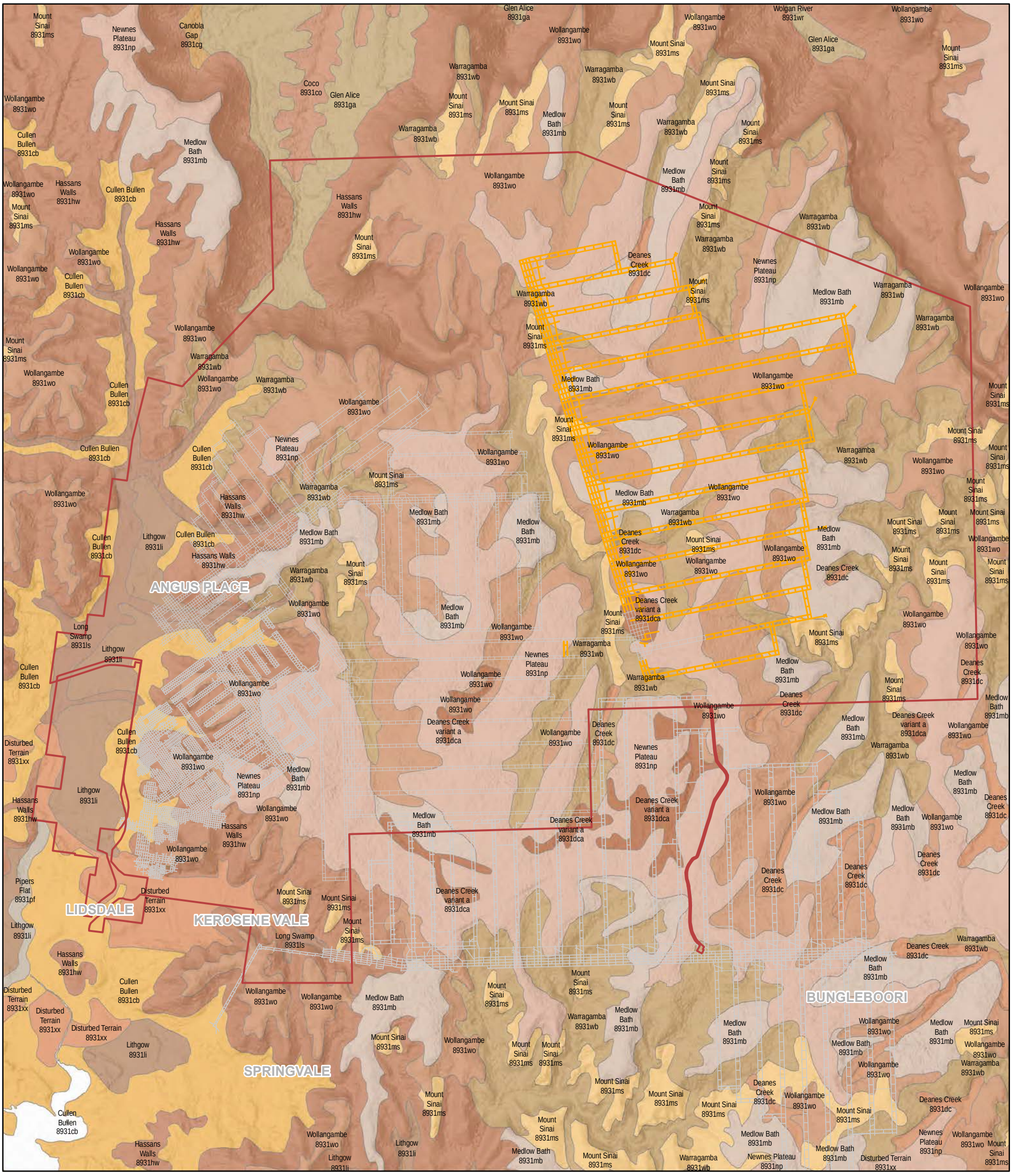
Table 3.3: Soil Landscape Characteristics

Soil Landscape (map unit)	Approximate area within PAA (ha)	Topographic Occurrence	Key characteristics
Wollangambe (8931wo)	2672	Rounded convex crests and moderately to steeply inclined side slopes on Narrabeen Group sandstones. Slopes usually <35 per cent.	High to severe water erosion, steep slopes, shallow soils, localised rock fall hazard, localised rock outcrop and low soil fertility.
Newnes Plateau (8931np)	2036	Level to gently undulating low crests and ridges on plateau surfaces of Triassic Sandstone. Slopes <10 per cent, and infrequent rock outcrop.	Highly permeable, stony soils of low fertility, low water holding capacity, high potential aluminium toxicity and localised shallow soils.
Warragamba (8931wb)	1609	Narrow convex crests and ridges and steep colluvial side slopes on Narrabeen Group sandstones with minor cliffs and scarps on steeper slopes. Slopes typically >35 per cent.	Mass movement hazard, steep slopes, sever water erosion hazard, rock fall hazard, acidic, stony soils of low fertility and rock outcrop.
Hassans Walls (8931hw)	1418	Cliffs derived from Narrabeen Group sandstones and steep colluvial talus side slopes developed over the Illawarra Coal Measures and the Shoalhaven Group. Slopes mostly >40 per cent.	Rock fall hazard, steep slopes, extreme water erosion, mass movement, localised shallow soils, high run-on, non-cohesive soils.
Medlow Bath (8931mb)	1097	Consists of narrow crests and moderately inclined side slopes on Narrabeen Group sandstones. Slopes of 10 – 20 per cent.	Shallow, stony, acid soils of low fertility, high potential aluminium toxicity, moderate erodibility and localised rock outcrop.
Mt Sinai (8931ms)	397	Narrow, rocky undulating crests and steep side slopes with many rocky benches and pagoda formations on Narrabeen Group Sandstones.	Extreme water erosion hazard, rock outcrop, steep slopes, rock fall hazard, wind erosion hazard, and stony shallow, acid, non-cohesive highly permeable soils with low fertility.
Lithgow (8931li)	335	Consists of flat to undulating rises and broad valley floors on Illawarra Coal Measures and the Berry Formation. Slopes <10 per cent.	Hard setting top soils, high run-on, localised rock fall hazards and localised potential aluminium toxicity.
Cullen Bullen (8931cb)	305	Rolling low hills and rises on Illawarra Coal Measures and the Berry Formation. Localised rock outcropping occurs as small isolated low scarps. Slopes are typically 10 – 25 per cent.	Dispersibility, erodibility, hard setting surface, acidity, low fertility, low wet bearing strength.
Long Swamp (8931ls)	236	Level to very gently inclined swamps on recent alluvium overlying the Permian Illawarra Coal Measures. Slopes mainly <3 per cent.	High run-on, permanent high water tables, waterlogging, high foundation hazard, and highly organic acid soils of low fertility.
Deanes Creek (8931dc)	131	Consists of narrow, gently inclined elongated valley-side tree swamps along drainage lines on Narrabeen Group Sandstones.	Permanently high water tables and periodic to permanent waterlogging, acid soils of low fertility, high run-on, and high foundation hazard.
Glen Alice (8931ga)	122	Rolling rises and low hills on Shoalhaven Group sediments in the Wolgan and Capertee Valley. Slopes of 5 - 20 per cent.	Hard setting top soils, localised salinity, localised alkalinity, high water erosion hazard, localised steep slopes and occasional localised flooding.

Figure 3.3: Soil Landscape



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Data Sources - Jacobs: Project Area, Infrastructure (2019); NSW Government Public Data: Roads, Hydrology, Placenames; Geosciences Australia (ELVIS): 50m Contours; Department of Planning, Industry and Environment NSW: Soil Landscapes; ESRI ArcGIS Image Service: World Elevation Terrain, World Topographic Map

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3.4 Stream Geomorphology and Characterisation

An assessment of stream geomorphology above the proposed Angus Place longwalls LW1001 to LW1015 was undertaken by Jacobs with the assessment report provided in Appendix F.

The assessment was undertaken as a desktop study supported by three days on site for field inspection and ground truthing. A total of 13 different sites were visited as part of a fieldwork program conducted in July 2019. Locations of the field inspection are provided on Table 3.4 and shown on Figure 3.4. Further details are provided in Appendix F.

Description of the stream geomorphology in the vicinity of the project is provided in the following section.

Table 3.4: Geomorphology Site Inspection Locations

Site No.	Site Name	Watercourse[1]	Stream Order	Upstream Catchment Area (ha)	River Style
1	Trail Six / Japan Swamp	Drainage Line 4	2	201	Intact valley infill
2	Waterfall Site	Drainage Line 5a	2	101	Gorge
3	Twin Gully Northern Tributary - Upstream	Drainage Line 3a	3	117	Channelised fill
4	Twin Gully Downstream	Drainage Line 3	3	163	Transition (channelised fill to gorge)
5	Twin Gully Downstream at Cascade	Drainage Line 3	3	13	Gorge
6	Twin Gully Southern Tributary Upstream	Drainage Line 3b	2	41	Channelised fill
7	Wolgan River	Wolgan River	4	1913	Gorge
8	Tristar Swamp Downstream	Drainage Line 2	3	109	Gorge
9	Tristar Swamp Upstream	Drainage Line 2a	3	157	Channelised fill
10	Tristar Swamp Upstream Southern Tributary	Drainage Line 2b	2	64	Channelised fill
11	Southern Panels	Drainage Line 1	2	160	Gorge
12	Carne West Swamp Downstream	Carne Creek Trib 1	2	228	Steep headwater
13	Gang Gang Swamp Downstream	Carne Creek Trib 2	3	278	Steep headwater

Note – [1] - Adopted nomenclature for unnamed drainage lines has been based on that developed by MSEC (2019) and is shown on Figure 4.4 of Appendix F.

3.4.1 River Style Characterisation

Four main geomorphic river styles are identified in the vicinity of the proposed longwalls. The geomorphic river styles and key characteristics are as follows:

- *Intact Valley Infill*, this is the geomorphic river style in which the majority of NPSS reside.
  - Characterised by low gradient, with an intact, concave valley infill that covers the valley floor.
  - Flow is typically subsurface with occasional surface expressions occurring at low points in the surface elevation.
  - Drainage channels are typically absent.

- Representative sites assessed include Trail Six / Japan Swamp, Twin Gully Swamp, Tristar Swamp, Gang Gang Swamp and Carne West swamp.

- *Channelised Infill*, is typically found on the inflow tributaries to the swamps
  - Characterised by low sinuosity, discontinuous channels located within an infilled, confined valley setting where the infilled surface typically abuts the valley margin.
  - Alternate phases of channel entrenchment (gullying) and filling occur. Where present channels are typically small and trench-like. Elsewhere, the valley floor is effectively the channel with shallow swale-like channels tending to poorly defined, discontinuous drainage lines.
  - Lateral inflow tributaries drop steeply down the valley sides at grades greater than 20% to join the main channel at typically perpendicular to near-perpendicular confluences.
- *Steep Headwater*
  - Characterised by steep-graded, bedrock confined channels located in narrow, confined valley settings that typically lead into downstream gorges.
  - Bedrock steps (waterfalls) and runs and cascades are prevalent.
- *Gorge*
  - Characterised by a confined valley setting where the single, continuous channel abuts the valley margin more than 90% of the time with no floodplain present.
  - Valley sides are steep to vertical (cliffs), sometimes deeply dissected by inflow tributaries leading to bedrock spurs which force the main channel to adopt a meandering path around them and resulting in a relatively sinuous planform.
  - Lower gradient sites with a wider valley setting also comprise some alluvial infilling of the valley floor into which the channel is incised.

3.4.2 Geomorphic Condition

A review of the existing geomorphic condition of the sires visited is provided as follows.

3.4.2.1 Intact Valley Infill (Swamps)

With the exception of Carne West and Gang Gang Swamps (which were selected as previously impacted reference sites), all sites were found to be in good condition and no concerns were noted. Each site appeared to be in good condition showing an appropriate behaviour and character for the river style.

3.4.2.2 Channelised Infill

All sites visited exhibited an appropriate behaviour and character for the river style. This river style is characterised by alternate phases of channel entrenchment (gullying) and filling with entrenchment typically initiated during infrequent high energy floods. All sites visited typically appeared to be in good condition with no adverse concerns; processes of channel development and infilling appeared to be in balance and riparian vegetation was found to be intact and undisturbed.

One site (Site 10, located in the upper reaches of Tristar Swamp southern tributary) was noted to have some relatively large-scale erosion and scour features including inflow gullying and undercutting and slumping of the over-large channel banks. The reach comprising of the enlarged channel was approximately 150m long and discontinuous. Continued upstream propagation of channel erosion is limited due to headcut down to bedrock and downstream the channel progressively reduces in size until it disappears. With the exception of a large inflow gully (which appeared to be actively headcutting) the channel appeared stable and well vegetated.

3.4.2.3 Steep Headwater

This river style is characterised by steep-graded, bedrock confined channels located in narrow, confined valley settings that typically lead into downstream gorges. Bedrock steps (waterfalls) and runs and cascades are prevalent. All sites visited within the Study area appeared to be in generally good condition showing an

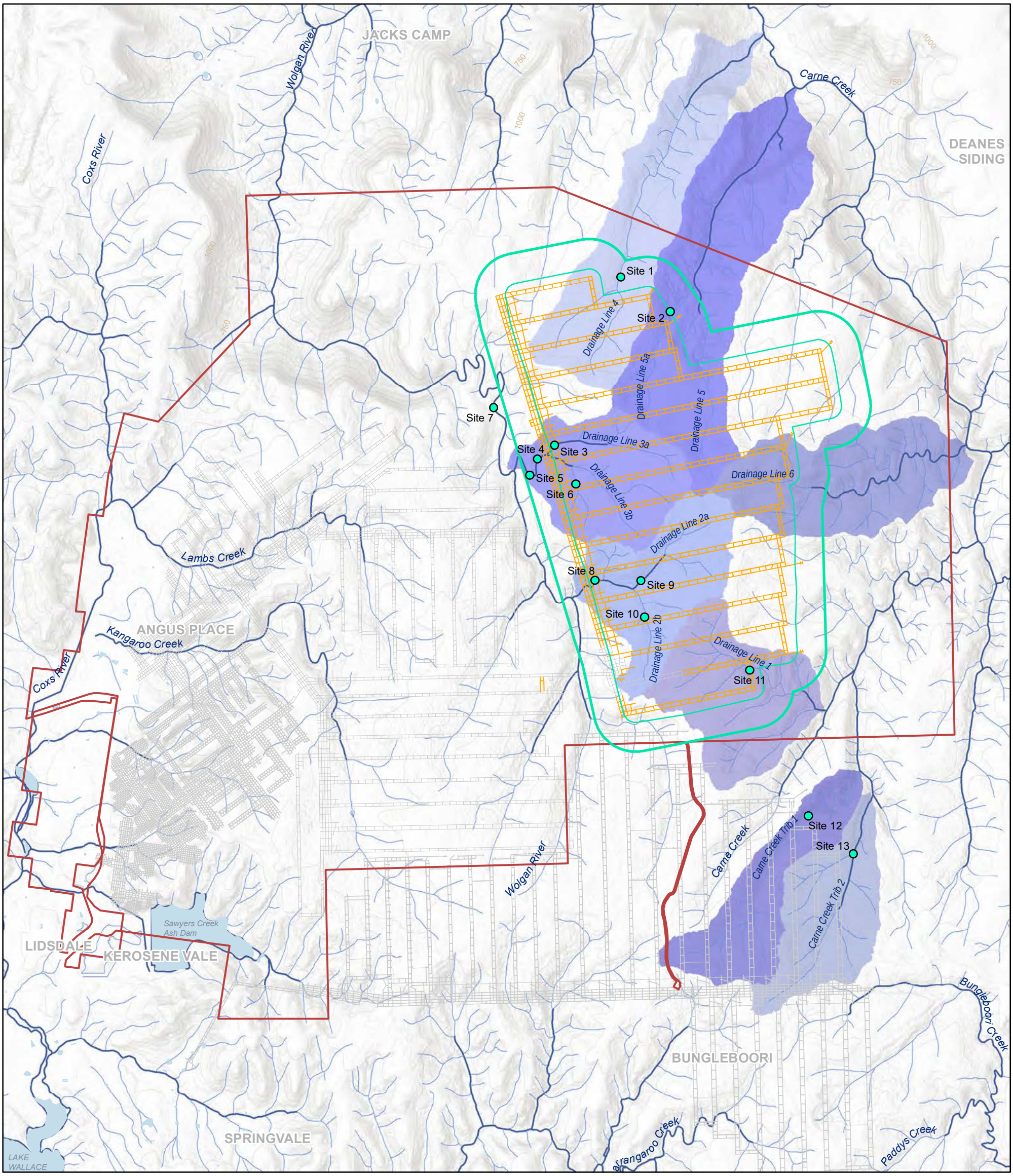
appropriate behaviour and character for the river style. It is noted however, that numerous sites are crossed by 4WD access tracks leading to increased sediments loads to the channels downstream of the crossings.

Two sites outside of the Study area that were visited (sites 12 and 13) were found to be moderately impacted. Both sites are located downstream of impacted swamps (Gang Gang and Carne West). The standing water level in both swamps has been lowered as a result of previous mining subsidence. This has caused a drying of the swamps and reduction/elimination of downstream baseflow. Downstream of the swamps the reaches exhibited infilling of plunge pools and the channel as well as a change in vegetation. Significant growths of vegetation within the channel including almost complete coverage of bedrock runs and rock ledges was seen. It is acknowledged that a large flood flow would likely scour out the plunge pools and remove a large proportion of the vegetative growth however the loss of baseflow and probable reduction in low flows appears to have reduced the ability to throughput sediment being supplied from the access tracks located immediately upstream at both sites.

3.4.2.4 Gorge

This river style is characterised by a confined valley setting with valley sides that are steep to vertical (cliffs). Valley sides are sometimes deeply dissected by inflow tributaries leading to bedrock spurs which force the main channel to adopt a meandering path around them and resulting in a relatively sinuous planform. All sites visited were found to be in generally good condition showing a behaviour and character appropriate to the river style. The Wolgan River is noted to have numerous 4WD track crossings. The crossing points are typically incised into the river banks and create localised contribution of increased sediment loads. The development of sand bars downstream of the crossing points was noted.

Figure 3.4: Geomorphology Site Investigations



Drainage Catchments
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8

Infrastructure
- Proposed Workings
- Existing Workings

Project Area
- Project Area

APE Study Areas
- 26.5 degree AoD
- 600m Study Area

Contours
- 50 Metre

Hydrology
- Water Areas
- Stream Order 1 - 2
- Stream Order 3 - 6
- Site Inspection Locations



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3.5 Surface Water / Groundwater Interaction

The dominant surface water / groundwater interactions on the Newnes Plateau involve infiltration and recharge processes to shallow groundwater and groundwater discharge to surface water. Infiltration of rainfall and runoff is likely to occur along the ridgelines and areas of exposed or shallow sub-cropping bedrock in the upper catchment areas.

Groundwater discharge to surface water occurs as seepages and drips from exposed seepage faces on cliff lines or exposed bedrock in drainage lines, and as seepage from sub-cropping bedrock to regolith or detrital soil profiles on valley flanks and along valley floors. Where of sufficient magnitude, these seepages may support the development of Newnes Plateau Hanging Swamps (NPHS) or Newnes Plateau Shrub Swamps (NPSS) (Section 3.6.1).

Groundwater seepage may contribute to stream baseflows either directly as discharge to drainage lines in the valley floor, or indirectly as a contribution to catchment subsurface flow.

3.6 Sensitive Receptors

Sensitive receptors that have been identified include:

- Temperate Highland Peat Swamps on Sandstone (THPSS) comprising NPHS and NPSS (discussed below, Section 3.6.1);
- Drainages and waterways as described in Section 3.2;
- Aquatic ecology associated with drainages and swamps (discussed in the Aquatic Ecology and Stygofauna Assessment, Cardno, 2019); and
- surface water users downstream of the Project including licenced water users and basic landholder rights.

3.6.1 Temperate Highland Peat Swamps on Sandstone

THPSS are listed as an Endangered Ecological Community (EEC) under the EPBC Act due to their restricted distribution and their vulnerability to ongoing threats. THPSS comprise both NPSS and NPHS. NPSS are listed as an EEC under the Biodiversity Conservation Act 2016. THPSS are characterised by highly organic sandy loams to mineral peat soils overlying sandstone at altitude, which supports a unique assemblage of flora. The federally listed Temperate Highland Peat Swamps on Sandstone EEC occurs in the Blue Mountains, Lithgow, Bombala and Wingecarribee Local Government areas. They have a naturally fragmented distribution pattern forming in response to extremely localised conditions which are created by a unique combination of topographic, geological, hydrological and groundwater influences (BMCC, 2010).

THPSS generally occur at altitudes from about 650 mAHD to 1200 mAHD. On the Newnes Plateau, the swamps are associated with Triassic sandstone plateau (Narrabeen Sandstone) and occur in shallow, low-sloping, often narrow headwater valleys, on long gentle open drainage lines in the lowest footslopes, low-lying broad valley floors, and in gully heads, open depressions on ridge tops, and steep valley sides associated with semi-permanent water seepage (SPRAT, 2019). On the Newnes Plateau, THPSS typically include valley fill Newnes Plateau Shrub Swamps (NPSS) and Hanging Swamps (NPHS) on the steep valley flanks and cliffs.

THPSS are associated with black to grey coloured, acid peaty soils, have moderate to high organic matter content with generally a sandy or loamy texture, and are poorly drained and hence permanently or periodically/intermittently water logged.

A summary of the surface water and groundwater interactions of the NPSS and NPHS Swamps is provided as follows (from Commonwealth of Australia, 2014):

3.6.1.1 Newnes Plateau Shrub Swamps

- NPSS *occur further down the catchment than headwater swamps, in the steeper terrain of incised valleys associated with second- or third-order streams.*

- *The steeper incision into the underlying sandstones means the swamps are more likely to intersect water-bearing layers within the horizontally bedded sandstone.*
- *The water regime for valley infill swamps therefore combines rainfall and surface water run-off, as well as groundwater inputs.*
- *The* NPSS *surface can be either permanently or ephemerally wet.*
- *Water quality within the swamps is variable, and is controlled by a combination of rainfall, run-off and groundwater quality.*
- *The* NPSS *is recharged through a combination of groundwater discharge from perched or regional sandstone aquifers, rainfall and run-off.*
- *Water flows through the swamps either as sheet flow along the surface of the peat, through the peat or through channels within the peat. These channels control the water level within the peat swamps.*
- *Groundwater discharge to the swamps is through either:*
  - *groundwater movement along fractures, joints or bedding planes that intersect the peat swamp*
  - *to a lesser extent, the lower permeability sandstone layers that intersect the peat swamp*
- *Depending on location in the landscape, the groundwater flow system could be local, intermediate or regional.*
- *Connection between aquifer and swamp is either permanent (more likely where the regional aquifer is the groundwater source) or ephemeral (more likely where perched aquifers are the groundwater source).*
- *Groundwater quality is variable, depending on residence time within the aquifer.*

3.6.1.2 NPHS

- NPHS *occur on steep valley sides or cliffs and are predominantly reliant on groundwater discharge that seeps out along bedding planes and low-permeability layers in the sandstone.*
- NPHS *occur at the interface between higher and lower permeability sandstone/shale layers.*
- *Sediment and peat deposition is minimal due to the steep topography, and is limited to sediment caught within vegetation roots.*
- *Groundwater discharge to the swamps is caused by the presence of low-permeability layers within the aquifer forcing water sideways to seep out of the cliff face.*
- *Groundwater contributions may be from perched aquifers, or as recently infiltrated water that flows along cracks and joints before discharging to the swamp.*
- *Groundwater flow system is local, and groundwater quality is expected to be fresh due to relatively short flow paths and residence times in the aquifer.*
- *Connection between aquifer and swamp is either permanent or ephemeral and occurs after rainfall.]*

3.6.1.3 Swamp Waterlogging

Water level responses and trends within swamps rely on a number of factors, including depths of swamp materials, catchment size and characteristics, and groundwater contribution. The degree of water logging of a swamp depends on the prevailing hydrology and water balance.

Where groundwater contribution and catchment sub-flow is relatively high, and swamp water levels are maintained at or near the surface by groundwater baseflow contributions, there is little available space for rainfall recharge, and rainfall and runoff are lost as surface flows. These swamps present relatively stable water levels with little fluctuation and are termed permanently waterlogged swamps.

Where swamp materials are thicker or groundwater contributions are lower, and water levels are maintained below the surface of the swamp, rainfall and runoff can infiltrate and recharge the swamp materials. This results in an increase in water levels with recharge and subsequent regression. Swamps displaying this behaviour are

termed periodically waterlogged swamps, although the swamp materials may be saturated at depth or partially drained, during the intervening periods. It is recognised that swamps can transition from permanently water logged to periodically water logged along their length, or over time, depending on the prevailing conditions.

Water level responses will also vary according to the response time of the various influencing stresses. Indicative response time magnitudes of some typical stresses are provided below:

- Rainfall and runoff – hours to days
- Catchment sub-flow – weeks to months
- Groundwater – shallow perched – months to years
- Groundwater – deeper – years to decades

3.6.1.4 Proposed Longwall Panels

Mapped THPSS in the vicinity of the APMEP are shown on Figure 4.1. Of these swamps:

- Tri Star and Twin Gully Swamps directly overly proposed longwalls;
- Trail Six/Japan Swamp lies partly within the angle of draw Study Area, although will not be directly undermined;
- Birds Rock Swamp, Crocodile Swamp and Wolgan River Upper Swamp lie within the 600m Study Area; and
- Wolgan River Swamp lies just outside the 600m Study Area.

3.7 Surface Water Users

Surface Water users in in the Upper Nepean and Upstream Warragamba Water Source (Wywandy Management Zone) and Hawkesbury and Lower Nepean Rivers Water Source (Colo River Management Zone) in the vicinity of the project have been obtained from the NSW Water Register (https://waterregister.waternsw.com.au/water-register-frame).

The locations of surface water users in the vicinity of the Project Application Area are provided on Figure 3.5, with details provided in Appendix A. A total of 15 water supply works and associated water access licences are registered in the vicinity of the Project Application Area.

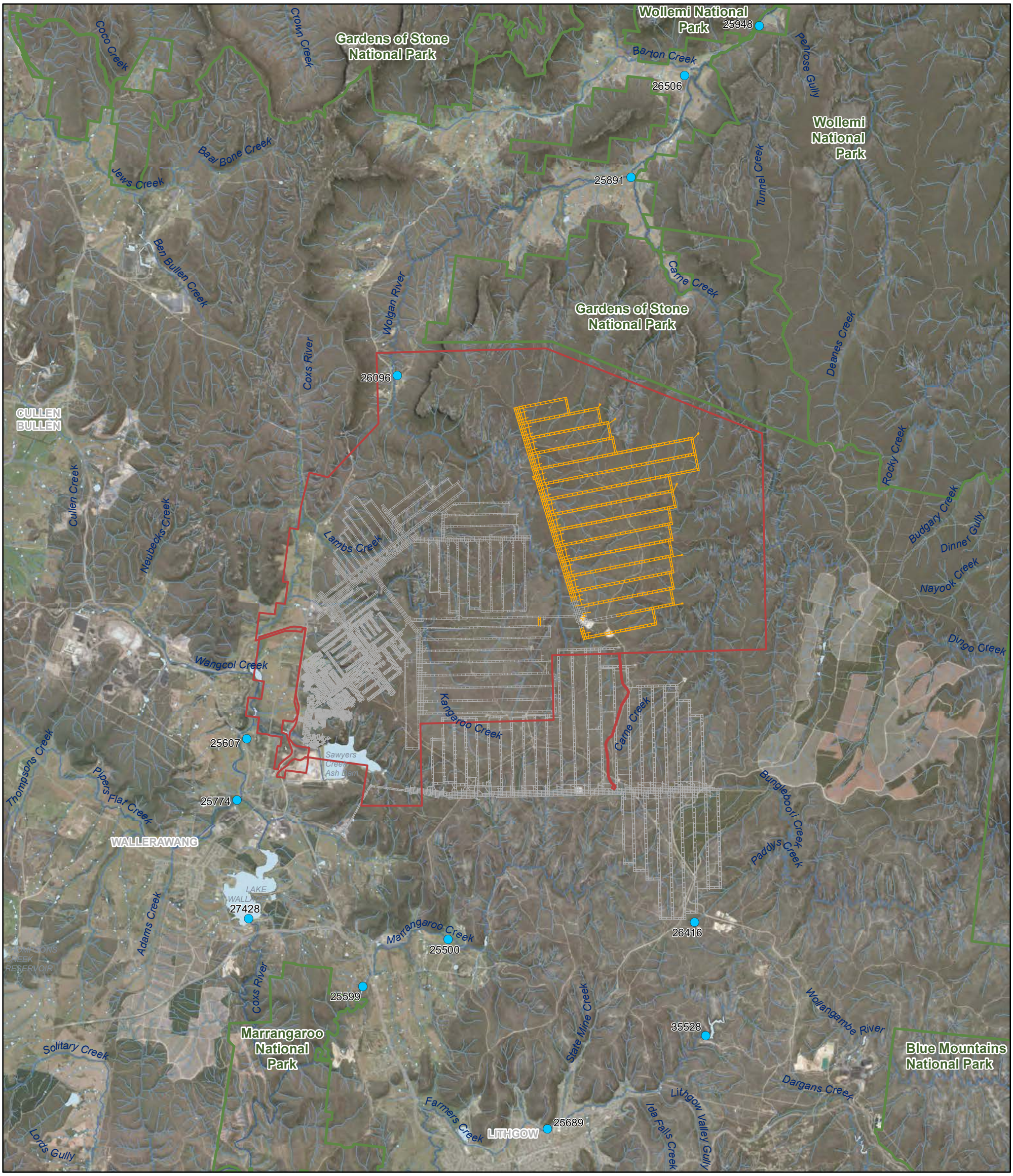
Within the Wywandy Management Zone, the major surface water user is WAL No. 27428 and encompasses the EnergyAustralia Coxs River Water Supply Scheme. That scheme connects Thompsons Creek Reservoir, Lake Wallace and Lake Lyell.

Of the identified water supply works:

- eleven are unregulated river licences
- three for are domestic and stock use
- one is for a major utility (Power Generation). It is noted that this WAL has three recorded draw points (Lake Lyell, Lake Wallace and Thompsons Creek Dam).

The closest users are within Carne Creek and the Wolgan River in the Wolgan Valley. Consideration for potential impacts to surface water users are discussed in Section 5.3.5.

Figure 3.5: Surface Water Users



Infrastructure
- Proposed Workings
- Existing Workings

Project Area
- Project Area

Tenures
- National Parks

Roads
- Primary Road
- Arterial Road
- Sub-Arterial Road
- Local Road
- Track-Vehicular

Hydrology
- Water Areas

Watercourse by relevance
- 1
- 2
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4. Surface Water Monitoring

Centennial maintains an extensive surface water monitoring network on the Newnes Plateau that comprises surface water quality and flow monitoring. The surface water monitoring network is provided on Figure 4.1. Monitoring locations relevant to the APMEP are discussed in the following sections. The surface water monitoring programme is summarised on Table 4.1.

In addition to the monitoring within the mine area, monitoring is also undertaken at several locations remote from the active mining area to serve as reference sites for assessment of potential future impacts from mining. These sites include Barrier Swamp, Best Swamp, and Firetail Swamp (Figure 4.1).

Table 4.1: Surface Water Monitoring Summary

Monitoring Site	Previously Impacted by Longwall Mining	Monitoring Record	Parameters Monitored
Wolgan River Downstream	Upstream tributaries Narrow Swamp, East Wolgan Swamp and Sunnyside Swamp previously undermined. Mine water discharge to Narrow Swamp and East Wolgan Swamp.	2008 to present	Manual flow gauging Water quality
East Wolgan D/S Junction	Upstream tributaries East Wolgan Swamp and Sunnyside Swamp previously undermined. Mine water discharge to East Wolgan Swamp.	2008 to present	Manual flow gauging Water quality
Kangaroo Creek Waterhole (KWH)	Undermined	2008 to present	Pool water depth (logger) Water quality
Kangaroo Creek Weir 1 (KCW1)	Downstream of undermined section	2008 to present	Weir depth/flow (logger)
Kangaroo Creek Upstream	Upstream of mine water discharge at LDP001	2008 to present	Water quality Manual flow gauging (from 2016)
Kangaroo Creek Downstream	Mine water discharge at LDP001	2008 to present	Water quality Manual flow gauging (from 2016)
Narrow Swamp Upstream (NSW1)	Undermined Mine water discharge to Narrow Swamp		Weir depth/flow (logger) Water quality
Narrow Swamp Downstream (NSW2)	Downstream of undermined section Mine water discharge to Narrow Swamp		Weir depth/flow (logger) Water quality
Tri Star Upstream	No	2016 to present	Manual flow gauging Water quality
Tri Star Downstream	No	2013 to present	Flow depth (logger)
Twin Gully	No	2016 to present	Manual flow gauging Water quality
Trail Six/Japan	No	Nil	Proposed Manual flow gauging Proposed Water quality
Barrier	No	2016 to present	Manual flow gauging Water quality

Monitoring Site	Previously Impacted by Longwall Mining	Monitoring Record	Parameters Monitored
Best	No	Late 2017 to present	Manual flow gauging Water quality
Firetail	No	Late 2017 to present	Manual flow gauging Water quality

4.1 Surface Water Flow

Flow monitoring comprises a combination of weirs (Kangaroo Creek and Narrow Swamp), flow depth gauges (Kangaroo Creek Waterhole and Tri Star Creek) and manual flow gauging.

Manual flow gauging is undertaken using the velocity area method, whereby flow velocity and water depth are measured at regular intervals along a cross-section of a stream channel. A Pygmy flow meter was used for velocity measurement up until 2018, at which point the flow meter was upgraded to an ultrasonic doppler flow meter. Monitoring is conducted at two weekly intervals.

A statistical summary of flow data is provided on Table 4.2 and Table 4.3. For the purposes of statistical analysis, where the swamp or stream is noted as flowing, but the flows are too low to allow accurate gauging, flows are approximated as half of the lowest gauged flow volume for that site.

It is noted that a statistical summary is not provided for Kangaroo Creek or Narrow Swamp, as flows in these drainages have historically been influenced by mining or mine water discharge. Flow gauging and surface water quality sampling have yet to be implemented at Trail Six/Japan Swamp. Water quality data for Trail Six/Japan Swamp is reported in the Groundwater Impact Assessment (Jacobs, 2019a) for swamp piezometer XS1.

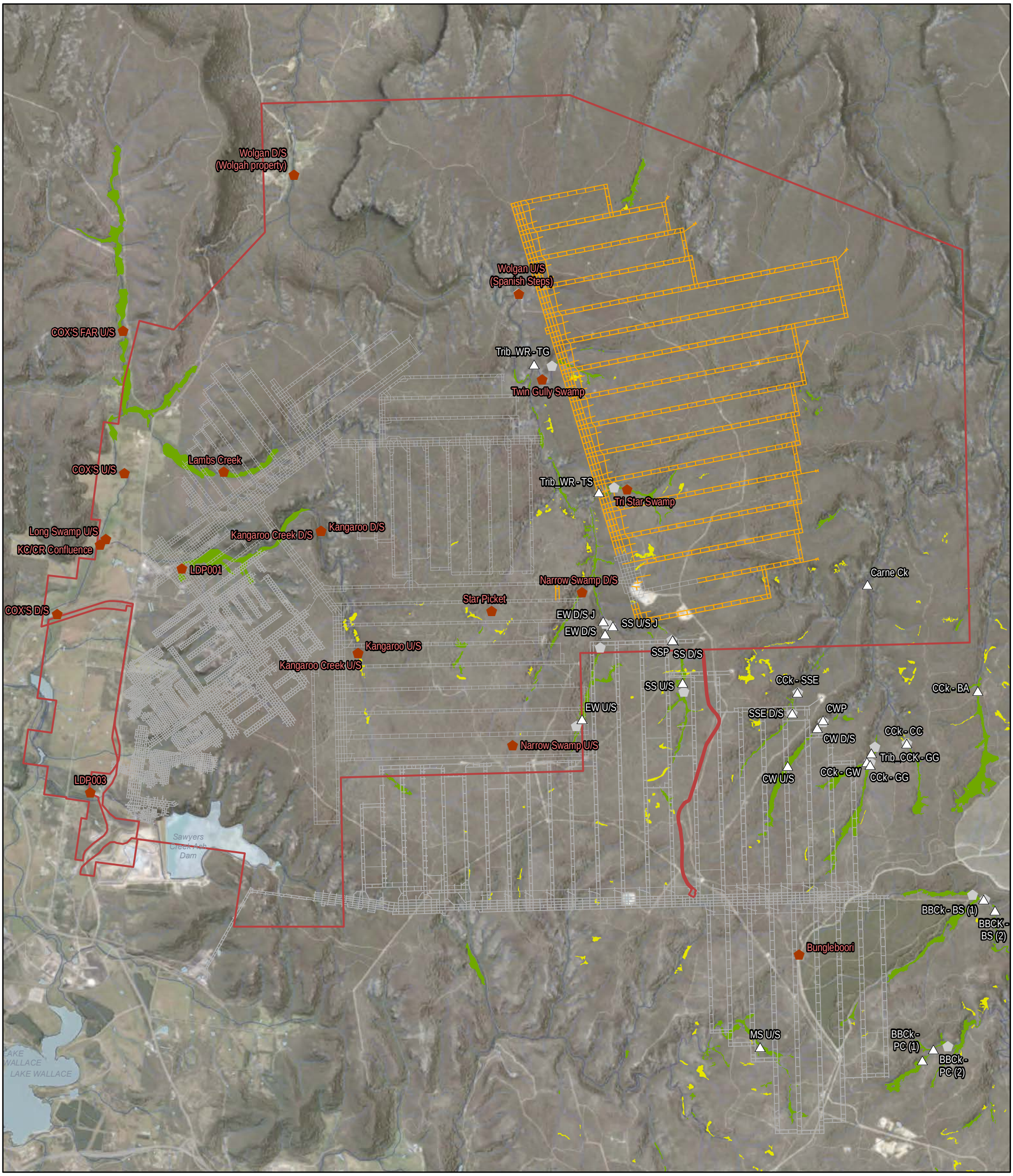
Table 4.2: Flow Gauging Summary – Wolgan River, Tri Star and Twin Gully

	Wolgan River Downstream	East Wolgan D/S Junction	Tri Star Swamp	Twin Gully Swamp
Mean (kL/day)	3477.4	649.1	422.7	243.1
90th Percentile (kL/day)	8657.5	1194.2	742.2	592.8
Median (kL/day)	1576.5	348.5	298.0	163.0
10th Percentile (kL/day)	228.5	74.0	164.2	38.8
Count	296	260	69	55
Zero Flow Observations	3	10	0	1

Table 4.3: Flow Gauging Summary – Barrier, Best and Firetail

	Barrier Swamp	Best Creek	Firetail Swamp
Mean (kL/day)	1063.4	374.4	64.4
90th Percentile (kL/day)	2822	719.4	203.2
Median (kL/day)	544	311	4.3
10th Percentile (kL/day)	60	4	0
Count	53	39	37
Zero Flow Observations	3	0	5

Figure 4.1: Surface Water Monitoring Locations



Infrastructure
- Proposed Workings
- Existing Workings

Project Area
- Project Area

Roads
- Primary Road
- Arterial Road
- Sub-Arterial Road
- Local Road
- Track-Vehicular

Hydrology
- Water Areas
- Stream Order 1 - 2
- Stream Order 3 - 6

Swamps
- Hanging
- Shrub

Surface Water Monitoring Sites
- Angus Place
- Springvale

Gauging Stations
- Gauging stations



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JACOBS

Angus Place Amended Project

Data Sources - Centennial Angus Place Pty Ltd: Project Area, Infrastructure (2019); Jacobs: Monitoring locations; NSW Government Public Data: Roads, Hydrology, Placenames; ESRI ArcGIS Image Service: World Elevation Terrain, World Topographic Map

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4.1.1 Wolgan River

Stream flow monitoring has been undertaken in the Wolgan River since 2008, at locations at the upper (East Wolgan D/S Junction) and lower extents (Wolgan River Downstream) of the proposed longwalls. Flows are shown on Figure 4.2 and flow statistics are summarised on Table 4.2.

The Wolgan River is observed to have flows 99% of the time at the downstream gauging site (Wolgan River Downstream) from the available monitoring data, compared to flows 96% of the time at the upstream gauging site (East Wolgan D/S Junction). Mean flows are of the order of 3,477 kL/day at the downstream site, increasing significantly from 649 kL/day at the upstream site.

It is noted that flows in the Wolgan River during 2008 and 2009 were influenced by emergency mine water discharges to Narrow Swamp and East Wolgan Swamp. The discharges would have comprised a significant component of the upstream flow volumes, but only a relatively minor portion of the downstream flow volumes.

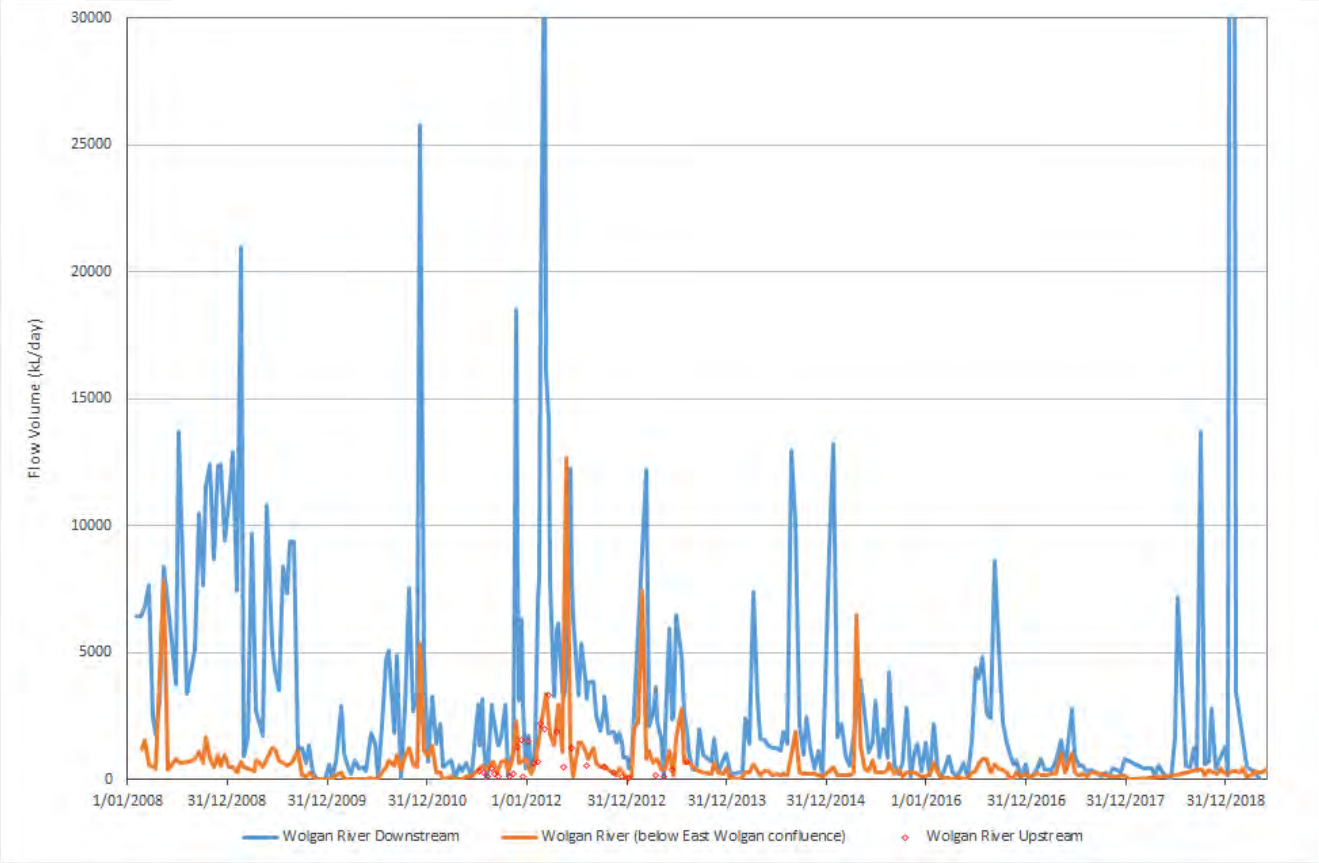


Figure 4.2: Wolgan River Flows

4.1.2 Kangaroo Creek

Stream flow and pool depth monitoring has been undertaken in Kangaroo Creek at Kangaroo Creek Waterhole (KWH) and Kangaroo Creek Weir (KCW1) since 2008. Kangaroo Creek has been undermined by Angus Place longwalls LW920 to LW970. KCW1 is located approximately 2.5 km downstream of KWH and has not been directly undermined.

Flow and water quality are also recorded at Kangaroo Creek upstream and downstream of the confluence with the Angus Place LDP001 discharge point; however, flows are dominated by discharge at LDP001. Flows for Kangaroo Creek D/S are provided in Appendix B.

Kangaroo Creek flow is presented on Figure 4.3 along with pool depths at KWH. Prior to undermining by longwall LW950 at the start of 2010, pool depth at KWH was relatively stable and of the order of 340 mm (0.34 m). It is noted that the pre-mining baseline is approximately 14 months duration. Following the initial undermining, KWH pool depths dropped rapidly. Pool depths are subsequently shown to recover on two occasions coinciding with significant flow events at KCW1. Following undermining by two subsequent longwalls (LW960 in May 2011, and LW970 in August 2012) no further significant pool depths are observed.

Flows observed at KCW1 show Kangaroo Creek flow to be intermittent and highly rainfall dependant. There is no true pre-mining baseline for KCW1, as the creek below KWH was mined up to by longwalls LW920 and LW930, and undermined by LW940 prior to monitoring commencing. Flows at KCW1 are shown to diminish between 2008 and 2013 with subsequent longwalls; however, the period also coincides with continued below average rainfall (refer Section 3.1.1). From 2013, no continuous flow periods are observed with only short-term responses to rainfall events.

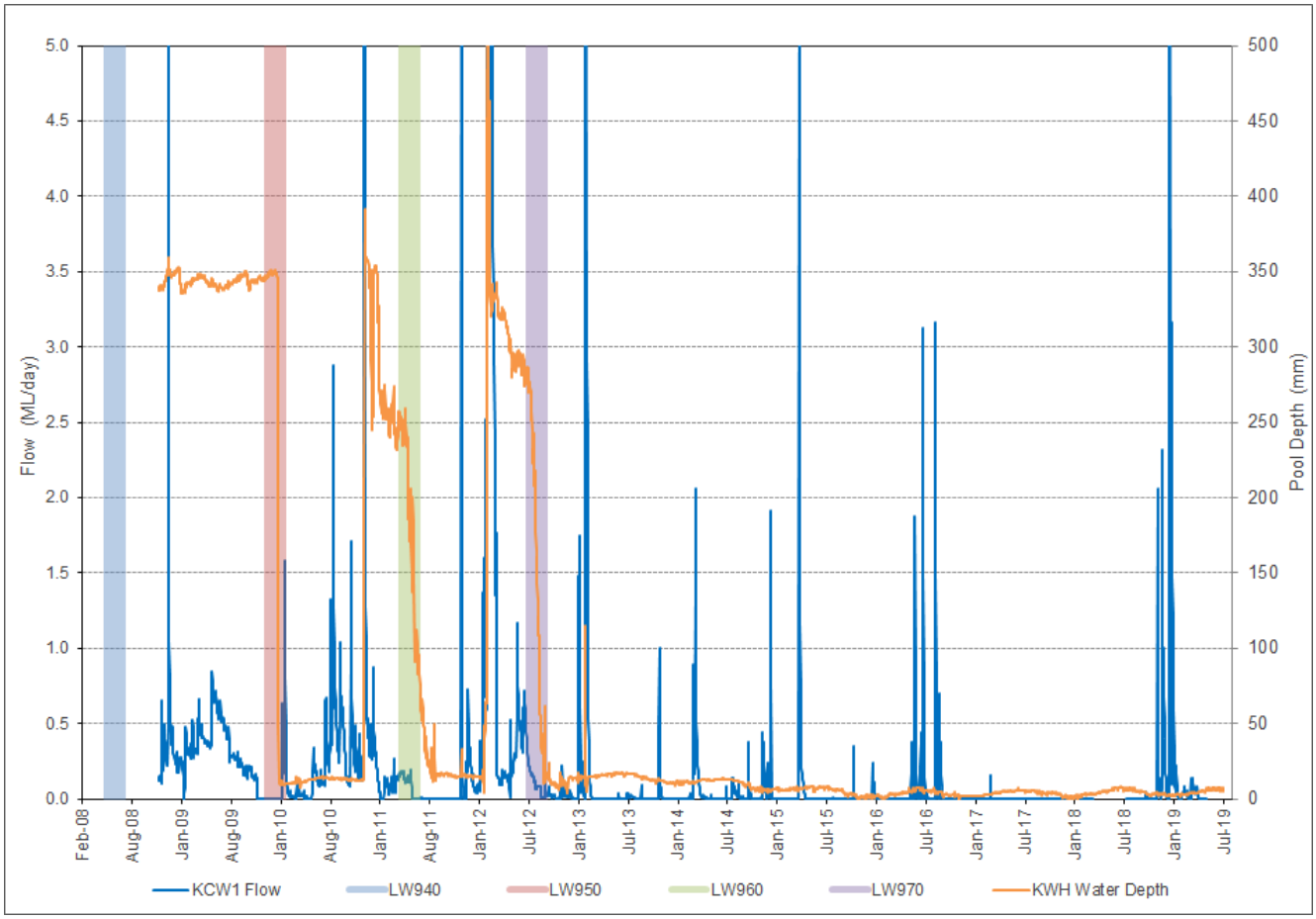


Figure 4.3: Kangaroo Creek Flows

4.1.3 Narrow Swamp

Manual flow monitoring has been undertaken within Narrow Swamp at Narrow Swamp downstream (DS) and upstream (US) monitoring points since the start of 2004, with continuous flows monitored at Narrow Swamp Weirs NSW1 and NSW2 commencing in 2008. Water quality sampling is also undertaken at NSW1 and NSW2.

Narrow Swamp has been undermined by longwalls LW920, LW940 and LW950, and has been historically used as a licensed discharge point for Springvale Colliery (LDP005) and Angus Place Colliery (LDP006). Currently, the discharge to Narrow swamp is limited to emergency release. Narrow swamp manually gauged flows are presented in Figure 4.4 alongside weir discharge rates.

The pre-mining data at Narrow Swamp upstream and downstream is limited with only three months of data before the swamp was undermined by LW920 in March 2004. It was further undermined in May 2007 by LW940 and in January 2009 by LW950. Historical flows are dominated by discharge from Springvale Colliery (LDP005) and Angus Place Colliery (LDP006).

Following the cessation of mine discharge, flows in Narrow Swamp are intermittent, responding only to periods of intense and prolonged rainfall as seen in March 2012, February 2013 and late 2018. From 2013 to 2017, no flows are recorded at all, which corresponds to below average rainfall over the period (Section 3.1.1). A brief period of flow is observed at NSW2 from October 2018 to February 2019.

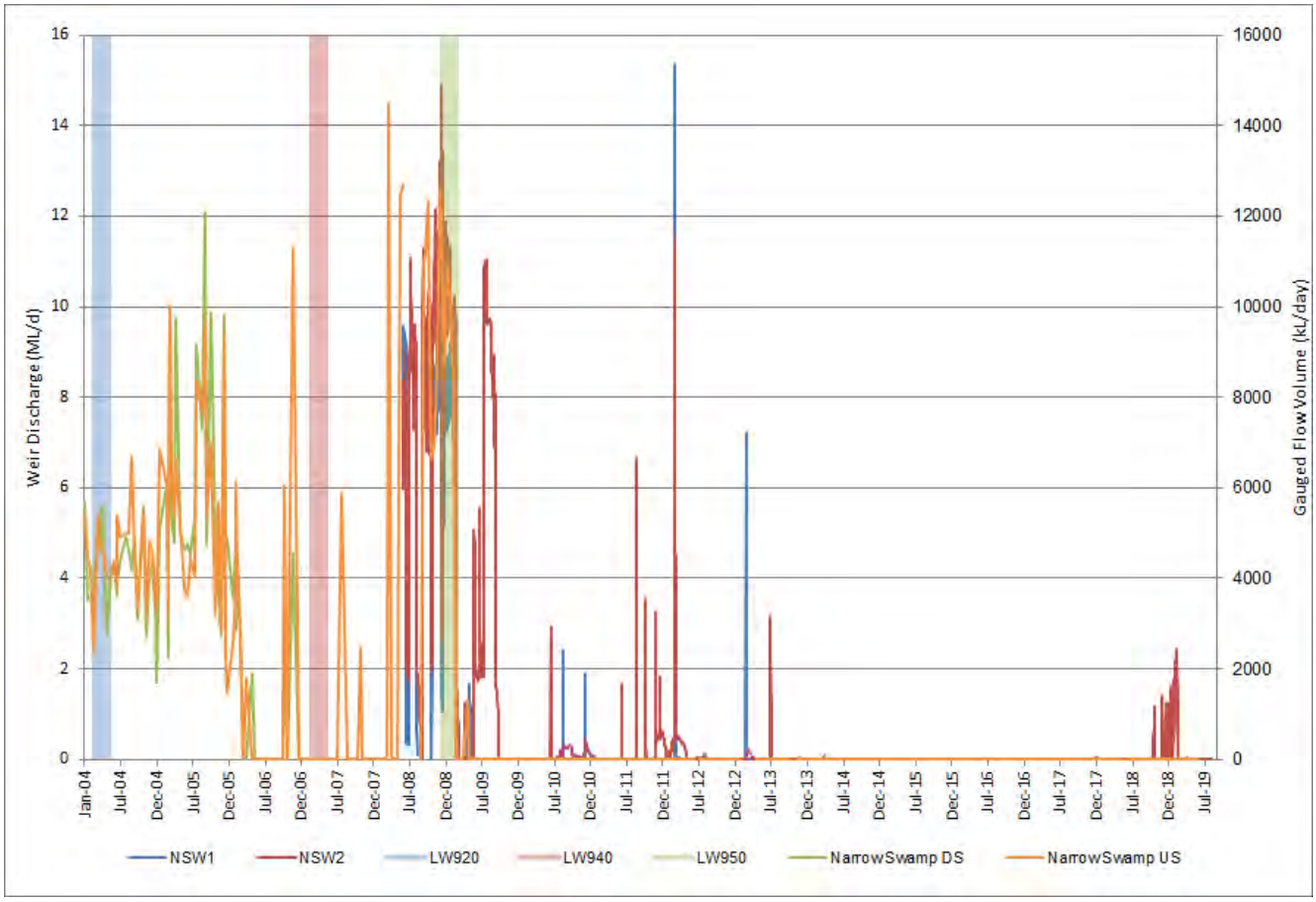


Figure 4.4 Narrow Swamp Flows

4.1.4 Tri Star and Twin Gully Swamps

Stream flow monitoring has been established within Twin Gully and Tri Star Swamps and monitoring data has been collected since 2016. A flow depth sensor has also been installed in Tri Star swamp that has recorded daily flow depths since 2013. The flow depth gauge is located approximately 500 m downstream of the gauging location. Flows are presented on Figure 4.5. Flow statistics are provided on Table 4.2.

Average flows observed in Tri Star Swamp and Twin Gully Swamp are 423 kL/day and 243 kL/day, respectively. The data shows that flows are observed 100% of the time at Tri Star Swamp, and 98% of the time at Twin Gully Swamp.

Flow depth data from below Tri Star Swamp indicate a gradual decline in average flow depths (and therefore volumes) over the period of observation. This decline is consistent with below average rainfall and declining CRD that is apparent on Figure 3.1 over the same period.

It is noted that it is proposed to develop a rating curve for the Tri Star level gauging site such that the long-term flow depth record can be converted to flow volumes.

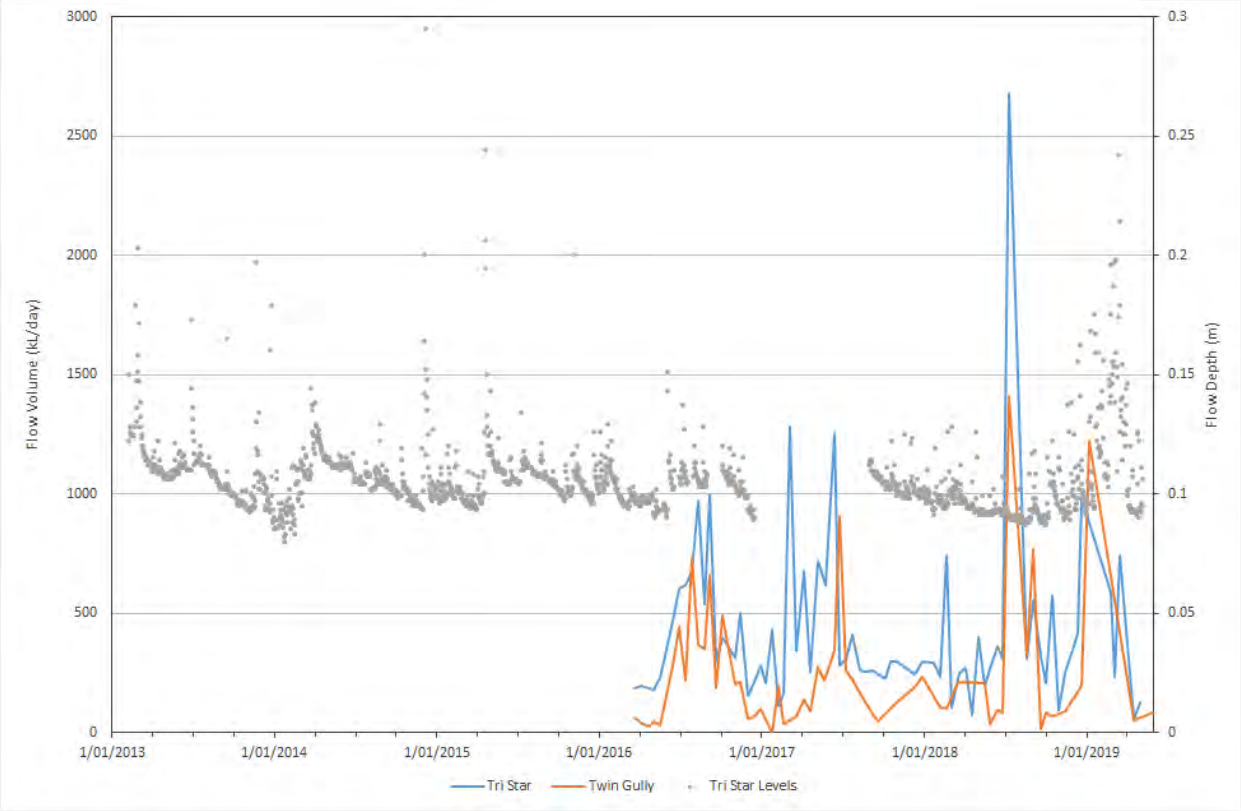


Figure 4.5: Tri Star and Twin Gully Swamp Flows

4.1.5 Firetail, Barrier and Best Reference Swamps

Stream flow monitoring commenced at Barrier Swamp in late 2016, and at Firetail swamp and Best Swamp in late 2017. Flows are shown in Figure 4.6 and summary statistics a provided in Table 4.3 . The gauging site for Best Swamp is located in the creek below the swamp, and the gauging site for Barrier and Firetail swamps are located within the swamps.

The average flow rate for Firetail swamp is 64 kL/day and flows are intermittent and highly dependent on rainfall with flow depths often too low to accurately gauge. The average flow for Barrier Swamp is 1,063 kL/day and is highly variable with rainfall, becoming dry on occasion. The average flow rate for Best Creek is 374 kL/day and flows are relatively consistent. During dry periods, flows are still observed but are often too low to accurately gauge.

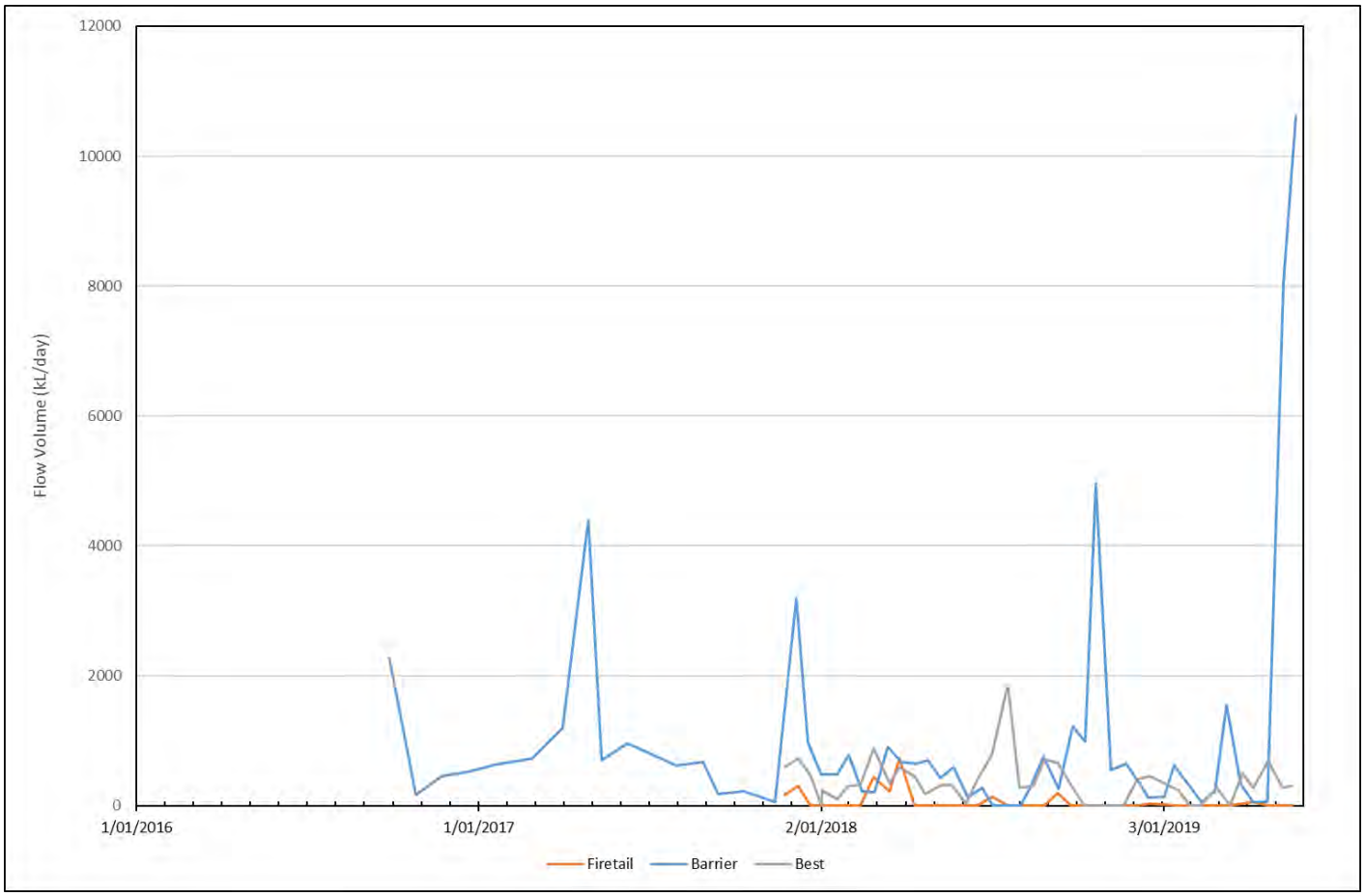


Figure 4.6 Firetail, Barrier and Best Swamp Flows

4.2 Surface Water Quality

Key surface water quality indicators of electrical conductivity (EC), pH, dissolved iron, and dissolved manganese are discussed in the following sections with plots of data provided in Appendix B. A tabulation of full laboratory analyses is provided in Appendix C. A statistical summary of the key water quality parameters for each site is provided on Table 4.4.

Surface water quality in the swamps are generally characterised by very low EC, and low concentrations of iron and manganese. The primary source of water for the swamps comes from a combination of rainwater runoff from the local catchment and from shallow perched aquifer systems. The pH is generally slightly acidic from the release of humic acid from organic matter in the swamp.

Table 4.4: Key Water Quality Indicator Statistics

Site ID	EC (µS/cm)	pH (units)	Iron (mg/L)	Manganese (mg/L)
	10th -90th Percentile (Mean)	10th -90th Percentile (Mean)	10th -90th Percentile (Mean)	10th -90th Percentile (Mean)
Wolgan River US	35 – 59 (47)	6.67 – 7.60 (7.08)	0.48 – 1.21 (0.84)	0.004 – 0.010 (0.007)
Wolgan River DS	31 – 444 (104)	6.12 – 7.90 (6.87)	0.24 – 0.76 (0.48)	0.004 – 0.012 (0.008)

Site ID	EC (µS/cm)	pH (units)	Iron (mg/L)	Manganese (mg/L)
	10th -90th Percentile (Mean)	10th -90th Percentile (Mean)	10th -90th Percentile (Mean)	10th -90th Percentile (Mean)
Kangaroo Creek US (LDP001)	71 – 1021 (418)	6.1 – 7.9 (6.86)	0.23 – 9.56 (3.77)	0.005 – 0.459 (0.185)
Kangaroo Creek DS (LDP001)	228 – 1082 (738)	6.96 – 8.65 (7.90)	0.09 – 0.91 (0.70)	0.004 – 0.095 (0.034)
Kangaroo Creek KWH (Newnes Plateau)	29 – 65 (44.8)	5.4 – 6.5 (5.9)	0.10 – 0.93 (0.51)	0.018 – 0.065 (0.048)
Narrow Swamp US	50 – 10110 (602)	6.42 – 8.60 (7.80)	0.09 – 0.91 (0.38)	0.006 – 0.209 (0.076)
Narrow Swamp DS	101 – 163 (133)	5.95 – 6.45 (6.19)	0.37 – 2.35 (1.41)	0.017 – 0.491 (0.231)
Tri Star (AP)	18 – 32 (26)	5.22 – 7.59 (6.22)	0.14 – 0.32 (0.22)	0.005 – 0.013 (0.009)
Tri Star (SV)	23 – 45 (34)	5.09 – 7.50 (6.17)	0.13 – 0.37 (0.24)	0.008 – 0.015 (0.011)
Twin Gully (AP)	19 – 35 (27)	5.20 – 7.80 (6.32)	0.14 – 0.34 (0.25)	0.004 – 0.015 (0.009)
Twin Gully (SV)	23 – 42 (32)	4.70 – 7.60 (5.90)	0.13 – 0.41 (0.27)	0.003 – 0.013 (0.007)
Barrier Swamp	25 – 50 (36)	4.50 – 6.30 (5.46)	0.16 – 0.57 (0.32)	0.005 – 0.010 (0.007)
Best Creek	27 – 53 (39)	4.28 – 6.30 (5.31)	0.09 – 0.29 (0.17)	0.008 – 0.014 (0.011)
Firetail Swamp	31 – 49 (41)	4.54 – 6.84 (5.43)	0.06 – 0.84 (0.27)	0.006 – 0.023 (0.013)

Wolgan River

Wolgan River was monitored at a downstream location commencing in 2008 and upstream commencing in 2010. During the emergency water discharge in 2008 and 2009, EC levels were elevated around 600 µS/cm, an order of magnitude greater than background environmental flows, and pH was generally alkaline. Post discharge water quality gradually returned to more neutral to slightly acidic conditions.

Water quality at Wolgan River upstream and downstream are comparable and characterised by slightly acidic to neutral conditions, and very fresh water with EC generally below 60 µS/cm. The levels of iron and manganese at both sites are low and comparable to other sites around the plateau.

Kangaroo Creek

Kangaroo Creek has been monitored on the Newnes Plateau at KWH, and in the Coxs River Valley, near the Angus Place Colliery pit top, at Kangaroo Creek upstream (US) and downstream (DS).

On Newnes Plateau, Kangaroo Creek has been predominantly dry and as such water quality samples are relatively intermittent. Samples are predominantly from 2014, with intermittent samples from 2015, 2016 and 2017.

When flowing, the water quality in Kangaroo Creek on the Newnes Plateau is characterised by low EC, low concentrations of Iron and Manganese, and moderately acidic conditions. These conditions are typical for swamps in the plateau that have not been impacted by discharges.

At Kangaroo Creek US and DS, located upstream (US) and downstream (DS) from LDP001, flows have been monitored from 2005, but water quality monitoring did not commence until 2011. Water quality is dominated by discharge from LDP001.

Both the upstream and downstream sites are observed to have elevated levels of EC (1000 µS/cm) and pH is generally alkaline in the downstream section and slightly acid to neutral in the upstream section.

Iron and manganese concentrations at the upstream site is observed to have a greater range when compared to other sites on the plateau, with 90th percentile concentrations at 9.56 mg/L and 0.459 mg/L for Iron and Manganese respectively. The concentrations are significantly lower at the downstream monitoring point, presumably due to precipitation resulting from the increased pH.

Narrow Swamp

Narrow swamp has been monitored for flow at both upstream and downstream sections since 2004 and water quality monitoring commenced in 2008. Narrow swamp is generally dry and historical flows have been dominated by mine water discharge.

Typical discharge water quality at Narrow swamp is characterised by high EC and elevated levels of Iron and manganese. The upstream section tends towards alkaline conditions and there is a general decreasing pH trend across the years. In the downstream section the pH range is narrow and is slightly acidic.

Tri Star and Twin Gully

Tristar and Twin Gully have previously been utilised as reference sites for Springvale monitoring and each swamp is monitored at two locations. The water quality within each swamp is very similar.

The water at both these swamps are characterised by very low EC, low concentrations of Iron and Manganese, and slightly acidic conditions. These conditions are typical for swamps in the plateau that have not been impacted by discharges.

Barrier, Best, and Firetail Swamps

Barrier, Best and Firetail swamps are reference sites located outside the mining lease. These swamps exhibit very low EC values and low concentrations of Iron and Manganese, and slightly acidic conditions.

5. Surface Water Assessment

5.1 Potential Impacts

5.1.1 Erosion and Sedimentation

During the establishment and operation of surface infrastructure, earthworks and excavations have potential to result in erosion of soils, and subsequent transport and deposition in waterways.

Earthworks will include the widening and upgrades to access tracks, clearing of vegetation, establishment of new tracks, levelling and foundation preparation for the establish of surface infrastructure, including ventilation and dewatering facilities and associated pipelines.

Notional surface infrastructure on Newnes Plateau, in addition to existing, will include:

- Dewatering bore facilities, including pipeline, electrical and access corridors, and switch rooms
- Pump stations
- Downcast ventilation facility.

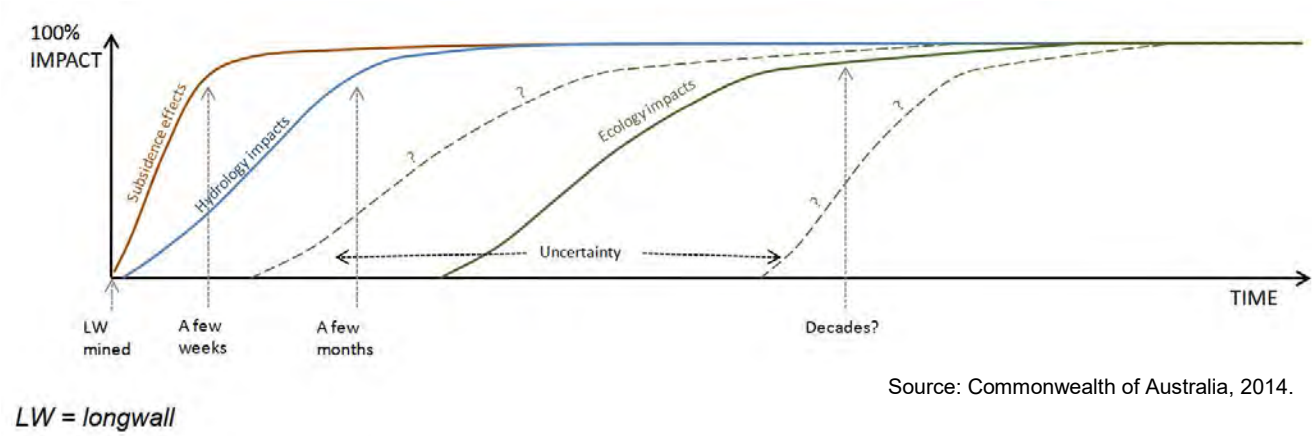
The final locations of surface infrastructure sites will be confirmed during detailed design.

It is noted that all proposed surface infrastructure, including access corridors, will be located on elevated ridges and plateaus. There will be no disturbance within or in close proximity to waterways.

5.1.2 Subsidence

Subsidence has potential to impact directly on the hydrological and hydrogeological regimes that support swamps. The IESC (Commonwealth of Australia, 2014) presents three broad impact categories that reflect the time lag between mining and potential impact (Figure 5.1):

- first-order subsidence impacts, which refer to the immediate impacts of subsidence (also called subsidence effects), such as cracking, shearing, tilting and reopening of bedding planes and joints within the sandstone
- second-order hydrological impacts, which refer to the impacts that result from subsidence effects, such as changes to swamp hydrology from altered groundwater or surface water flow paths, and water quality impacts
- third-order ecological impacts, which are the result of changes to swamp hydrology and water quality, such as peat erosion and the ecological response of flora and fauna.
- It is noted that third-order impacts have the potential to lag significantly behind initial undermining and the occurrence of subsidence and hydrological impacts, potentially by years or even decades.
- In addition to the potential impacts of being directly under mined, Centennial (Centennial, 2017 and 2018) note the potential for swamps, which reside in structurally controlled valleys, to be impacted by longwalls up to two kilometres away if the geological structure is intercepted by the longwall (refer to Groundwater Impact assessment (Jacobs, 2019a) for further information).



Source: Commonwealth of Australia, 2014.

Figure 5.1: Potential Timeline for Observation of Impacts

5.1.2.1 Predicted Subsidence

Predicted mine subsidence is presented and discussed in the MSEC (2019) Subsidence Impact Assessment. Total predicted subsidence for the 1000 panel area is shown on Figure 5.2. Maximum predicted subsidence is of the order of 2.3m above longwall LW1005 and beneath Tri Star Swamp. Subsidence is maximised due to the increased seam thickness and reduced depth of cover in the Tri Star swamp valley. Subsidence diminishes to the north with reduced seam thickness and height of extraction.

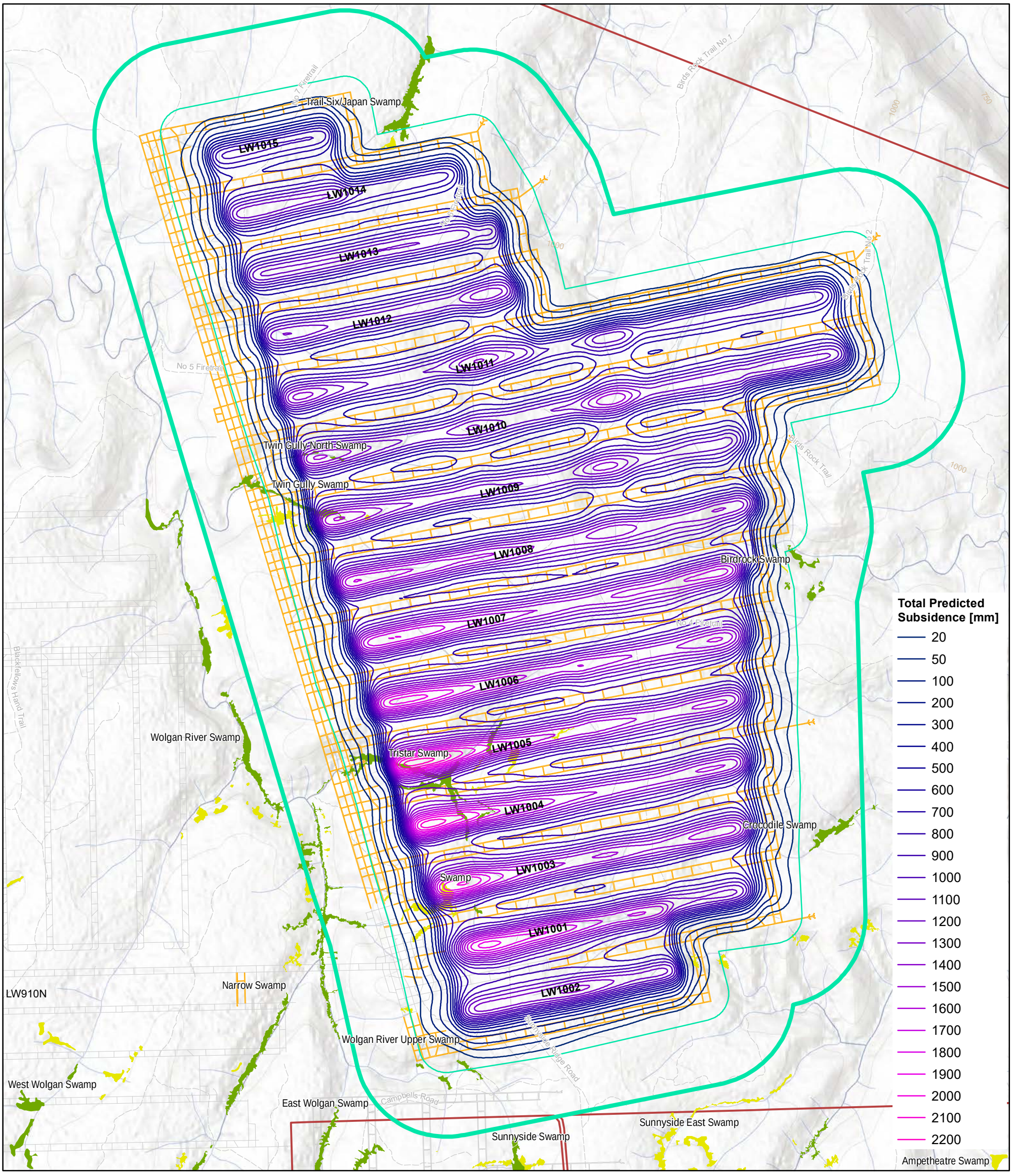
5.1.2.2 Observed Impacts

A summary of impacts observed to THPSS above Angus Place Colliery and Springvale Mine is provided in Table 5.1.

5.1.3 Water Quality

As the project will have no mine water discharges to the environment, there will be no detrimental impacts to water quality as a result of discharge. No deterioration in surface water quality (pH, EC, TSS, Fe, or MN) has been identified at Angus Place Colliery or Springvale Mine resulting from subsidence, and as such water quality impacts due to subsidence are not expected as a result of the APMEP.

Figure 5.2: Total Predicted Subsidence



Infrastructure
- Proposed Workings
- Existing Workings

Project Area
- Project Area

Contours
- 50 Metre

Watercourse - Order
- Stream Order 1 - 2
- Stream Order 3 - 6

Swamps
- Hanging
- Shrub

APE Study Areas
- 26.5 degree AoD
- 600m Study Area



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Angus Place Amended Project

Data Sources - Centennial Angus Place Pty Ltd: Project Area, Infrastructure (2019); NSW Government Public Data: Roads, Hydrology, Placenames; Geosciences Australia (ELVIS): 50m Contours; Office of Environment and Heritage NSW: Tenures; ESRI ArcGIS Image Service: World Elevation Terrain, World Topographic Map

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Table 5.1: THPSS and Previous Longwall Mining at Angus Place and Springvale Collieries

Swamp	Longwalls	Type 1 or Type 2 structures	Measured subsidence effects (near swamp)	Observed changes to piezometer levels	Observed physical impacts and environmental consequences
Junction Swamp	Above Springvale LW408 and LW409	Wolgan lineament zone (Type 1)	1058mm subsidence 4.1mm/m tensile strain 13.1 mm/m compressive	Correlation between aquifer standing water levels adjacent to swamp and the cumulative rainfall deviation over 15 years of monitoring. Baseline monitoring commenced in May 2002 NB Wolgan Lineament (west) was undermined to the south west of Junction Swamp by Longwall 405 in December 2000, October 2001 by Longwall 406, and August 2002 by Longwall 407.	Vegetation dieback, major incision and erosion (in some instances down to bedrock), associated with loss of peat layer, significant loss of ecosystem function and ecological resilience, and ecological and geomorphic threshold exceedance
Kangaroo Creek Swamp	Above Angus Place LW940 and LW950	Kangaroo Creek lineament (Type 1)	1012mm subsidence 5.8mm/m tensile strain 26.3 mm/m compressive	Reduction in swamp piezometer levels when LW940 mined directly beneath the swamp and lineament. Following declines all water levels remain predominantly below base of piezometer.	Decline in water levels –now predominantly below base of piezometer. Change in species assemblage (diversity of native species), change in condition of key species, increase in non-live vegetation
West Wolgan Swamp	Above Angus Place LW930 to LW950	J Lineament (identified by J. Shepherd)	1071mm subsidence 4.0mm/m tensile strain 6.2 mm/m compressive	Correlation between swamp standing water levels and the cumulative rainfall deviation over 14 years of monitoring. Baseline monitoring commenced in May 2005 NB J Lineament was undermined to the north of West Wolgan Swamp by Longwall 920 in October 2004 and Longwall 24 in Quarter 1, 2000.	Piezometer data reflects periodic waterlogging in response to rainfall. Vegetation monitoring undertaken but sufficient baseline data not available to assess impact of mining.
Narrow Swamp North	Above Angus Place LW920 and LW940	Wolgan lineament zone (Type 1)	1739 mm subsidence 6.2 mm/m tensile strain 15.4 mm/m comp. strain	Narrow Swamp North Swamp piezometers (NS3 and NS4) were installed in February 2008, after mining beneath Narrow Swamp North was completed in May 2007. All water levels remain predominantly below base of piezometer.	Scouring, waterlogging and changes to water quality due to mine water discharge from Springvale Mine LDP005.
Narrow Swamp South	Above Angus Place LW950 and LW960	Wolgan lineament zone (Type 1)	Not measured, expected to be similar to Narrow Swamp North	Reduction in swamp piezometer levels when LW940 mined directly beneath the lineament approximately 0.2 km north of the swamp. Some changes may be due to the cessation of mine water discharge along the drainage line. Following declines all water levels remain predominantly below base of piezometer.	Incision, a massive active head cut, and with significant impairment of resilience and ecosystem processes. Observed impacts likely due to mine water discharge from Springvale Colliery, any impacts due to longwall mining likely to be completely masked.

Swamp	Longwalls	Type 1 or Type 2 structures	Measured subsidence effects (near swamp)	Observed changes to piezometer levels	Observed physical impacts and environmental consequences
East Wolgan Swamp	Above Angus Place LW960 to LW980 and Springvale LW411 and LW412	Wolgan lineament zone (Type 1)	365mm subsidence 13.3mm/m tensile strain 17.6 mm/m compressive	Reduction in swamp piezometer levels (bottom of bores) when LW411 mined directly beneath the swamp and lineament. Some changes may be due to the cessation of mine water discharge along the drainage line. Following declines all water levels remain predominantly below base of piezometer.	Vegetation dieback, major incision and erosion (in some instances down to bedrock), associated with loss of the peat layer, significant loss of ecosystem function and ecological resilience, and with ecological and geomorphic threshold exceedance. Some impacts likely to be associated with mine water discharge from Springvale Colliery
Sunnyside Swamp	Between Springvale LW413A/B, LW414 and LW415	-	100 mm subsidence 1 mm/m tensile strain 3 mm/m comp. strain	No detected mining-related changes in swamp piezometers levels.	No surface cracking or deformations identified
Sunnyside East Swamp	Above Springvale LW416 to LW419	Deanes Creek lineament (Type 1)	607 mm subsidence 5.8 mm/m tensile strain 6.5 mm/m comp. strain	Temporary changes in swamp piezometer levels when LW414 mined beneath the Deanes Creek lineament at a distance of 2.25 km. Reduction in swamp piezometer levels when LW415 mined beneath the Deanes Creek lineament at a distance of 1.5 km. Following declines all water levels remain predominantly below base of piezometer.	No surface cracking identified. Decline in water levels – now predominantly below base of piezometer. Change in species assemblage (diversity of native species), change in condition of key species, increase in non-live vegetation
Carne West Swamp	Above Springvale LW418 and LW419	Deanes Creek lineament (Type 1)	750 mm subsidence 1.0 mm/m tensile strain 3.1 mm/m comp. strain	Temporary changes in swamp piezometer levels when LW415 mined beneath the Deanes Creek lineament at a distance of 1.8 km. Reduction in swamp piezometer levels when LW416 mined beneath the Deanes Creek lineament at a distance of and 1.6 km. Following declines all water levels remain predominantly below base of piezometer.	No surface cracking identified, Decline in water levels – now predominantly below base of piezometer. Change in species assemblage (diversity of native species), change in condition of key species, increase in non-live vegetation cover,
Gang Gang Swamp South West	Above Springvale LW420 and LW421	Type 2	969mm subsidence 3.4 mm/m tensile strain 9.6 mm/m comp. strain	Reduction in swamp water levels at GW1 and GW2 prior to being directly undermined. Possibly related to LW417 and LW418 intersection of structures. Decline at GW3 following undermining of swamp and intersection of lineament at GW1. Following declines, all water levels remain predominantly below base of piezometer.	No surface cracking identified. Decline in water levels – now predominantly below base of piezometer. Change in species assemblage (diversity of native species), change in condition of key species, increase in non-live vegetation

Swamp	Longwalls	Type 1 or Type 2 structures	Measured subsidence effects (near swamp)	Observed changes to piezometer levels	Observed physical impacts and environmental consequences
Gang Gang Swamp East	Above Springvale LW420 and LW421	Type 2	652mm subsidence 3.3 mm/m tensile strain 3.3 mm/m comp. strain	Slow decline at GG1 from August 2016 consistent with CRD. Decline accelerates August 2017 as LW420 intersects underlying lineament. GG2 decline in October 2016, no apparent correlation to LW activity (note limited baseline data). GG3 abrupt decline from March 2018 as LW421 approached lineament beneath GG1. Following declines all water levels remain predominantly below base of piezometer.	No surface cracking identified. Decline in water levels – now predominantly below base of piezometer. Change in species assemblage (diversity of native species), change in condition of key species, increase in non-live vegetation
Pine Swamp Upper Swamp	Outside and adjacent to Springvale LW425	-	253mm subsidence 12.0 mm/m tensile strain 7.7 mm/m comp. strain	Declines in water levels at BS1 and BS2 from October 2017 that are consistent with CRD. Further strong declines from January 2019 that coincide with intersection of LW425 with underlying lineament.	No surface cracking identified. Decline in water levels – now predominantly below base of piezometer.
Paddy's Creek Swamp	150 m south-west of Springvale LW425	-	<20mm subsidence	Several water level declines and recovery following commencement of LW425 in August 2018. Possibly climate related but water levels stable prior to LW425.	No surface cracking or deformations identified. Temporary changes in swamp piezometer levels which may be related to the extraction of Longwall 425

5.2 Site Water and Salt Balance

A Site Water and Salt Balance assessment (GHD, 2019) has been undertaken to describe the site water and salt balance of Angus Place Colliery under existing and proposed conditions and to assess the impact of the APMEP. The Site Water and Salt Balance assessment is provided in Appendix D.

The Site Water and Salt Balance includes surface and underground components of Angus Place Colliery and considers inflows from direct rainfall onto surface water storages, runoff from catchments into pit top storages, groundwater inflows into mine workings and potable supply from Lithgow City Council.

Outflows from the water balance include evaporation from the surface of water storages, discharge through LDP001 into Kangaroo Creek (currently at a rate up to 10ML/d but treated to 350µS/cm), discharge to the Coxs River through LDP002 (sediment control structure), discharge from LDP005 (effluent from on-site Sewage Treatment Plant), continued transfer to the Fire Tanks at Angus Place Colliery pit top for reuse or transfer to the Springvale Water Treatment Project (SSD 7592) via the Angus Place Haul Road Pipeline or transferred to the Springvale Water Treatment Project Water Transfer Pipeline via existing and proposed additional dewatering bore facilities and associated infrastructure.

As presented in Appendix D (GHD, 2019), the Amended Project will include construction and operation of additional dewatering bore facilities, including associated electrical easements, booster stations and pipeline connections, on the Newnes Plateau to enable the transfer of water from the existing and proposed workings to the Springvale Water Treatment Project Water Transfer Pipeline.

5.2.1 Site Water Management

Key components of site water management at Angus Place and the conceptual water cycle are shown on Figure 5.3. Pit top catchment areas and water management features are shown on Figure 5.4 and Figure 5.5. A water management schematic is presented on Figure 5.7.

As presented in detail in Appendix D, the overall configuration of water management at Angus Place Colliery will not change due to the Amended Project. Groundwater encountered during mining of the 1000 Panel Area will be managed by transfer to the Springvale Water Treatment Project Water Transfer Pipeline via existing and proposed additional dewatering bore facilities and associated infrastructure. Groundwater inflow to the 1000 Panel Area will also be managed by underground transfer to the 900 Panel Area. Further detail on underground water management is presented in Appendix D.

5.2.1.1 Potable and Wastewater

Potable water is provided to the administration and bathhouse buildings at the Angus Place Colliery pit top by the municipal water supply from Lithgow City Council.

Grey water and sewage from the administration and bathhouse buildings is treated on-site in a sewage treatment plant before being directed to Maturation Ponds and disposed via spray irrigation through LDP005.

5.2.1.2 Management of Clean and Dirty Water

The clean water management system at Angus Place Colliery consists of a series of diversion bunds and drains around the pit top that intercept clean runoff prior to it entering disturbed areas. This water is directed off-site into Kangaroo Creek. The system is designed to minimise the amount of runoff from clean catchments areas entering the dirty water management system. The clean (vegetated) and dirty (hardstand) water catchments are shown on Figure 5.4.

The dirty water management system at Angus Place receives catchment runoff from the pit top. Dirty water runoff reports to the 302 Portal, Filter Pond, Oil Water Separator, Primary Ponds and Secondary Pond. Water cascades through the dirty water ponds and ultimately reports to the Settling Ponds. Water from the Settling Ponds is discharged via LDP002 into the Coxs River.

5.2.2 Harvestable Water Rights

Dams solely for the capture, containment and recirculation of drainage and/or effluent, consistent with best management practice or Local Government Council to prevent the contamination of a water source, are exempt from the Harvestable Rights requirements, providing they are sized in accordance with relevant guidelines.

Detailed discussion of Erosion and Sediment Control is presented further below.

5.2.3 Underground Water Management

Under existing conditions, groundwater inflows into the 800 Panel area and 900 Panel area are extracted to the pit top from various locations underground. At the pit top, water is transferred to the Fire Fighting Tanks where it is available for use in fire-fighting and as process water in the Coal Handling Plant (when the mine is in operation). Excess water that is not used is treated using reverse osmosis in the Water Treatment Plant and discharged via LDP001. The plant is designed to achieve a discharge stream of 10 ML/day with 350 µS/cm, as measured at the point of discharge.

The residuals from the water treatment plant are temporarily stored within the underground workings within the Angus Place Colliery.

Water from the 900 Panel area may also be extracted by the 940 Bore and transferred to the surface infrastructure and conversely water from surface may be transferred back to the 900 Panel area via the 930 Bore as required.

It is noted that the options for underground water management presented in Figure 5.7 pertain to minor, internal changes to configuration of underground water management, if and when required. All internal transfers will be managed in accordance with groundwater water access licences and will not lead to changes to sensitive receptors, including NPSS and NPHS, surface watercourses (discharge from Angus Place Colliery through LDP001 will cease from 1 January 2020) or other surface water users. Accordingly, minor, internal changes to underground water management will have no impact to sensitive receptors as there is no change to flows or salinity at those receptors.

5.2.4 Proposed Changes to Water Management

The APMEP requires changes to the management of underground water at Angus Place Colliery. The APMEP includes the development and extraction from the 1000 Panel area, which will result in additional groundwater inflow. This groundwater will be managed by transferring to the Springvale Water Treatment Project. Water in the 1000 Panel area may also be managed by underground transfer to the 900 Panel area.

The overall configuration of water management at the Angus Place Colliery pit top will not be modified by the Amended Project. Licenced Discharge Point LDP001 will be decommissioned following cessation of discharges in December 2019 and LDP002 will continue to operate as a rainfall-based discharge point. Water discharged off site will continue to be done so in accordance with EPL467.

A pipeline for the APMEP will be constructed to transfer wastewater to the Lithgow City Council main sewerage line. Once the transfer of wastewater from the Angus Place Colliery pit top to the Lithgow City Council main sewerage line is completed, LDP005 and the associated irrigation area will no longer operate. The construction of the wastewater pipeline will be the subject of a separate development application through Lithgow City Council. The proposed pipeline will be constructed and operational prior to the commencement of longwall extraction at the Angus Place Colliery.

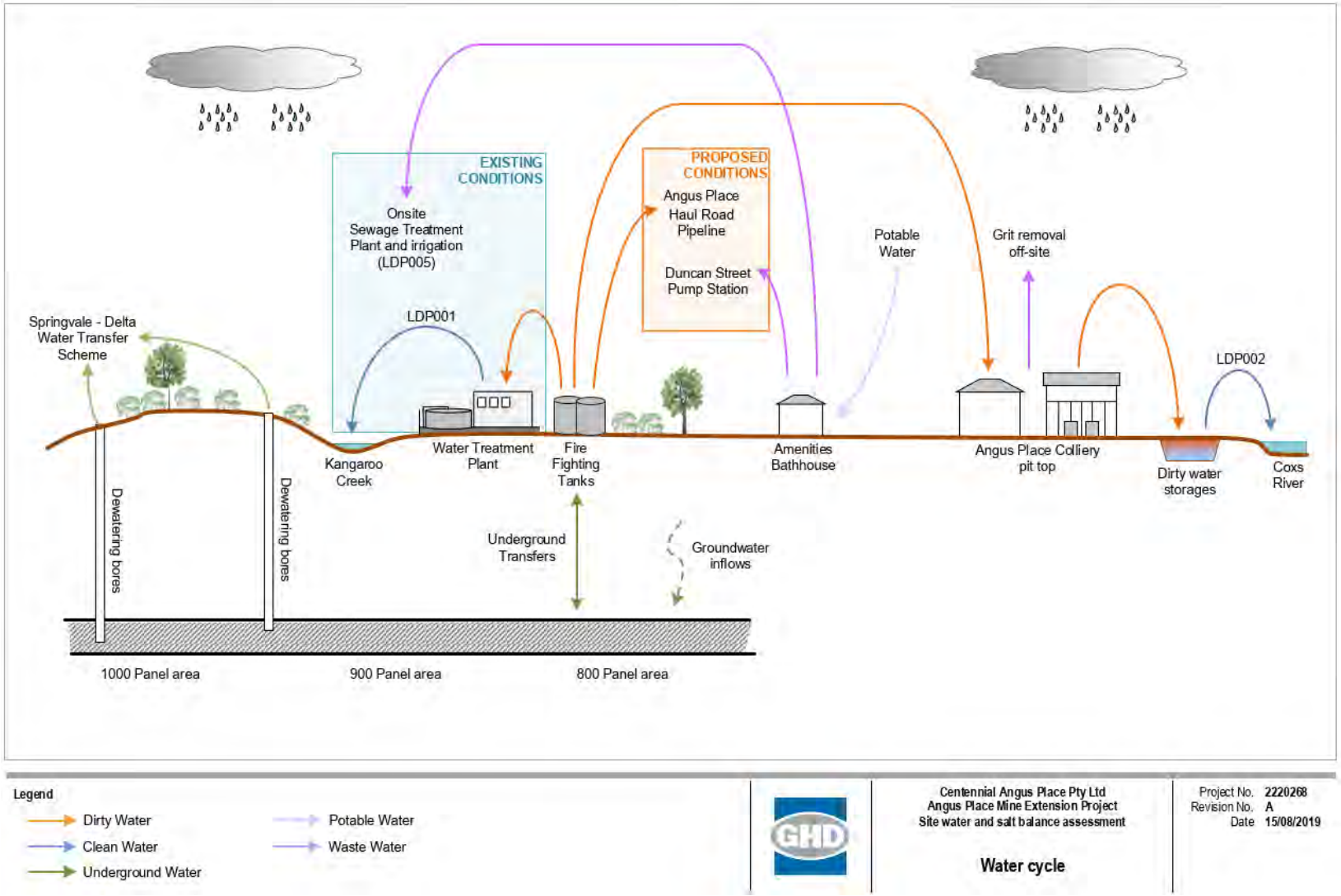


Figure 5.3: Site Water Cycle Figure

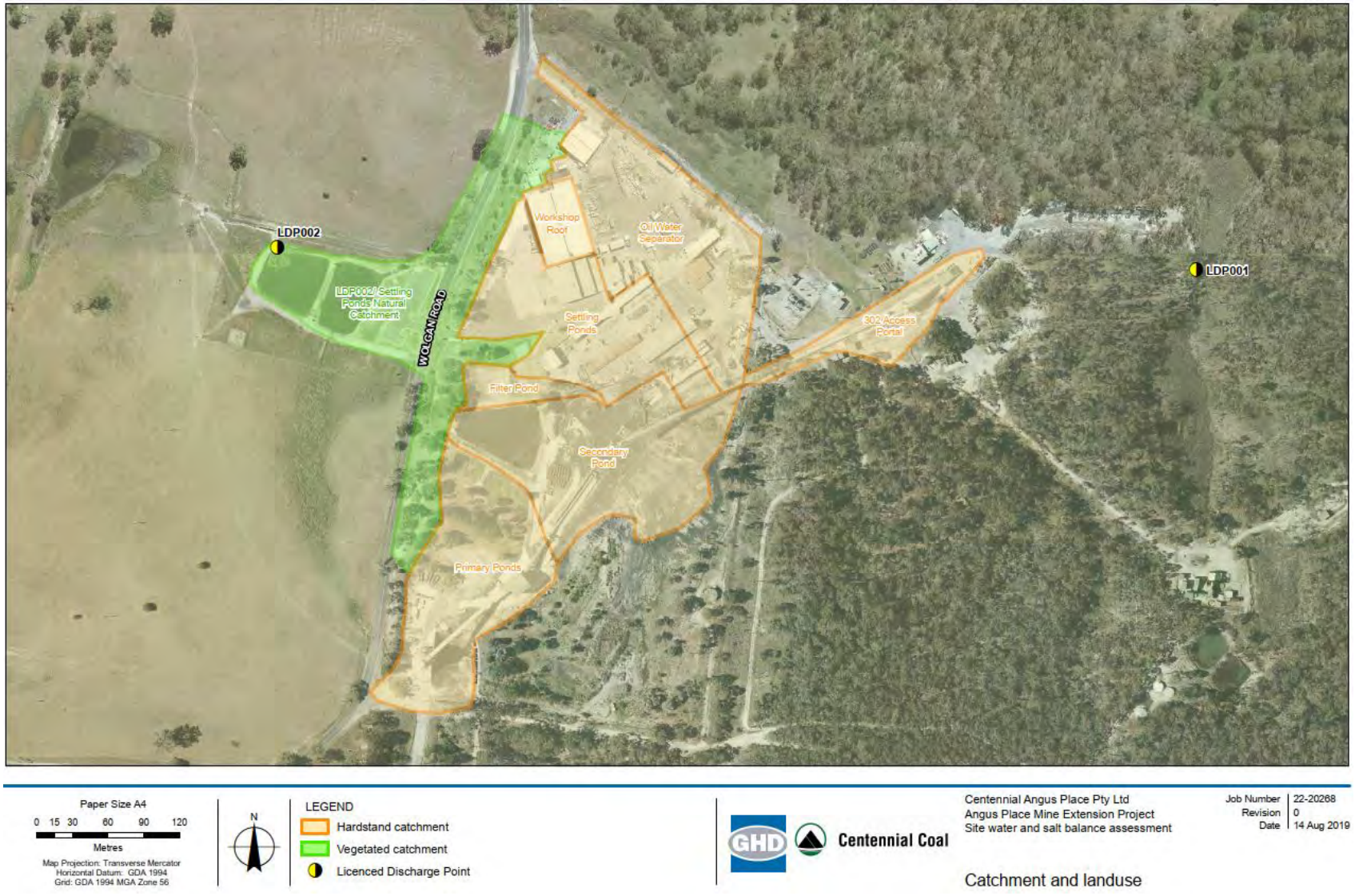


Figure 5.4: Pit Top Catchment Areas



Figure 5.5: Pit Top Water Management Features

5.2.5 Predicted Dewatering

Mine dewatering requirements for the APMEP have been assessed in the Hydrogeological Model Report (JBS&G, 2019a). Predicted inflows from the 800, 900, and 1000 panel areas are shown on Figure 5.6 and in Appendix D.

Inflows peak at around 26ML/day following the commencement of mining at LW1002 in 2025, and then fluctuate in the range 18 to 20ML/day until end of mining in 2038. Post mining there is a steady decline in inflows until the pumps are turned off in 2053.

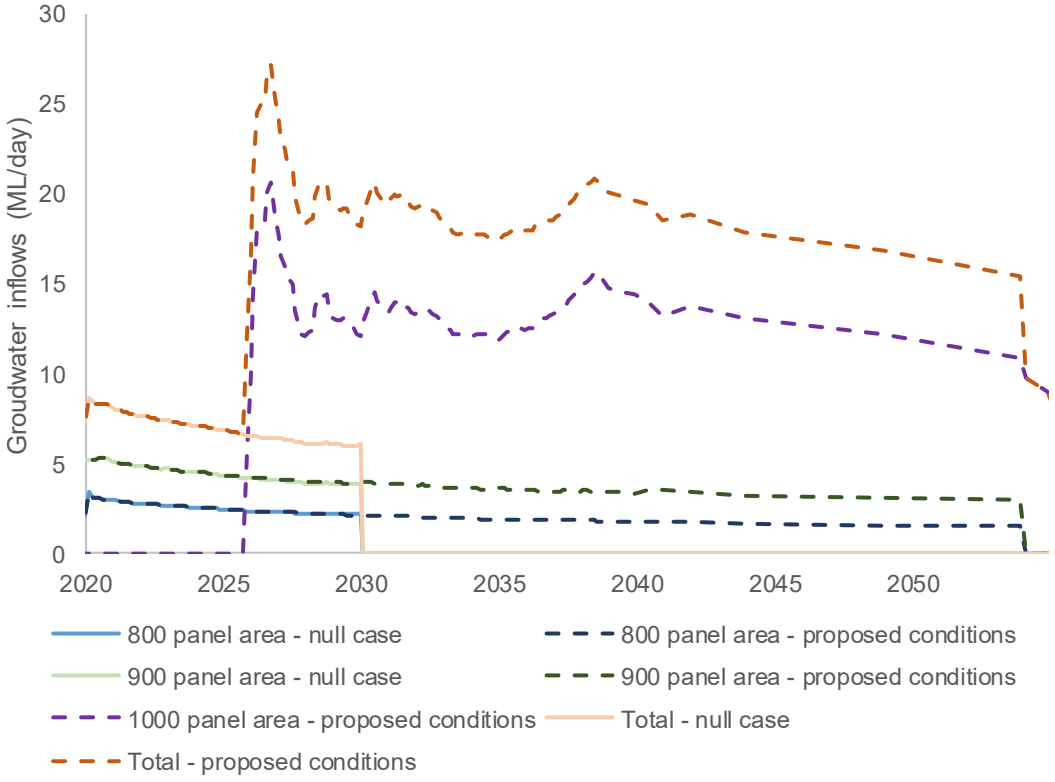


Figure 5.6: Predicted Mine Dewatering

5.2.6 Model Results

Model results are presented for the existing conditions (2019) and for the period of peak dewatering (nominally 2027). A summary of the water and salt balances are provided on Table 5.2 and presented schematically for the Proposed conditions on Figure 5.7 and Figure 5.8.

Table 5.2: Annual Average Water and Salt Balance

	Water		Salt	
Water management element	**Existing conditions (2019) (ML/year)**	**Proposed conditions (2027) (ML/year)**	**Existing conditions (tonne/year)**	**Proposed conditions (2027) (tonne/year)**
INPUTS				
Direct rainfall onto storages	9	7	0	0
Catchment runoff	24	24	5	5
Groundwater inflows	3176	7471	2234	5256

	Water		Salt	
Water management element	**Existing conditions (2019) (ML/year)**	**Proposed conditions (2027) (ML/year)**	**Existing conditions (tonne/year)**	**Proposed conditions (2027) (tonne/year)**
External potable water supply	2	29	0	1
TOTAL INPUTS	**3211**	**7531**	**2239**	**5262**
OUTPUTS				
Evaporation	15	11	0	0
Discharge through LDP001	3647	0	861	0
Discharge through LDP002	19	19	6	6
Discharge through LDP005	1	0	0	0
Transfer to Lithgow City Council mains	0	29	0	1
Transfer to SWTP	0	7771	0	5255
Losses from operations	2	2	1	0
TOTAL OUTPUTS	**3684**	**7831**	**868**	**5262**
CHANGE IN STORAGE				
Surface water storages	0	0	0	0
Underground water storages	-473	0	1371	0
TOTAL CHANGE IN STORAGE	**-473**	**0**	**1371**	**0**
BALANCE				
Inputs – outputs – change in storage	0	0	0	0

Key changes due to the Project are as follows:

- Direct rainfall, catchment runoff and evaporation of the Angus Place Colliery pit top are expected to remain unchanged from existing conditions. The difference between the proposed conditions and baseline conditions corresponds to the decommissioning of the Maturation Ponds following the connection of wastewater from Angus Place Colliery to the Lithgow City Council mains.
- Potable water use is expected to increase during operations as a result of the APMEP.
- Discharges via LDP001 are expected to cease by 2020.
- No change to discharges from LDP002 are expected as a result of the APMEP.
- Under existing conditions, the volume of water in the 800 Panel area and 900 Panel area are expected to decrease.

Overall the water and salt balance shows a net beneficial impact on the Coxs River catchment in terms of salt loads being released to the environment through discharge at LDP001.

No changes to water management of the Angus Place Colliery pit top are expected as a result of the Project, including no change to discharges via the rainfall-based discharge point of LDP002.

The modelling undertaken for this assessment does not consider the potential effects of climate change. With respect to groundwater, the Groundwater Impact Assessment and Hydrogeological Model report (Jacobs, 2019a and JBS&G, 2019a) concludes that there is limited influence of climate on model predictions, and therefore the potential impacts of the APMEP with respect to groundwater inflows and dewatering requirements are not expected to be sensitive to climate change. No change to the water management of the pit top, including discharges via LDP002, are expected as a result of the APMEP, and therefore the potential impacts of the Project with respect to rainfall-based discharges are not expected to be sensitive to climate change.

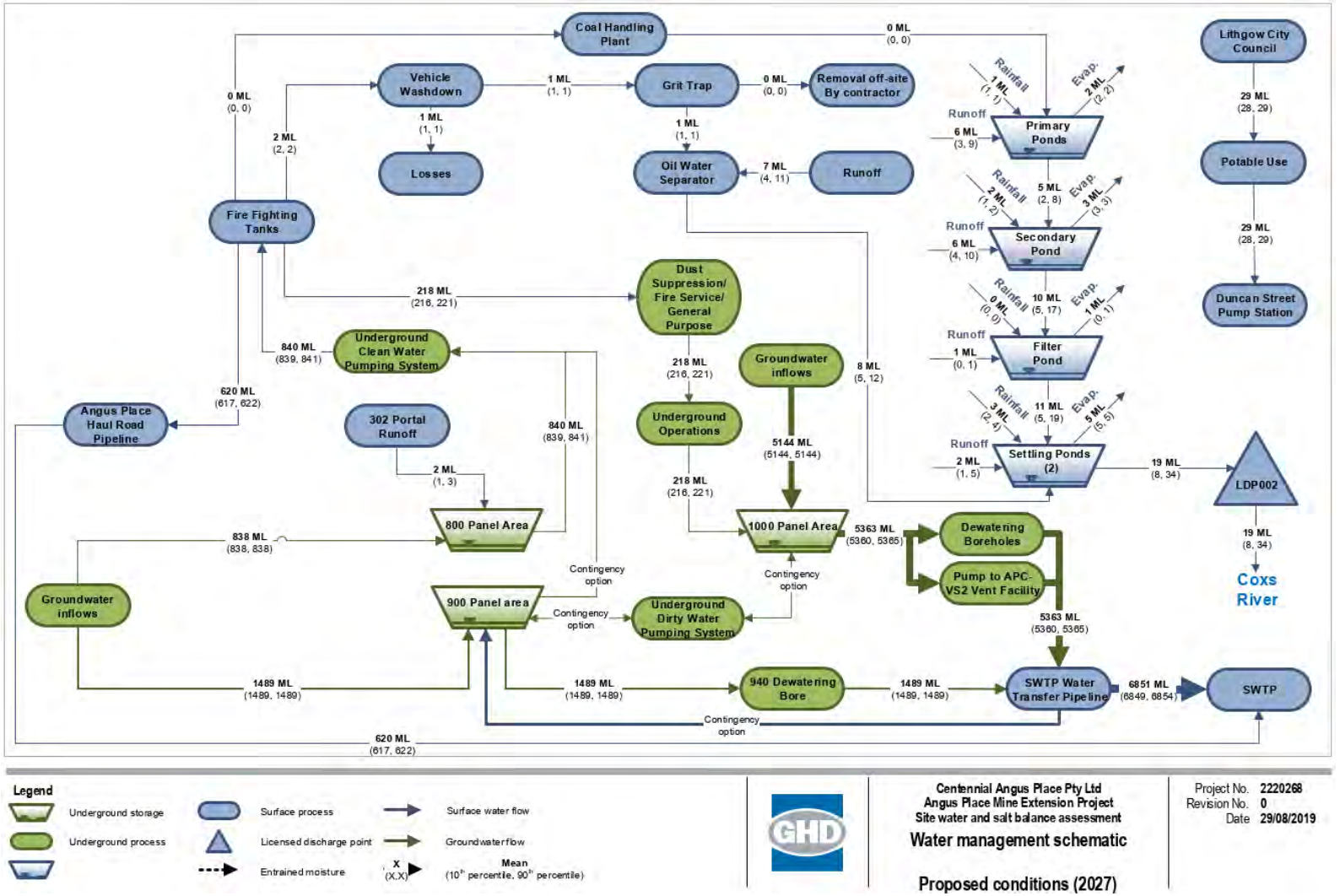


Figure 5.7: Annual Water Transfers – Proposed Conditions (2027)

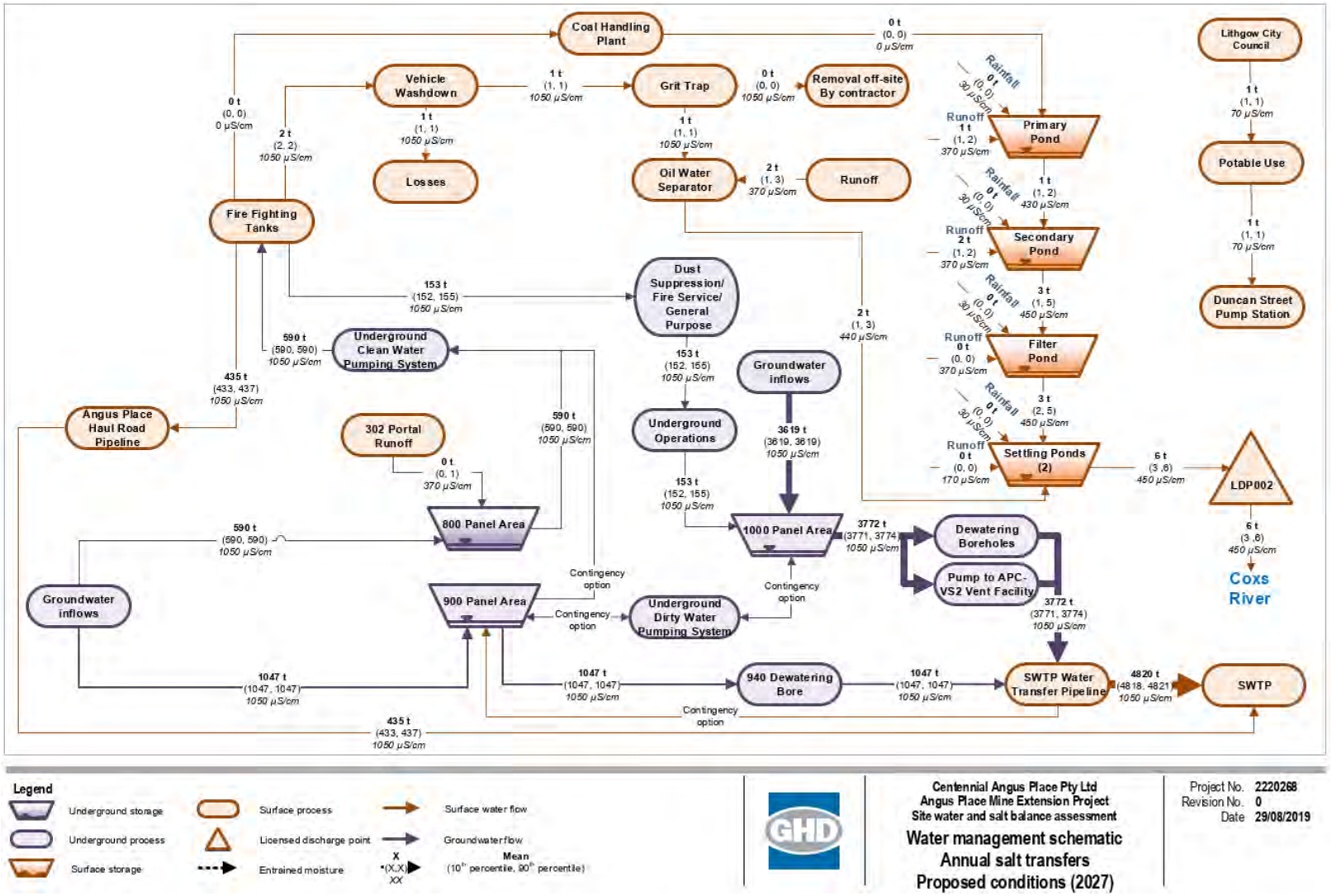


Figure 5.8: Annual Salt Transfers – Proposed Conditions (2027)

5.3 Subsidence Impacts on Watercourses and Newnes Plateau Shrub Swamps

Subsidence analysis has been undertaken by MSEC (MSEC, 2019) to determine:

- total predicted subsidence
- predicted change in streambed profile
- predicted tensile and compressive strain.

The model was calibrated based on site observation and an extensive library of mining-induced subsidence in the NSW Coalfields. Further detail on model approach is presented in MSEC (2019). Total predicted subsidence above longwalls LW1001 to LW1015 is presented on Figure 5.2.

5.3.1 Stream Grade

Predicted changes to grades of drainage lines for key swamps as presented in MSEC (2019) are summarised below and on Figure 5.9 to Figure 5.11. Predicted changes along other drainages are provided in MSEC (2019) and are considered in the Hydraulic Modelling (Section 5.3.3).

The greatest grade changes occur where drainage lines traverse the margins of a subsidence trough, stepping into or out of the subsidence trough. This has potential to result in increased flow velocity and stream power for increased grades and reduced velocity and power for decreased grades. Predicted changes to stream flow dynamics are discussed in Section 5.3.3.

The greatest predicted reduction in grade is within Tri Star Swamp stepping out of the LW1005 subsidence trough of approximately 30mm/m (Figure 5.9). It is noted that there are no reversals in grade and as such no areas of ponding are predicted. The reduction in grade in Tri Star Swamp, while not resulting in pooled water, may have potential to result in increased flow depth during peak flow due to the backing up of flows.

The maximum predicted increase in grade is of the order of 10mm/m and is not considered to be significant from a stream flow perspective.

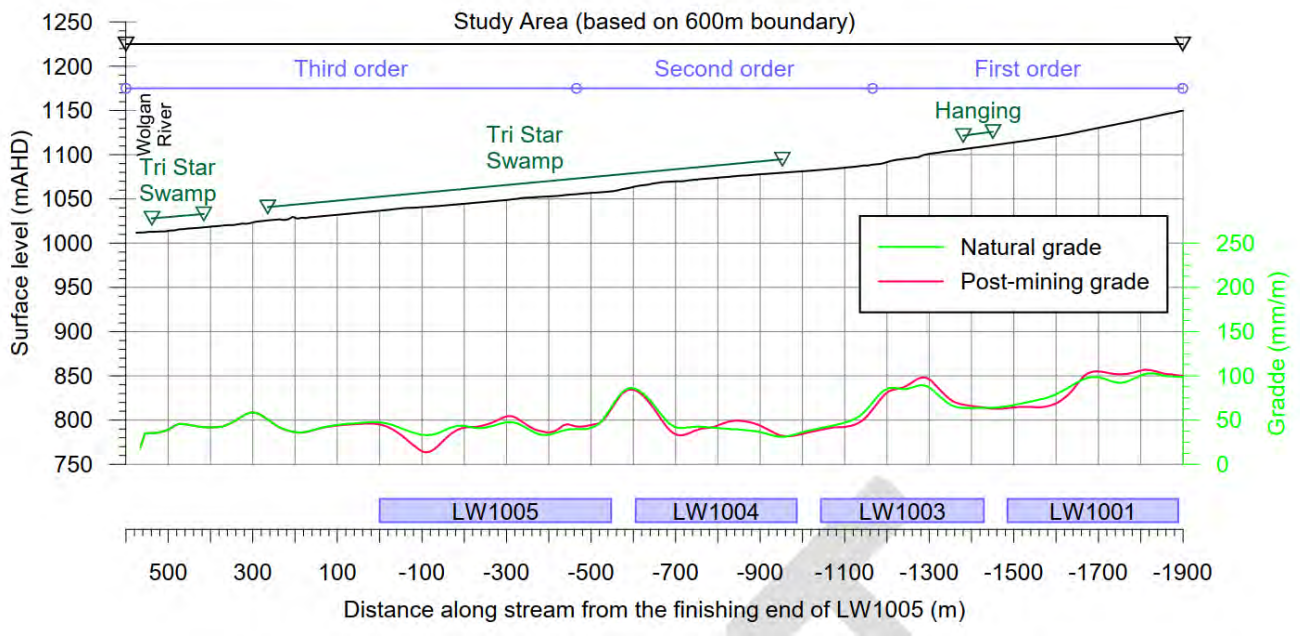


Figure 5.9: Tri Star Swamp - Drainage Line 2b

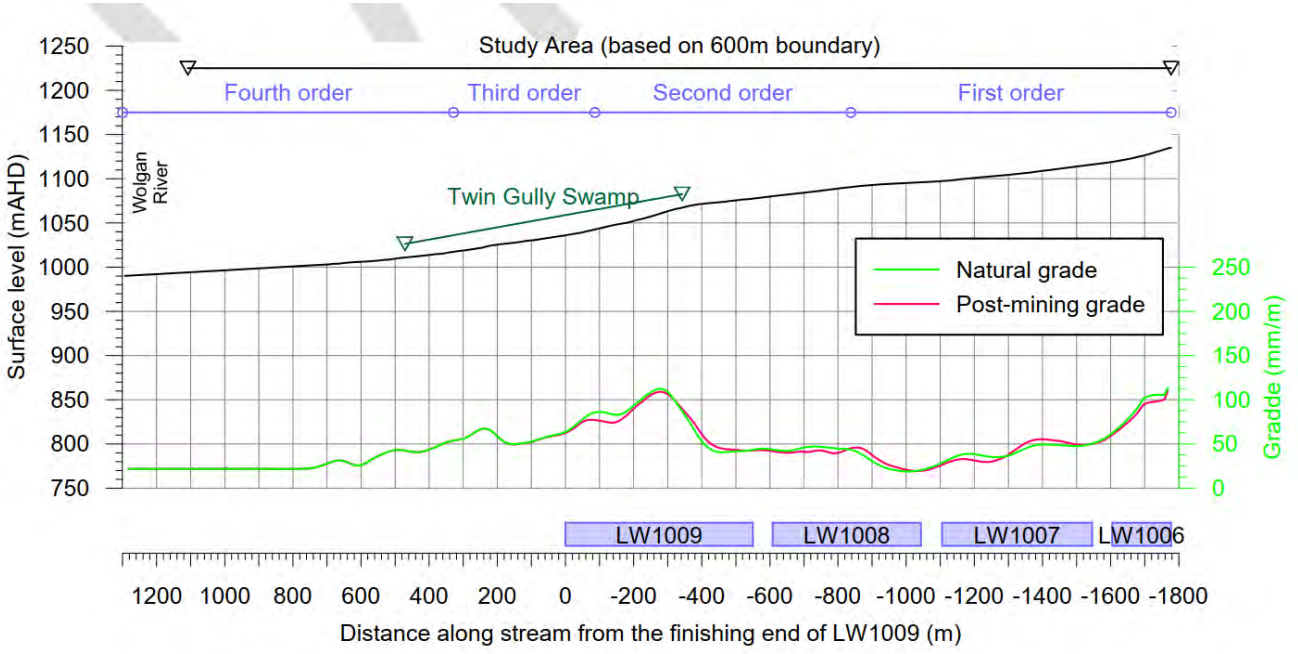


Figure 5.10: Twin Gully - Drainage Line 3b

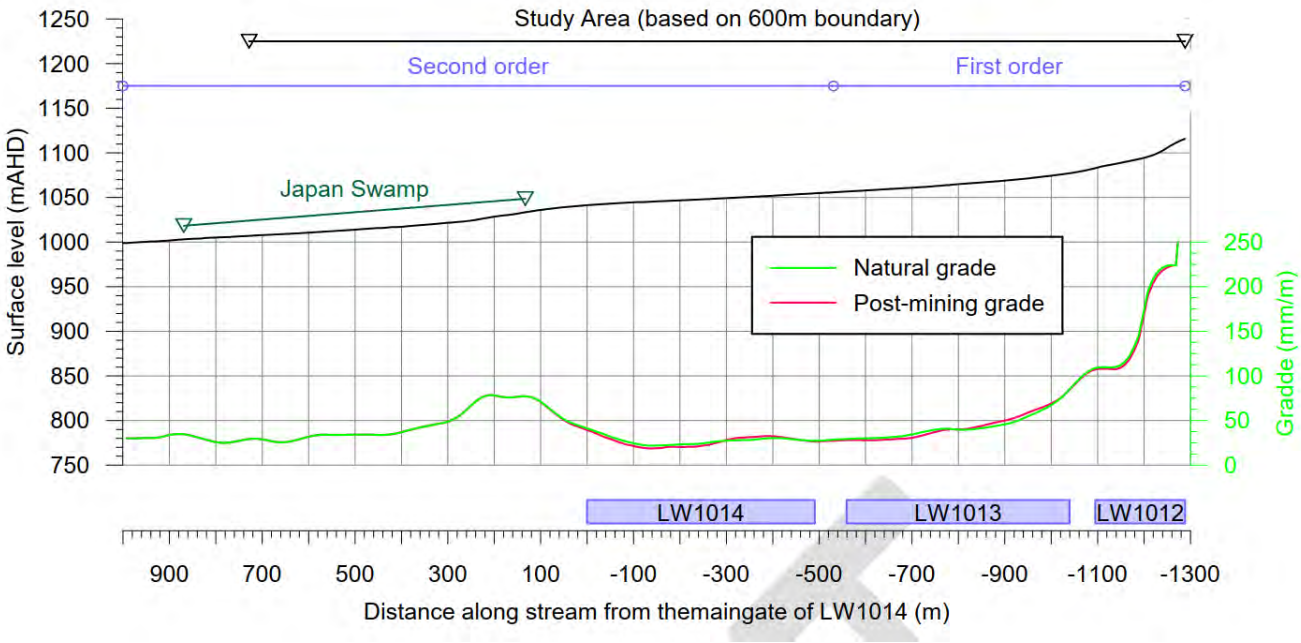


Figure 5.11: Trail Six / Japan Swamp - Drainage Line 4

5.3.2 Potential Flow Loss Due to Surface Cracking

Development of fractures within the sandstone bedrock underling watercourses across the Study Area caused by mining subsidence could significantly increase local hydraulic conductivity. This can significantly reduce, or in some cases effectively eliminate baseflow as well as shortening flow recession after flow events. This loss of flow can lead to the progressive drying of downstream swamps which can result in impacts including loss of wetland plant species, drying and desiccation of the swamp peat, increased potential for incision and erosion of the swamp surface during high flow events. During high flow events however, the increased surface flow will likely exceed the capacity of any subsurface fracture network surface and hence ensure continuation of surface flow.

Swamps also provide significant attenuation of flows and afford affective regulation of downstream stream flow and supply of sediment. This attenuation serves to sustain flows downstream during prolonged dry periods whilst moderating the impacts of larger flows as well as limiting the supply of sediment throughput.

MSEC (2019) note that the APMEP will likely result in surface cracking. Crack widths are expected to be typically between 10 mm and 50 mm although localised cracking with widths greater than 50 mm can also develop. Outside of the proposed mining area and the 26.5° angle of draw, the crack widths are expected to be typically less than 10 mm; however, localised cracking with widths greater than 25 mm can also develop. Additionally, MSEC (2019) also note that mining-induced compression due to valley closure effects could also result in dilation and the development of bed separation in the topmost bedrock, as it is less confined. This dilation due to valley closure is expected to develop predominately within the top 10 m to 20 m of the bedrock. Compression can also result in buckling of the topmost bedrock resulting in heaving in the overlying surface soils. No significant impacts are expected outside the 600m Study Area.

The extent to which loss of flow is propagated downstream is dependent on the nature of the watercourse. In gaining systems (i.e. the groundwater levels adjacent to the river channel are higher than the river channel) the water lost to the fracture network will return to the surface further downstream in unimpacted areas. Re-emergence of flow is however dependent on no further downward flows into the mine workings as a result of more generalised subsidence impacts within the overburden strata (Commonwealth of Australia, 2014).

In losing systems there is already an existing tendency for water to naturally move away into the groundwater system. However, this process can be enhanced by the development of a mining-induced fracture network resulting in the loss of additional surface flows. In this instance, surface flow losses are not returned to the downstream channel and surface flows will only be re-established when the watercourse becomes a gaining system further downstream.

The first and second order sections of the drainage lines are located upstream of the NPSS. The upper reaches of the drainage lines are ephemeral and therefore surface water generally flows during and for short periods after rain events. The third order streams are located within and downstream of the NPSS. The total length of the third order sections of the drainage lines located directly above the proposed mining area is approximately 2 km. While there is potential for flow losses due to subsidence cracking at surface the potential impacts are hard to quantify and have not been observed in the monitoring data. Previously undermined swamps at Angus Place and Springvale Collieries have typically had declining flows due to a combination of subsidence induced groundwater losses and prevailing dry conditions.

Surface water flow diversions could occur along the sections of drainage lines that are located directly above and adjacent to the proposed longwalls. In times of heavy rainfall, the majority of the runoff would flow over the fractured bedrock and soil beds and would not be diverted into the dilated strata below. In times of low flow, however, surface water flows can be diverted into the dilated strata below the beds.

Jacobs (2017) observed flows losses from the drainage line below Gang Gang Swamp above Springvale Colliery, with return of flows some 40m downstream on one occasion and 120m downstream on a second visit with reduced flow volumes. Subsequent attempts to observe and monitor the flow return were hampered by prevailing dry conditions and lack of flow.

Both the point of flow loss and initial flow return observed below Gang Gang Swamp were over rock substrate, where sub-horizontal bedding planes had opened on the eastern margin of the drainage. The drainage line at this point was sub-parallel to the margin of Springvale LW422, running from within the subsidence trough to above the chain pillar, in a zone of maximum tensile strain on the margin of the subsidence trough.

5.3.3 Stream Geomorphology

Changes in stream grade due to subsidence at the main THPSS above and adjacent to the APMEP are discussed in Section 5.3.1 and presented on Figure 5.9 to Figure 5.11.

Hydraulic modelling (Jacobs, 2019c) has been undertaken to assess the influence of subsidence on stream hydraulics and key indices such as stream power. Stream power, defined as the product of water density (about 1000 kg/m3), gravitational acceleration (9.8 m/s2), discharge (m^3/s), and channel slope (m/m), is a useful predictor of channel form and dynamics because it quantifies the amount of 'work' that can be done by a stream, such as moving sediment on the bed or in the banks of the river. Changes in bed grade due to subsidence have the potential to alter the dynamic of a system. The hydraulic modelling assessment report is provided as an appendix to the Geomorphology Assessment (Appendix F).

Total predicted subsidence, as presented on Figure 5.2, was superimposed on the pre-mining surface topography by Mine Subsidence Engineering Consultants. Hydraulic modelling was undertaken in TUFLOW to simulate hydrodynamic behaviour under a range of rainfall conditions for the both the pre-mining and post-mining landforms to assess relative change in stream dynamics due to subsidence.

Modelled stream power for the one in 20 year rainfall event, or 5% annual exceedance probability (AEP), for the pre-mining scenario is presented on Figure 5.12. From Figure 5.12 it can be seen that stream power ranges significantly for the 5% AEP rainfall scenario from low energy environments with stream power less than 20 W/m^2, to very high energy environments with stream power greater than of 10,000 W/m^2. The higher energy environments are typically within incised and bedrock-controlled channels as the drainages exit the Newnes Plateau. However, some higher energy drainages are also noted within the plateau area, typically associated with steeper more incised valleys with broad catchment areas.

Figure 5.13 shows the modelled stream power with the influence of subsidence. In general stream power is of similar magnitude before and after mining, however there are some localised areas where predicted change exceeds 50% (positive or negative) of the pre-mining condition as summarised below (also refer Appendix F).

5.3.3.1 Stream Power Change

Areas of predicted stream power change greater than 50% are labelled A to J on Figure 5.13. Change in stream power is presented in Appendix F. It should be noted that stream power typically shows significant spatial variability. The values shown in the table are therefore only indicative of the stream power values in the vicinity of these locations.

Table 5.3: Location with significant stream power increases (5% AEP event)

Location (refer to Figure 3-4)	% Change	Stream Power Existing (W/m²)	Stream Power Design (W/m²)
A	50 to 100	< 50	< 100
B	50 to 100	< 50	< 100
C	50 to 100	< 50	< 50
D	50 to 100	< 150	< 200
E	50 to 100	50 to 1000	50 to 1000
F	50 to 100	< 50	< 50
G	50 to 100	< 150	< 200
H	50 to 100	< 100	< 150
I	50 to 100	< 2000	< 2000

Location (refer to Figure 3-4)	% Change	Stream Power Existing (W/m²)	Stream Power Design (W/m²)
J	50 to 100	< 20	< 20

It is noted that location J is associated with an area of flat ground on the Plateau in the vicinity of the Angus Place East ventilation facility. Existing case stream power is very low and exaggerates the significance of change due to the APMEP. The developed case stream power is also relatively low and the increased stream power does not present a significant additional risk of erosion.

For locations C and F, both existing and developed stream power values typically remain below 50 W/m². While the change as a percentage is significant, it expected that the increased stream power does not present a significant additional risk of erosion due to the dense riparian vegetation and intact nature of the existing channels.

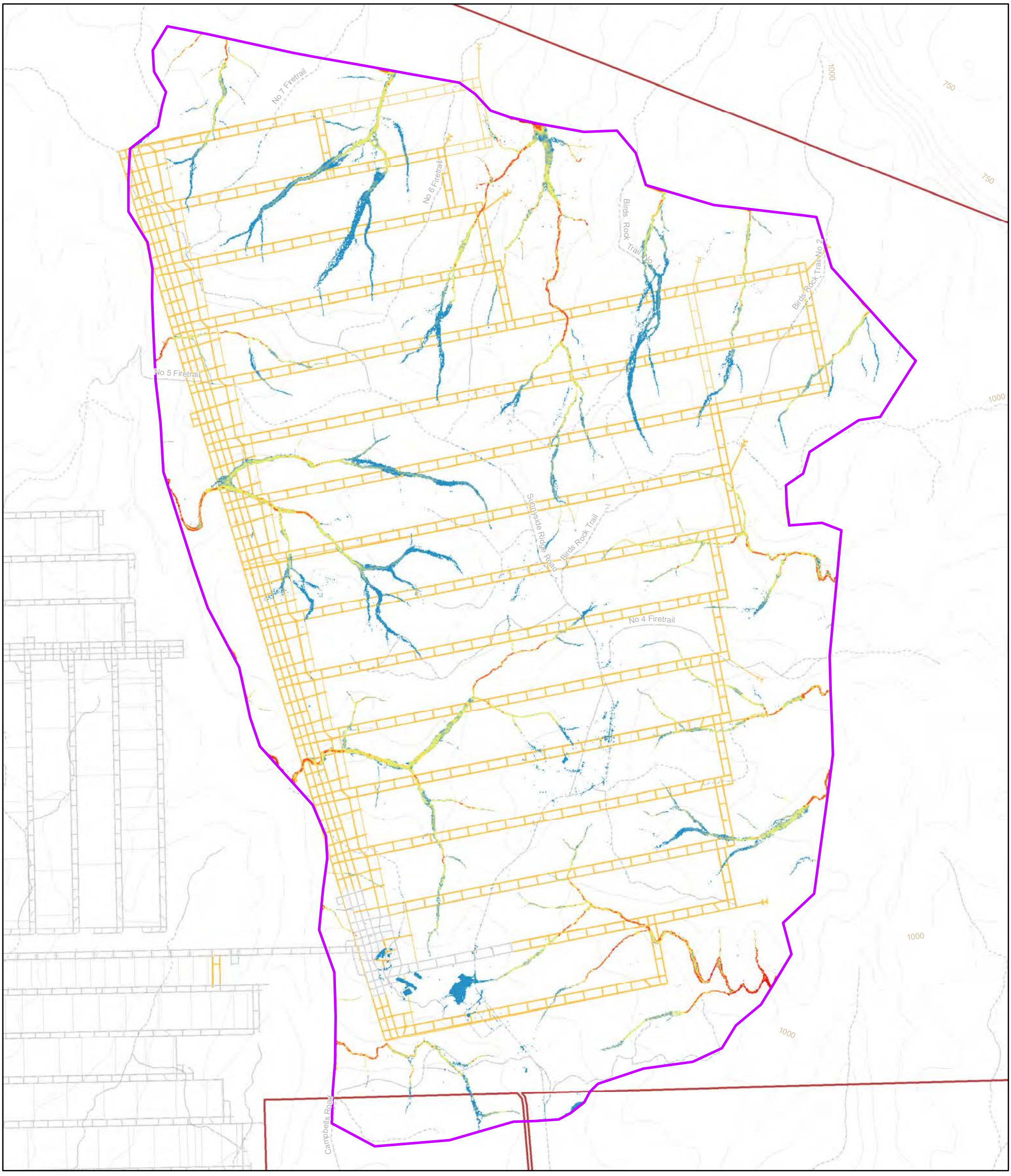
For locations, E and I, existing stream power can be as high as 1,000 W/m² to 2,000 W/m². At this magnitude, removal of riparian vegetation and erosion is expected under the existing condition and it is anticipated that the channel are likely incised at this location. Increased stream power in the design case is therefore not expected to present a significant additional erosional risk above that already experienced under existing conditions.

For the remaining locations (A, B, D, G and H), the increased levels of stream power may still be insufficient to initiate erosion given the dense riparian vegetation and intact nature of the existing channels. It is recommended that site specific investigations be conducted at each location following significant flood events in order to assess existing resilience and to develop a baseline level of understanding of the potential for erosion at these locations.

In several locations, reductions in stream power can be seen in the model results. These can be explained by a slight reduction in peak discharge at some locations, a reduction in bed slope, or a combination of these two factors. It is expected that in these locations an increased potential for vegetation establishment would exist. This, in consequence, may lead to small changes in the alignment of the waterways in these areas. It is not expected that this will lead to significant and noticeable changes.

Areas with significant predicted change in stream power should be monitored during mining to assess whether significant scouring or sedimentation is occurring.

Figure 5.12: Angus Place Pre-mining Stream Power for 20Y event



Angus Place Amended Project

Source: Organisation1: Dataset Name, (Year); Organisation2: Dataset Name, (Year)
Group same yeared datsets together if they belong in same organisation. Can run over two lines. see example below.

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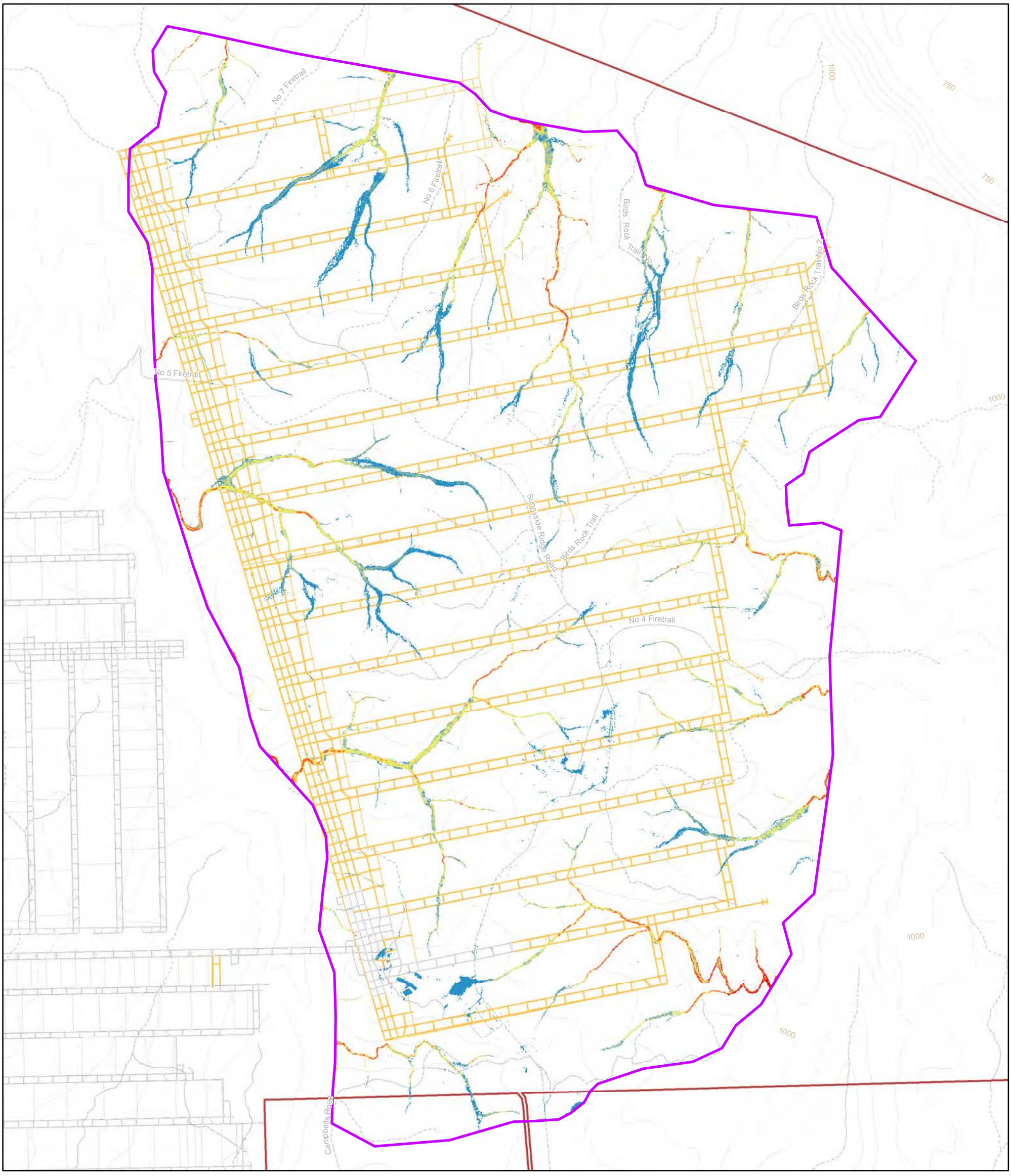
Figure 5.13: Angus Place Post-mining Stream Power for 20Y event



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5.3.4 Swamp Water Balance Model

To assess the potential change to surface water flow in surface water catchments, including THPSS, due to mining (both subsidence and depressurisation effects), a combined GoldSIM/Australian Water Balance Model (AWBM) was developed. The model is referred to as the Springvale Angus Place Swamp Water Balance Model (SAPSWBM) and is presented in Appendix E (JBS&G, 2019b). It was also the intent of the SAPSWBM to develop a rainfall/mining/groundwater response relationship to swamp environments to assist in the differentiation of mining and climatically induced flow conditions.

As presented in JBS&G (2019b), it was identified during an early stage of the development of the SAPSWBM that groundwater contribution into catchments containing NPSS was important and surface rainfall/runoff processes were not sufficient, on their own, to match observed manual flow gauging in those swamps. Accordingly, the SAPSWBM comprises surface rainfall/runoff processes via the AWBM but also includes groundwater contribution obtained from the numerical groundwater model developed for the Amended Project (JBS&G, 2019). The groundwater contribution was partitioned according to surface water sub-catchments and therefore provided spatially and temporally distributed input, however the two models were run separately. It is noted that the SAPSWBM is a daily rainfall/runoff model, whereas the numerical groundwater model is based on quarterly changes to its boundary conditions with model output at approximately Month 1 and Month 3 in each quarter.

Subsidence-related changes were accommodated for in the groundwater model. This involved changes to hydraulic properties of the model cell at ground surface that lay above each mining cell (mining cells occurred in the Lithgow Seam for Springvale Mine and Angus Place Colliery, including the 1000 Panel Area).

5.3.4.1 Impacts to THPSS

Output from the SAPSWBM is summarised below with respect to each of the NPSS of interest, within of close to the 600m Study Area.

Wolgan River Swamp

Table 5.4 presents model output from the SAPSWBM for Wolgan River Swamp. This model output location is referred to as point WR05a and is to the west of LW1006 through LW1008.

Table 5.4: Summary SAPSWBM Model Output (WR05a) – Wolgan River Swamp

	U10 Results (Flow ML/day)			U90 Results (Flow ML/day)		
Flow Percentile	PROPD	NULL	%[1]	PROPD	NULL	%[1]
Min	0.55	0.54	2	0.54	0.78	-30
5%	1.1	1.1	1	1.1	1.2	-10
10%	1.4	1.3	3	1.3	1.4	-11
20%	1.7	1.6	4	1.5	1.7	-9
50%	2.2	2.2	2	2.1	2.2	-7
80%	4.2	4.1	1	4.0	4.2	-4
90%	8.9	8.8	1	8.7	8.8	-2
95%	17	17	0	17	17	-1
Max	1081	1081	0	1080	1081	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

From Table 5.4, output from the SAPSWBM indicates that the modelled change in median flow will range from an increase of 2% in the U10 results to a decrease of 7% in the U90 results. At the 10th% flow level, output from the model indicates an increase of 3% in the U10 results and a 11% decrease in the U90 results.

Whilst the modelled change is of moderate magnitude, the change is not considered to be significant since the median flow rate is 2.2ML/d at that location and the 10th% flow rate is 1.4ML/d.

Given the above, it is considered that the impact of the modelled change on Wolgan River Swamp is not significant.

Wolgan River Upper Swamp

Table 5.5 presents the output from the SAPSWMB in Wolgan River Upper Swamp. This location is associated with model output point WR10.

Table 5.5: Summary SAPSWBM Model Output (WR10) – Wolgan River Swamp Upper Swamp

	U10 Results (Flow ML/day)			U90 Results (Flow ML/day)		
Flow Percentile	PROPD	NULL	%[1]	PROPD	NULL	%[1]
Min	0.25	0.25	3	0.25	0.34	-26
5%	0.55	0.54	2	0.52	0.54	-3
10%	0.70	0.65	7	0.63	0.64	-1
20%	0.86	0.81	6	0.77	0.79	-2
50%	1.16	1.12	4	1.08	1.09	-1
80%	2.18	2.15	1	2.10	2.16	-3
90%	4.77	4.74	1	4.69	4.71	0
95%	9.4	9.3	1	9.2	9.3	0
Max	615	615	0	615	615	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

From Table 5.5, the modelled change in median flow at the Wolgan River Upper Swamp ranges between +4% and -1%. At the 10th% level, the modelled change in flow ranges between +7% and -1%.

The modelled change in flow is up to a moderate increase and a negligible decrease. Accordingly, the modelled change in flow on Wolgan River Upper Swamp is not considered to be significant, because the magnitude of decrease is negligible.

Tri-Star Swamp

Table 5.6 presents the modelled change in flow at various frequencies for Tri-Star Swamp.

It is noted that Table 5.6 contains two sets of results, referred to as the U10 and U90 results. The two sets of results reflect the stochastic output from the groundwater model, where multiple realisations of model parameters were generated and processed; with the 10th percentile (referred to as the U10 results) and 90th percentile results (referred to as the U90 results) simulated in the SAPSWBM.

Accordingly, the output from the SAPSWBM should be considered as a modelled range (being 90% confident that the value is between the U10 and U90 results) rather than the traditional approach of a single answer.

Further detail of predictive uncertainty analysis is undertaken in the groundwater model is presented in the Groundwater Impact Assessment (Jacobs, 2019a).

It is also noted that only the modelled 10th and 50th percentile flows are presented. It is considered that it will be at low flows (10th percentile) that any predicted changes will be of most significance.

Table 5.6: Summary of SAPSWBM Model Output – Tri-Star Swamp

	U10 Results (Flow ML/day)			U90 Results (Flow ML/day)		
	PROPD	NULL	%[1]	PROPD	NULL	%[1]
Min	0.15	0.16	-6	0.14	0.26	-45
5%	0.26	0.29	-11	0.25	0.37	-31
10%	0.32	0.33	-5	0.30	0.41	-28
20%	0.38	0.40	-5	0.33	0.46	-27
50%	0.50	0.51	-2	0.44	0.55	-21
80%	0.83	0.83	0	0.75	0.88	-14
90%	1.6	1.6	-1	1.5	1.6	-7
95%	2.9	2.9	0	2.9	3.0	-4
Max	173	173	0	173	173	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

From Table 5.6, the Proposed Case (PROPD) and Null Case (NULL) are presented. The Proposed Case is continuation of mining at Angus Place Colliery into the 1000 Panel Area and the Null Case is continuation of Care and Maintenance at Angus Place Colliery (present state) followed by transition to rehabilitation phase.

Further detail of the SAPSWBM assumptions are presented in Appendix E (JBS&G, 2019b).

From Table 5.6, for the U10 results, the modelled median (50th%) flow is 0.51ML/day in the Null Case and is 0.50ML/day in the Proposed Case. This represents a 2% decrease and is a negligible change. For the 10th% flows (low flows), the U10 results are 0.33ML/day in the Null Case and are 0.32ML/day in the Proposed Case, and represents a 5% decrease. From Table 5.6, for the U90 results, the difference between Proposed and Null Case is a 21% decrease in modelled median flows (50th%) and is a 28% decrease in the 10th% flows.

The modelled change in surface water flow is large and the impact of that magnitude of change is expected to be significant.

Climate change scenarios are also presented in Appendix E (JBS&G, 2019b), however, high and low rainfall scenarios result in essentially the same magnitude of change.

Twin Gully Swamp

Table 5.7 presents the modelled change in surface water flow for Twin Gully Swamp.

Table 5.7: Summary of SAPSWBM Model Output – Twin Gully Swamp

	U10 Results (Flow ML/day)			U90 Results (Flow ML/day)		
Flow Percentile	PROPD	NULL	%[1]	PROPD	NULL	%[1]
Min	0.10	0.08	24	0.09	0.09	3
5%	0.18	0.17	12	0.18	0.20	-8
10%	0.22	0.20	8	0.21	0.23	-7
20%	0.27	0.25	11	0.26	0.28	-7
50%	0.37	0.35	7	0.37	0.39	-4
80%	0.75	0.72	4	0.75	0.77	-3
90%	1.6	1.6	2	1.6	1.6	-1

	U10 Results (Flow ML/day)			U90 Results (Flow ML/day)		
Flow Percentile	PROPD	NULL	%[1]	PROPD	NULL	%[1]
95%	3.2	3.1	1	3.2	3.2	-1
Max	191	191	0	191	191	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

From Table 5.7, the modelled change to median flow (50th%) is +7% in the U10 results and is -4% in the U90 results. From Table 5.7, the modelled change in the 10th% flows is +8% in the U10 results and is -7% in the U90 results.

It is noted that a positive change in flow occurs in the model due to changes in hydraulic properties in model cells in the groundwater model leading to more groundwater being discharged to surface water. As noted in the Groundwater Impact Assessment (Jacobs, 2019a), the mechanism for positive impacts occurring in the groundwater model is through the material property changes in the subsidence profile with enhanced horizontal hydraulic conductivity allowing greater lateral transmission of groundwater to seepage faces. While similar responses were predicted in the 2014 EIS (CSIRO, 2013), in practice this effect has not been observed in the monitoring data (flow or water level). It is not clear if this is due the prevailing drying climate masking the effect or if it does not eventuate in reality.

The predicted changes range between a minor to moderate increase and a minor to moderate decrease. It is considered that the impact of the magnitude of change in flows in Twin Gully Swamp may be moderate, and is less than that predicted for Tri-Star Swamp. This is expected to be influenced by the difference in extraction height and depth of cover between the two locations.

Climate change simulations at Twin Gully Swamp presented in Appendix E do not result in any significant difference in predicted change.

Trail Six /Japan Swamp

Table 5.8 presents the modelled change in flow at various frequencies at Trail Six / Japan Swamp.

Table 5.8: Summary of SAPSWBM Model Output – Trail Six Swamp

	U10 Results (Flow ML/day)			U90 Results (Flow ML/day)		
Flow Percentile	PROPD	NULL	%[1]	PROPD	NULL	%[1]
Min	0.04	0.04	0	0.06	0.06	0
5%	0.09	0.09	7	0.12	0.12	-3
10%	0.11	0.11	2	0.14	0.16	-15
20%	0.15	0.14	6	0.16	0.19	-14
50%	0.21	0.20	4	0.24	0.26	-8
80%	0.45	0.43	5	0.47	0.49	-4
90%	0.91	0.90	1	0.95	0.98	-3
95%	1.9	1.8	1	1.9	1.9	-2
Max	117	117	0	117	117	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

From Table 5.8, output from the SAPSWBM indicates a change in median modelled flow (50th%) of +4% in the U10 results and -8% in the U90 results. For the 10th% flow frequency, the modelled change due to the Amended Project is a +2% increase in the U10 results and is a -15% decrease in the U90 results.

The magnitude of the changes in the U90 results range from moderate to large and are expected to be significant. This is due to the low value of flow in the THPSS, being ~0.20ML/d (2.3L/s) at 50th% level and

~01.2ML/d (1.4L/s) at the 10th% level. Accordingly, small changes in numerical value lead to large changes by percentage and because the THPSS is a low flow environment, changes to flow are likely to be significant.

Climate change results presented in Appendix E (JBS&G, 2019b) indicate that expected impact in High Rainfall and Low Rainfall Scenarios are essentially the same as that presented in Table 5.8.

Birds Rock Swamp

Table 5.9 presents the change in model output in the sub-catchment containing Birds Rock Swamp. This location is associated with point CC03 and resides within the Carne Creek catchment.

Table 5.9: Summary of SAPSWBM Model Output (CC03) – Birds Rock Swamp

	U10 Results (Flow ML/day)			U90 Results (Flow ML/day)		
Flow Percentile	**PROPD**	**NULL**	**%[1]**	**PROPD**	**NULL**	**%[1]**
Min	0.05	0.05	1	0.06	0.10	-42
5%	0.09	0.09	-1	0.12	0.15	-20
10%	0.12	0.13	-4	0.14	0.17	-19
20%	0.14	0.14	-3	0.18	0.21	-15
50%	0.19	0.19	0	0.26	0.29	-13
80%	0.35	0.35	0	0.42	0.46	-8
90%	0.69	0.69	-1	0.76	0.80	-5
95%	1.3	1.3	0	1.4	1.4	-3
Max	83	83	0	84	84	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

From Table 5.9, output from the SAPSWBM indicates a modelled change in median flow ranging between 0% and -13%. From Table 5.9, at the 10th% level, the modelled change is ranges between a 4% decrease and a 19% decrease.

From Table 5.9, the modelled change is a moderate to large decrease, and is considered to be significant because the magnitude of flow at the 50th% level is 0.2 to 0.3ML/d and is 0.12 to 0.17ML/d at the 10th% level.

Climate change scenarios are also presented in Appendix E (JBS&G, 2019b), however, high and low rainfall scenarios result in essentially the same magnitude of change.

Crocodile Swamp

Table 5.10 presents output from the SAPSWBM for Crocodile Swamp. Crocodile Swamp is located in a tributary of Carne Creek and is associated with model output location CC04a.

Table 5.10: Summary of SAPSWBM Model Output (CC04a) – Crocodile Swamp

	U10 Results (Flow ML/day)			U90 Results (Flow ML/day)		
Flow Percentile	**PROPD**	**NULL**	**%[1]**	**PROPD**	**NULL**	**%[1]**
Min	0.02	0.02	17	0.02	0.02	-6
5%	0.06	0.05	8	0.06	0.06	1
10%	0.08	0.07	5	0.06	0.07	-1
20%	0.10	0.09	7	0.07	0.08	-1
50%	0.14	0.14	5	0.11	0.11	-1
80%	0.24	0.23	3	0.23	0.23	-1

	U10 Results (Flow ML/day)			U90 Results (Flow ML/day)		
Flow Percentile	PROPD	NULL	%[1]	PROPD	NULL	%[1]
90%	0.48	0.47	2	0.46	0.47	-1
95%	0.92	0.91	1	0.91	0.91	0
Max	57	57	0	57	57	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

From Table 5.10, the modelled change in flow at the 50%th level ranges between 5% increase in the U10 results to a 1% decrease in the U90 results. At the 10th% level, the modelled change also ranges between a +5% and -1% in the U10 and U90 results respectively.

From Table 5.10, the modelled magnitude of decrease is negligible, therefore the expected impact of that change on Crocodile Swamp is insignificant.

Climate change scenarios are also presented in Appendix E (JBS&G, 2019b), however, high and low rainfall scenarios result in essentially the same magnitude of change.

5.3.4.2 Surface Watercourses

In addition to modelled changes to surface water flow at THPSS, and as presented in Appendix E (JBS&G, 2019b), the domain of the SAPSWBM is significantly larger than just the THPSS and includes Carne Creek and the Wolgan River in the northeast, Bungleboori Creek to the east and the Coxs River (above Lake Lyell) to the west. Accordingly, modelled changes to surface water flow were available at locations other than at THPSS. Those outputs are presented in Appendix E (JBS&G, 2019c).

It is noted that only the surface water courses immediately surrounding the Project are discussed below.

Carne Creek

Table 5.11 presents the output from the SAPSWBM in Carne Creek at location CC02. Location CC02 is situated on Carne Creek, to the east of the 1000 panel area.

Table 5.11: Summary of SAPSWBM Model Output (CC02) – Carne Creek

	U10 Results (Flow ML/day)			U90 Results (Flow ML/day)		
Flow Percentile	PROPD	NULL	%[1]	PROPD	NULL	%[1]
Min	1.5	1.5	4	1.6	1.8	-8
5%	2.9	2.9	2	3.0	3.1	-4
10%	3.6	3.4	3	3.5	3.7	-4
20%	4.1	4.0	3	4.1	4.3	-4
50%	6.2	6.1	2	6.2	6.4	-3
80%	14	14	1	14	14	-1
90%	32	31	0	32	32	-1
95%	65	65	0	65	65	0
Max	3272	3272	0	3272	3272	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

From Table 5.11, the modelled change to surface water flow is Carne Creek is +2% in the U10 results and is -3% for the U90 results for median flows (50th%). At the 10th% flow level, the U10 result is +3% and the U90 results is -4%. The magnitude of change is relatively minor, and the impact is not considered to be significant as the flow volume is much higher.

Wolgan River- below confluence with Carne Creek

Table 5.12 presents model output at location WR02. Location WR02 is situated on the Wolgan River below the confluence with Carne Creek.

Table 5.12: Summary of SAPSWBM Model Output (WR02) – Wolgan River below Carne Creek

	U10 Results (Flow ML/day)			U90 Results (Flow ML/day)		
Flow Percentile	PROPD	NULL	%[1]	PROPD	NULL	%[1]
Min	4.5	4.3	5	4.8	5.2	-7
5%	9.1	8.9	2	9.7	10.0	-3
10%	11	11	2	12	12	-4
20%	13	13	2	14	14	-4
50%	20	20	1	21	22	-3
80%	52	52	0	54	54	-1
90%	90	90	0	91	92	-1
95%	177	177	0	178	179	0
Max	9517	9516	0	9518	9518	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

From Table 5.12, the modelled median flow is approximately 20ML/day. From Table 5.12, the modelled change to median flow (50th%) is +1% in the U10 results and is -3% in the U90 results. From Table 5.12, the modelled change at the 10th% flow level is +2% in the U10 results and is -4% in the U90 results. The magnitude of change is considered to be minor to moderate and the impact is not considered to be significant.

Wolgan River – above confluence with Carne Creek

Table 5.13 presents model output at location WR03. Location WR03 is situated on the Wolgan River above the confluence with Carne Creek.

Table 5.13: Summary of SAPSWBM Model Output (WR03) – Wolgan River above Carne Creek

	U10 Results (Flow ML/day)			U90 Results (Flow ML/day)		
Flow Percentile	PROPD	NULL	%1	PROPD	NULL	%[1]
Min	1.6	1.5	5	1.8	2.0	-12
5%	3.5	3.4	3	3.7	3.9	-4
10%	4.4	4.3	3	4.6	4.8	-4
20%	5.2	5.1	2	5.5	5.7	-3
50%	7.9	7.8	1	8.3	8.5	-2
80%	25	24	1	25	25	-1
90%	48	48	0	48	48	0
95%	60	60	0	60	60	0
Max	3774	3774	0	3774	3774	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

From Table 5.13, the modelled median flow is approximately 8ML/day. From Table 5.13, the modelled change to median flow (50th%) is +1% in the U10 results and is -2% in the U90 results. From Table 5.13, the modelled change at the 10th% flow level is +2% in the U10 results and is -4% in the U90 results. The magnitude of change is considered to be minor to moderate and the impact is not considered to be significant.

Wolgan River – west of 1000 panel area

Table 5.14Table 5.14 presents the output from the SAPSWBM at location WR04. Location WR04 is situated on the Wolgan River to the west of the 1000 panel area.

Table 5.14: Summary of SAPSWBM Model Output (WR04) – Wolgan River west of 1000 panel area

	U10 Results (Flow ML/day)			U90 Results (Flow ML/day)		
Flow Percentile	PROPD	NULL	%[1]	PROPD	NULL	%[1]
Min	1.1	1.0	7	1.1	1.4	-19
5%	2.4	2.3	4	2.4	2.6	-7
10%	3.0	2.9	4	3.0	3.1	-5
20%	3.6	3.5	3	3.5	3.7	-5
50%	5.4	5.3	2	5.3	5.5	-4
80%	16	16	1	16	16	-1
90%	31	31	0	31	31	-1
95%	38	38	0	38	38	-1
Max	1990	1990	0	1990	1990	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

From Table 5.14, the change in modelled median flow (50th%) is +2% in the U10 results and is -4% in the U90 results. At the 10th% flow level, the modelled change is +4% in the U10 results and is -5% in the U90 results. The magnitude of change in flow at the 50th% and 10th% level is minor to moderate. The modelled change is not considered to be significant because the flow rate at the 50th% level is of the order of 5.5ML/day and at the 10th% level is approximately 3ML/day.

Coxs River

Table 5.15 presents the output from the SAPSWBM in the Coxs River below the confluence with Sawyers Swamp Creek.

Table 5.15: Summary of SAPSWBM Model Output (CR03) – Coxs River below Sawyers Swamp Creek

	U10 Results (Flow ML/d)			U90 Results (Flow ML/d)		
Flow Percentile	PROPD	NULL	%[1]	PROPD	NULL	%[1]
Flow Percentile	PROPD	NULL	%1	PROPD	NULL	%1
Min	0.83	0.81	3	0.83	0.86	-3
5%	1.6	1.6	3	1.6	1.6	0
10%	2.0	1.9	3	1.9	1.9	0
20%	2.5	2.5	2	2.4	2.4	0
50%	4.3	4.3	1	4.2	4.2	0
80%	12	12	0	12	12	0
90%	32	31	0	31	31	0
95%	67	67	0	67	67	0
Max	4608	4608	0	4608	4608	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

From Table 5.15, the modelled change, at the 50th% flow level, ranges between +1% in the U10 results to -0% in the U90 results. At the 10th% flow level, the modelled change ranges between +3% in the U10 results to -0%

in the U90 results. From Table 5.15, the magnitude of change is negligible and hence the impact to surface water flow is considered insignificant. Given that the change to flow in the Coxs River is negligible, and there is no change to surface water quality due to the Amended Project, the Project will satisfy the Neutral or Beneficial Effect on Water Quality test.

5.3.5 Surface Water Users

The surface water users in the vicinity of the Amended Project are identified on Figure 3.5 with details provided in Appendix A.

As discussed in Section 3.7, there are users in Upper Nepean and Upstream Warragamba Water Source (Wywandy Management Zone) that reside in smaller tributaries that are a significant distance from the Project Area and therefore will not experience change to surface water flow. Accordingly, results from the SAPSWBM were not extracted for those users.

There are several nearby surface water users in the Hawkesbury and Lower Nepean Water Source (Colo River Management Zone). Output from the SAPSWBM for those users is presented in Appendix E (JBS&G, 2019c).

5.3.5.1 Wywandy Management Zone

Table 5.15 presents the output from the SAPSWBM in the Coxs River below the confluence with Sawyers Swamp Creek. That location is identified as CR03 in Appendix E (JBS&G, 2019c).

From Table 5.15, the change to surface water flow at that location is negligible and hence the impact of the Amended Project on surface water flows is considered insignificant.

Accordingly, the impact to the surface water user (WAL No. 25607) at that location is insignificant. Similarly, output presented in Appendix E (JBS&G, 2019c) indicates that the impact to surface water user (WAL No. 25774) is also insignificant, as is the impact to the major utility surface water user (WAL No. 27428).

5.3.5.2 Colo River Management Zone

Table 5.12 presents a summary of the output from the SAPSWBM in the Wolgan River below the confluence with Carne Creek. That location is identified as WR02 (WAL No. 25948 and 26506) in Appendix E (JBS&G, 2019c).

From Table 5.12, the change to surface water flow at that location is minor and, given the magnitude of flow, the impact of the Amended Project on surface water users at that location (WAL No. 25948 and 26506) is considered insignificant.

From Appendix E (JBS&G, 2019c), location WR03 (WAL No. 25891) is located on the Wolgan River above the confluence with Carne Creek. From Table 5.8 of Appendix E, the change in modelled median flow (50th%) is +1% in the U10 results and is -2% in the U90 results. At the 10th% flow level, the modelled change is +3% in the U10 results and is -4% in the U90 results. Accordingly, the change to surface water flow is minor to moderate and the impact of the change on surface water user (WAL No. 25891) is considered insignificant.

From Appendix E (JBS&G, 2019c), location WR04 (WAL No. 26096) is located on the Wolgan River to the northwest of the 100 Panel Area. From Table 5.9 of Appendix E, the change in modelled median flow (50th%) is +2% in the U10 results and is -4% in the U90 results. At the 10th% flow level, the modelled change is +4% in the U10 results and is -5% in the U90 results. From Appendix A, the entitlement of WAL No. 26096 is 4ML/water year compared to median flow at that location of ~5.5ML/day. Accordingly, whilst the magnitude of change to surface water flow at that location is minor to moderate, the impact of that change on the surface water user (WAL No. 26096) is insignificant because the quantity of take by that user is very small.

5.4 Surface Water Quality

Surface water monitoring at Angus Place and Springvale Mine has not identified any water quality impacts to surface flows as a result of mining and accordingly, no future impacts to groundwater are anticipated during operation. In addition, there will be no discharge of treated or untreated mine water to the Coxs River via LDP001.

Following mine closure there is potential for groundwater seepage in the vicinity of the sealed portals. Water quality will notionally be commensurate with current mine inflows refer Table 4.6 of the Groundwater Impact Assessment). There is also potential for a component of acid generation within the mine voids and contributing overlying unsaturated formations. The potential for this will be assessed and managed at the mine closure planning stage.

5.5 Responses to IESC comments

Responses to IESC comments in relation to the Angus Place Extension Project EIS are provide as follows.

IESC01) Requirement to characterise existing surface water, groundwater and ecological conditions for the majority of Temperate Highland Peat Swamps on Sandstone (THPSS).

Since the time of Angus Place Mine Extension Project, significant additional investigation has been undertaken on the THPSS at both Angus Place Colliery and Springvale Mine.

Groundwater monitoring data, including soil moisture, at Tri-Star, Twin Gully and Trail Six Swamps is presented in this report. Surface water flow data is presented in the Surface Water Impact Assessment (Jacobs, 2019) and the Swamp Water Balance Model report (JBS&G, 2019).

Ecological assessment is presented in the Ecological Impact Assessment.

IESC02) Seasonal surface water flow and an assessment, or estimation, of the baseflow component of the Coxs River.

Quarterly stress periods have been adopted in the groundwater model to incorporate seasonal variation. As presented in the Hydrogeological Model Report (JBS&G, 2019a), historical climate data was used during the calibration period and NARCliM based climate data was used for the prediction period.

Modelled contribution of groundwater to surface water flow was implemented in the groundwater model through inclusion of all surface watercourses and seepage fluxes where particular layers terminate as an outcrop in cliffsides.

The relative change to contribution of groundwater to surface water flow was then assessed using the Swamp Water Balance Model and is presented in the Surface water Impact Assessment (Jacobs, 2019).

IESC04) Finer scaled, site specific models, informed by a conceptualisation of the hydrology and hydrogeology, would be needed to have confidence in the predictions of groundwater impacts to individual swamps.

Site specific groundwater models were investigated during development of the Swamp Water Balance Model. It was found, however, that a regional groundwater model was necessary due to the scale of changes due to mining. Accordingly, finer scale modelling was achieved through the Swamp Water Balance Model, which received output from the regional groundwater model (JBS&G, 2019b and Appendix E).

IESC05) Water quality impact estimations for the Coxs River need to consider the increased discharge volumes to Coxs River resulting from reduced demand from the Wallerawang Power Station.

This aspect was addressed at the time through the Regional Water Quality Impact Assessment Model (RWQIAM). In any regard, in accordance with Angus Place Colliery Modification 5 (JBS&G, 2018), The APMEP will not discharge raw or treated mine water, from 1 January 2020.

5.6 NSW River Flow Objectives

An assessment of the APMEP against the NSW River Flow Objectives is provided in Table 5.16 with respect to third order drainages and higher. It is noted that potential impacts relating to THPSS will be addressed under the EPBC Act.

Table 5.16: NSW River Flow Objectives

River Flow Objective	Compliant	Assessment
Protect natural pools in dry times "Protect natural water levels in pools of creeks and rivers and wetlands during period of no flow"	Yes	As outlined in Section 5.3.4.2, the APMEP is not predicted to have a significant impact on flows in the Wolgan River or Carne Creek.
Protect natural low flows "Protect natural low flows"	Yes	As outlined in Section 5.3.4.2, the APMEP is not predicted to have a significant impact on flows in the Wolgan River or Carne Creek.
Maintain wetland and floodplain inundation "Maintain or restore natural inundation patterns and distribution or floodwaters supporting natural wetland and floodplain ecosystems"	Yes	As outlined in Section 5.3.4.2, the APMEP is not predicted to have a significant impact on flows in the Wolgan River or Carne Creek.
Maintain natural flow variability "Maintain or mimic natural flow variability in all streams"	Yes	As outlined in Section 5.3.4.2, the APMEP is not predicted to have a significant impact on flows in the Wolgan River or Carne Creek.
Maintain groundwater ecosystems "Maintain groundwater within natural levels and variability, critical to surface flows and ecosystems"	Yes	As outlined in the Groundwater Impact Assessment (Jacobs, 2019) no significant drawdown of the water table is expected beneath Wolgan River or Carne Creek.

5.7 Neutral or Beneficial Impact

During mining the Project will meet the requirements of the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 for neutral or beneficial effect on water quality for a continuing development.

From 2020 all mine inflows from existing workings will be transferred to the Springvale Water Treatment Project for desalination and beneficial reuse at the Mount Piper Power Station with the exception of up to 1.8 ML/day average discharges occurring from Springvale Mine's LDP001.

Potential seepages following mine closure and mine void water level recovery will need to be assessed at the mine closure planning stage.

6. Licensing

6.1 Water Access Licence Requirements

This section summarises the surface water access licencing requirements due to incidental take of surface water or reduction in surface water flows. The surface sources relevant to the Project are discussed in Section 2.2.1.1 and presented on Figure 2.1.

The take from surface water sources due to mining activity was calculated based on the difference in outflow from drain (DRN) cells and river (RIV) within each of the surface water sources between the Proposed and Null Cases. It is noted that predictive uncertainty results are not presented with respect to calculation of licensable take. Model output is calculated from the Proposed and Null Case simulations using calibrated parameter values and have been apportioned per licencing water year (July through to June).

The licensable surface water take due to reduced flow (baseflow reduction) is presented in Figure 6.1 and tabulated in Table 6.1. It is noted that there was only surface water take from the Wywandy Management Zone and the Colo River Management Zone due to the Proposal.

Water take from the Wywandy Management Zone is relatively minor and only occurs in the 2029 to 2030 and 2030 to 2031 water years with a maximum take of 13ML/year.

Water take from the Colo River Management Zone peaks at 26ML/year during mining in 2030 to 2031. Post mining water take then increases, peaking at 84ML/year in 2041 to 2042 and 2042 to 2043.

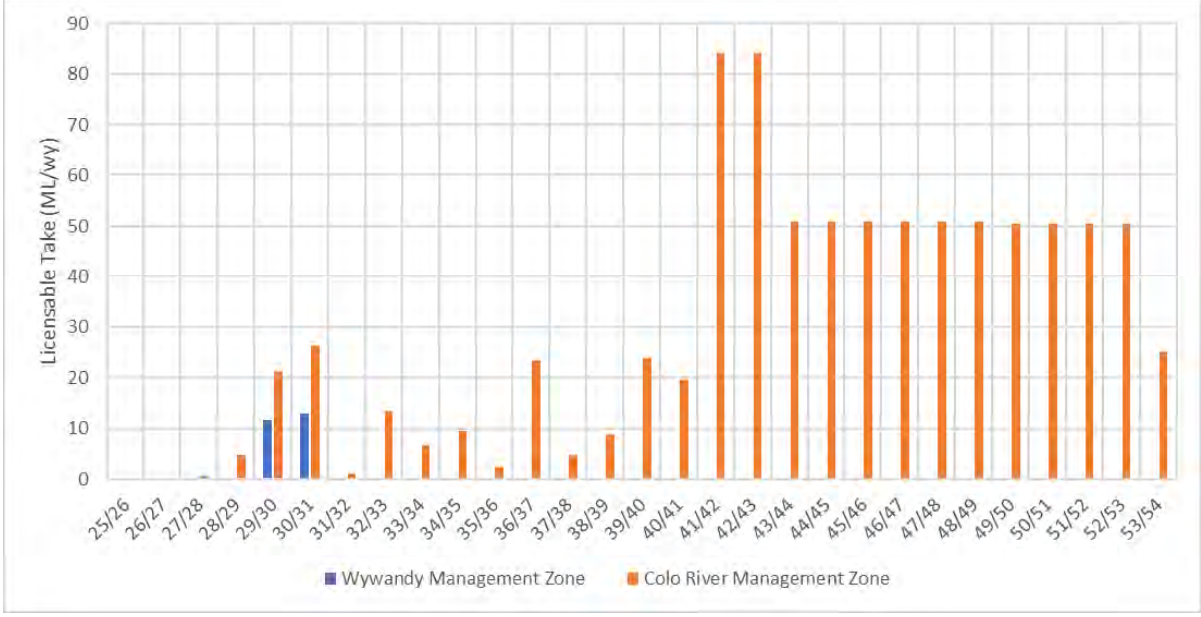

Figure 6.1: Licensable Surface Water Take

It is noted that Centennial has interests in surface water allocations in both the Wywandy Management Zone and Colo River Management Zone totalling 145 ML/yr and 1293 ML/yr respectively. These allocations are more than sufficient to cover the predicted surface water take. In the event that additional licence volumes would be required, then these would need to be purchased on the open market or through a controlled allocation order. It is understood that incidental water takes from a surface water source, such as reduced baseflow contribution due to groundwater drawdown, are not subject to cease to pump rules, as outlined in the relevant water sharing plan.

Table 6.1: Licensable Surface water Take (ML/year)

Water Year	Wywandy Management Zone	Colo River Management Zone
Mining		
2025/2026	0	0
2026/2027	0	0
2027/2028	0	1
2028/2029	0	5
2029/2030	12	21
2030/2031	13	26
2031/2032	0	1
2032/2033	0	13
2033/2034	0	7
2034/2035	0	10
2035/2036	0	2
2036/2037	0	24
2037/2038	0	5
2038/2039	0	9
Post Mining		
2039/2040	0	24
2040/2041	0	20
2041/2042	0	84
2042/2043	0	84
2043/2044	0	51
2044/2045	0	51
2045/2046	0	51
2046/2047	0	51
2047/2048	0	51
2048/2049	0	51
2049/2050	0	51
2050/2051	0	51
2051/2052	0	51
2052/2053	0	51
2053/2054	0	25

6.2 Environmental Protection Licences

Centennial holds an EPL for mining for coal and associated works (EPL467). The EPL covers the mining operation, surface facilities and overland conveyors at Angus Place Colliery. The provisions of EPL467 prescribe water quality and volumetric discharge limits of various surface water pollutants to designated licensed discharge points (refer Section 2.2.2).

Under the proposed Amended Project, discharge of treated stormwater at LDP002 remains unchanged, and discharge of mine water make via LDP001 and treated effluent discharge via LDP005 (once longwall extraction commences), will no longer be required.

6.3 Cumulative Impact Considerations

Potential cumulative impacts in relation to the APMEP for surface water have been assessed in the Hydrogeological Model (JBS&G, 2019a) the outputs from which are incorporated into the Swamp Water Balance Model (JBS&G, 2019a and Appendix E) as follows:

- A Proposed Case, based on the APMEP and extension of existing mining operations at Angus Place Colliery into the 1000 Panel Area, also includes maintaining Springvale Mine in a dewatered state through to 2053.
- A Null Case, based on cessation of mining at Angus Place Colliery, and the existing and approved operations at Springvale at the end of 2029.
- Potential influences from Clarence Colliery are also included in the Hydrogeological Model.

The adopted approach takes into account the potential changes to surface water flow due to surrounding existing and approved operations before assessing the proposed changes due to the APMEP. The adopted approach assumes all changes to surface water are due to the Amended Project, inclusive of changes associated with the extension of duration of dewatering at Springvale Mine.

7. Monitoring and Management

7.1 Erosion and Sediment Control

7.1.1 Pit Top

Erosion and sediment control facilities at Angus Place Colliery pit top will not change with the Amended Project. The existing erosion and sediment control facilities were assessed at the time of the EIS and found to be consistent with relevant guidelines (DECC, 2008).

Accordingly, there is no impact due to the Amended Project on erosion and sediment control at the Angus Place Colliery pit top because there is no change to these facilities and there is no change to current configuration of surface site water management.

7.1.2 Newnes Plateau

All auxiliary infrastructure that may be required to be installed associated with additional dewatering bore facilities (including electrical easements, booster stations and pipeline connections) will be subject to a Construction and Environmental Management Plan (CEMP).

The CEMP will be prepared in accordance with the relevant guidelines (DECC, 2008) and, as such, the impact of the Amended Project on erosion will be negligible, by design.

7.2 Surface Water Monitoring

Surface water monitoring for the APMEP will continue to utilise the existing surface water and swamp monitoring network that is already in place. The monitoring network and approach will be similar to that adopted for the current Springvale Mine developed in consultation with the Springvale Independent Monitoring Panel.

Notionally this would require the following additional monitoring:

- The establishment of a flow and water quality monitoring sites at the bottom end of Trail Six/Japan Swamp, Bird Rock Swamp and Crocodile Swamp.

7.3 Stream Condition Monitoring

Annual stream condition monitoring will be implemented at key locations along water courses that overly or are within 600m of the proposed extraction area.

Monitoring will comprise a combination of photographic monitoring and site observation to identify influences of sedimentation or scouring. Areas identified as potentially sensitive to subsidence and change in stream dynamics, such as the incised section of drainage in the upper reaches of Tri Star Swamp southern tributary, may also be subject monitoring of scarp heights and head cut height and progression.

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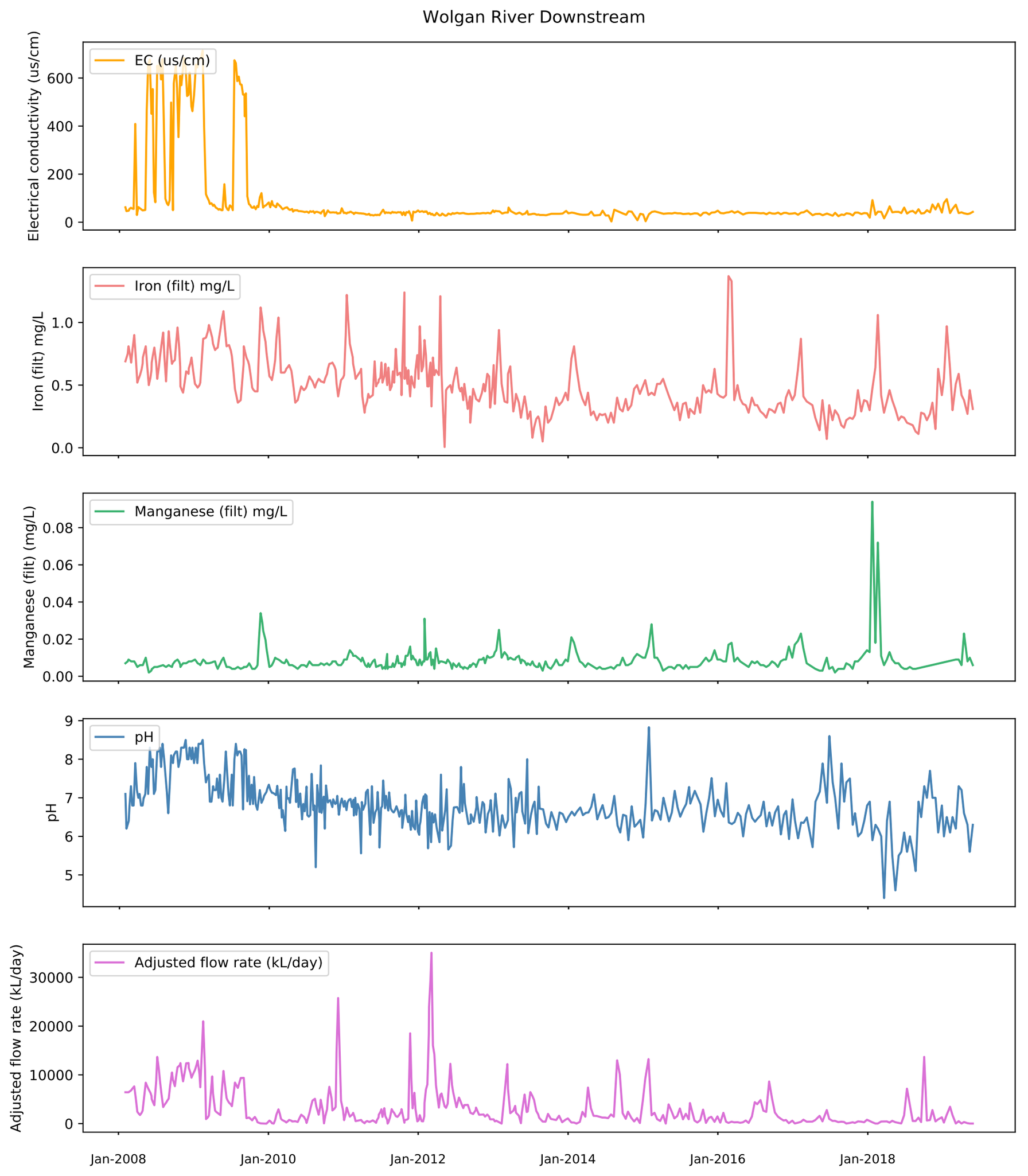
Appendix A. Surface Water Users

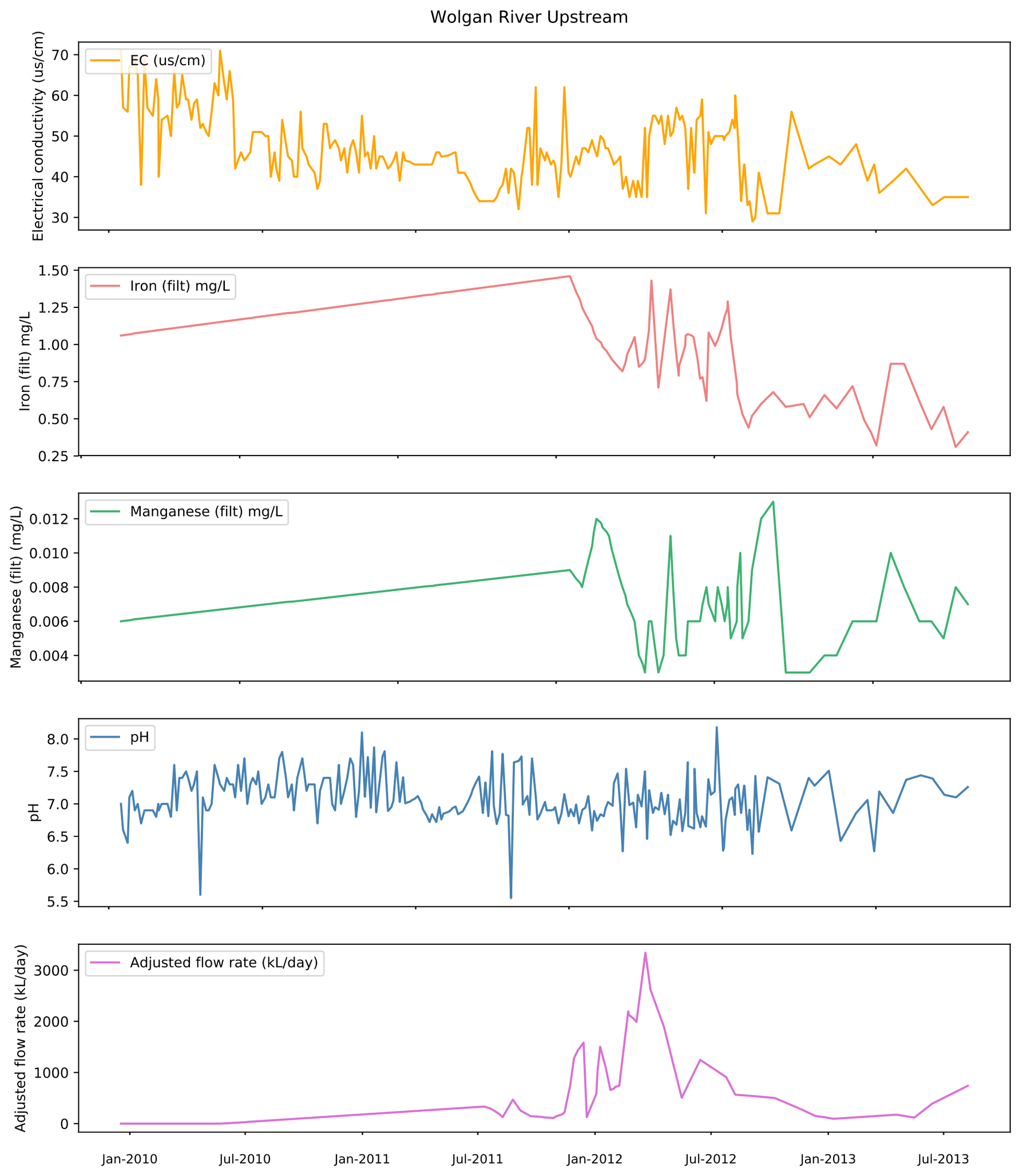
Licence and Approval							Approval Details				Work Details			
WAL Number	Licence Category and Entitlement	Approval ID	Lot	DP	Location	Comments	Kind of Approval	Issue Date	Expiry Date	Status	Work Type	Description	Number of Works	Status
25948	Unregulated River 29 (units or ML)	10CA104306	27	751624	Wolgan River within the Wolgan Valley	11.5km north-east to longwall 1015	Water Supply Works and Water Use	1-Jul-11	11-Apr-26	Current	Diversion Works - Pumps	50mm Centrifugal Pump	1	Active
26506	Unregulated River 60 (units or ML)	10WA104760	2	1127218	Wolgan River within the Wolgan Valley	9.5km north-east to longwall 1015	Water Supply Works	1-Jul-11	30-Jun-24	Current	Diversion Works - Pumps	50mm Centrifugal Pump	1	Active
25891	Unregulated River 42 (units or ML)	10WA104809	26	751666	Carne Creek within the Wolgan Valley	6.5km north-east to longwall 1015	Water Supply Works	1-Jul-11	30-Jun-24	Current	Diversion Works - Pumps	150mm Centrifugal Pump	1	Active
26096	Unregulated River 4 (units or ML)	10CA105539	3	722335	Wolgan River within the Wolgan Valley	4km north-west to longwall 1015	Water Supply Works and Water Use	1-Jul-11	30-Jun-24	Current	Diversion Works - Pumps	100mm Centrifugal Pump	1	Active
25659	Unregulated River 145 (units or ML)	10WA102715	5	858201	Pipers Flat Creek, approximately 8.5km north-west to Lake Wallace	17.5km west to longwall 1002	Water Supply Works	1-Jul-11	18-May-26	Current	Diversion Works - Pumps	Other Pump	1	Active
25500	Unregulated River 43 (units or ML)	10CA102870	1	998434	Marrangaroo creek, approximately 5km east to Lake Wallace	9.5km south-west to longwall 1002	Water Supply Works and Water Use	1-Jul-11	30-Jun-24	Current	Diversion Works - Pumps	80mm Centrifugal Pump	1	Active

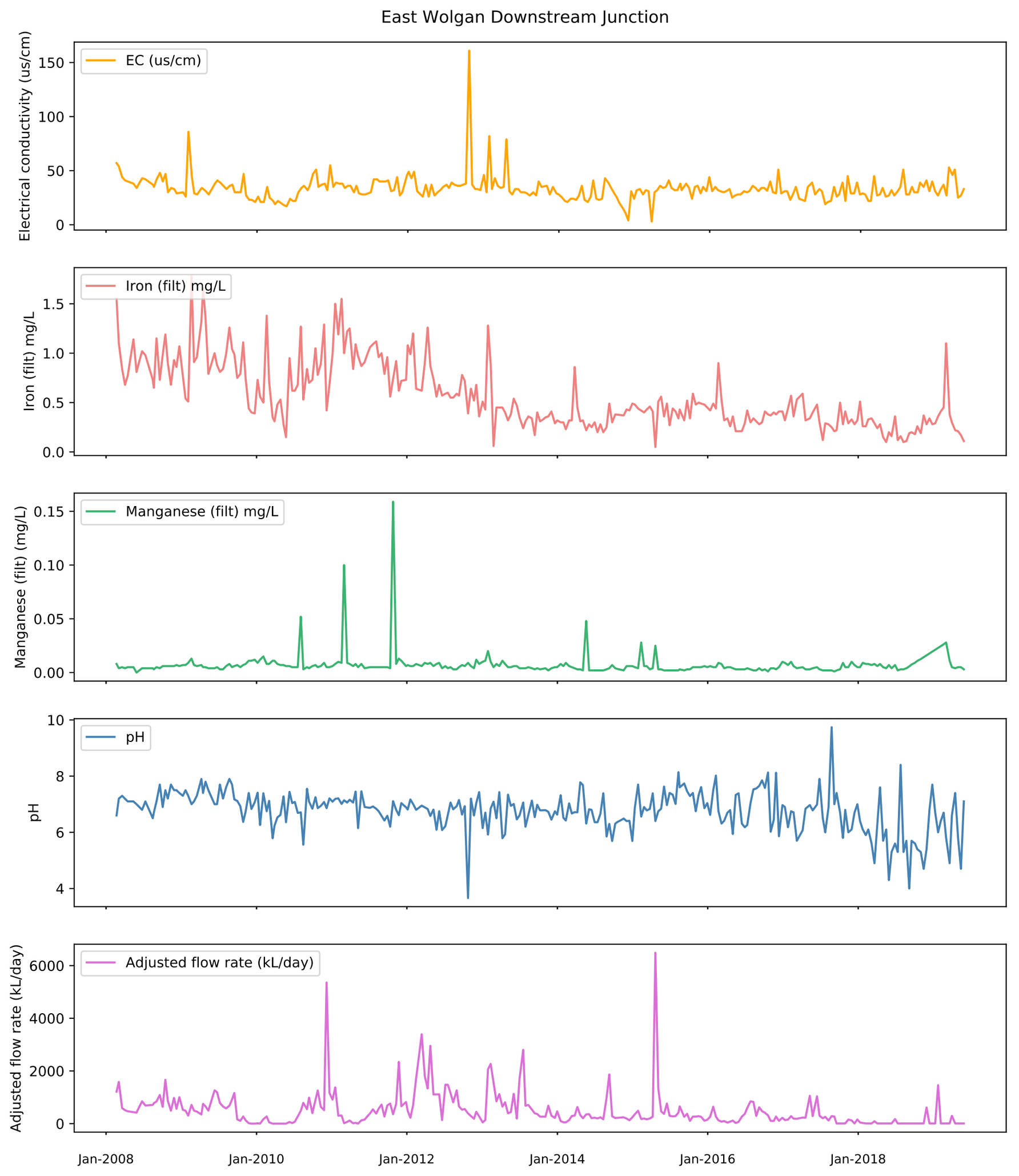
Licence and Approval							Approval Details				Work Details			
WAL Number	Licence Category and Entitlement	Approval ID	Lot	DP	Location	Comments	Kind of Approval	Issue Date	Expiry Date	Status	Work Type	Description	Number of Works	Status
25774	Unregulated River 1 (units or ML)	10WA102993	8	252472	Pipers Flat Creek, approximately 1.8km north to Lake Wallace	11km south-west to longwall 1002	Water Supply Works	1-Jul-11	10-Mar-26	Current	Diversion Works - Pumps	Pumping Plant	1	Active
25689	Domestic and Stock 2 (units or ML)	10WA103090	1	917251	Farmers Creek within Corney Town	13.5km south to longwall 1002	Water Supply Works	1-Jul-11	30-Jun-24	Current	Diversion Works - Pumps	25mm Centrifugal Pump	1	Active
25599	Unregulated River 2 (units or ML)	10WA103119	1	183968 184062	Marrangaroo creek, approximately 3km south-east to Lake Wallace	11.5km south-west to longwall 1002	Water Supply Works	1-Jul-11	28-May-25	Current	Diversion Works - Pumps	80mm Centrifugal Pump	2	Active
											Storages	Overshot Dam	2	Active
25607	Unregulated River 10 (units or ML)	10CA103248	2	574754	Coxs River, 250m downstream of junction with Sawyers Swamp Creek	10.5km west to longwall 1002	Water Supply Works and Water Use	1-Jul-11	30-Jun-24	Current	Diversion Works - Pumps	50mm Centrifugal Pump	1	Active
25622	Domestic and Stock 1 (units or ML)	10WA103362	1	173596	-	Approval expried, not included in the shapefile	Water Supply Works	1-Jul-11	23-Mar-15	Expired	Diversion Works - Pumps	38mm Centrifugal Pump	1	Active
35528	Domestic and Stock [Town Water Supply]	10CA117953	423	1152284	Farmers Creek, approximately	11lm south to longwall 1002	Water Supply	5-Oct-12	4-Oct-22	Current	Diversion Works - Other	450mm Diversion Pipe	1	Active

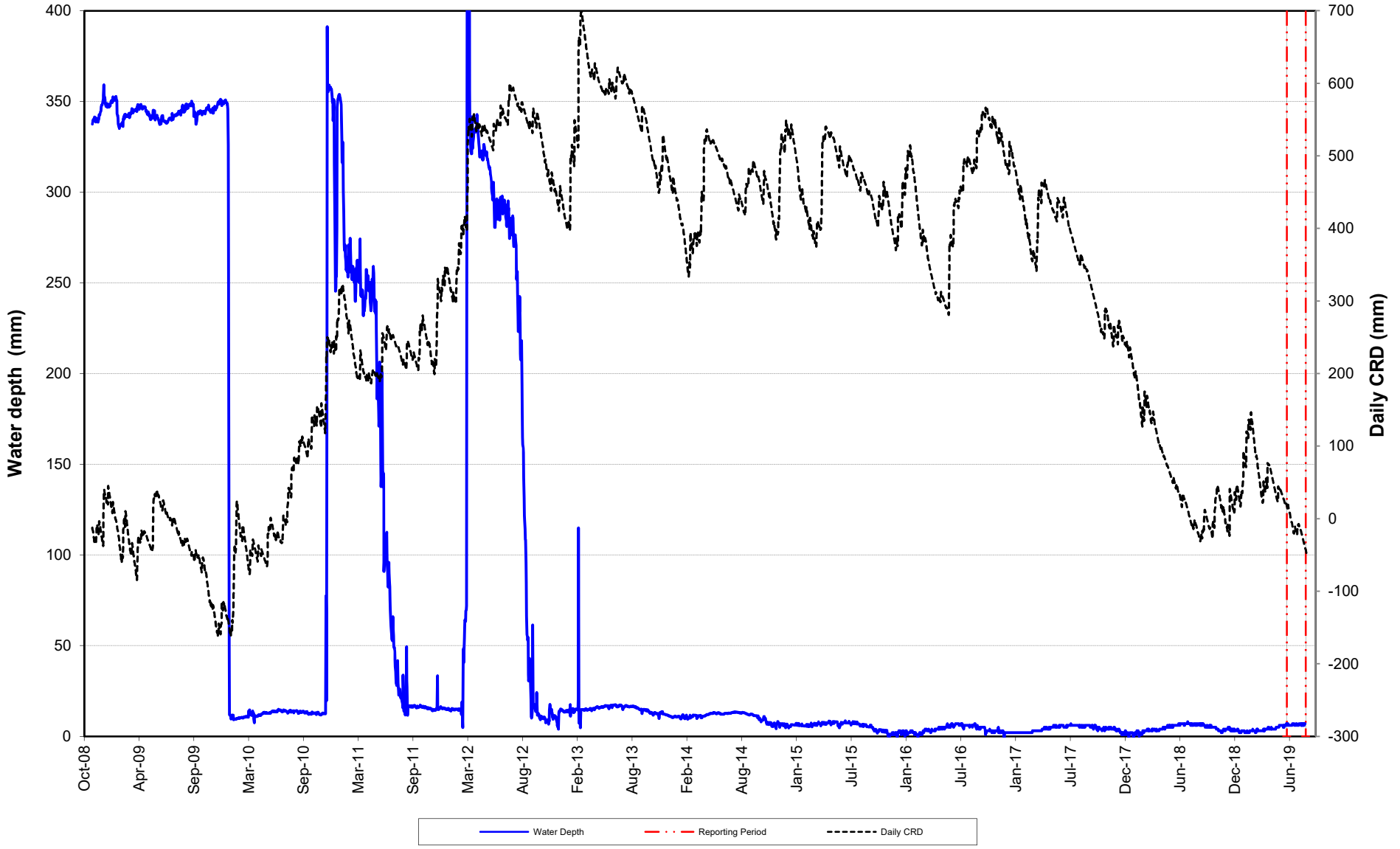
Licence and Approval							Approval Details				Work Details			
WAL Number	Licence Category and Entitlement	Approval ID	Lot	DP	Location	Comments	Kind of Approval	Issue Date	Expiry Date	Status	Work Type	Description	Number of Works	Status
	1500 (units or ML)				3km upstream of Corney Town		Works and Water Use				Storages	Overshot Dam	1	Active
27428	Major Utility [Power Generation] 25000 (units or ML)	10CA117220			Lake Lyell	21km south-west to longwall 1002	Water Supply Works and Water Use	1-Jul-11	30-Jun-31	Current	Storages	Lake Lyell	1	Active
					Lake Wallace	12.5km south-west to longwall 1002					Storages	Lake Wallace	1	Active
					Thompsons Creek Dam	20km south-west to longwall 1002					Storages	Thompson Creek Dam	1	Active
26416	Unregulated River 5 (units or ML)	10WA104990	47/50	751655	Paddy's Creek, 1km upstream of Paddy's Creek Swamp	8km south to longwall 1002	Water Supply Works	1-Jul-11	27-Nov-25	Current	Diversion Works - Pumps	Pumping Plant	1	Active
			50	751655							Storages	Excavation	1	Active
			47	751655							Storages	Excavation	1	Active
27080	Unregulated River 10 (units or ML)	10CA116483	10	1238614	Thompsons Creek, 1.5km upstream of Thompsons Creek Dam	22km south-west to longwall 1002	Water Supply Works and Water Use	1-Jul-11	30-Jun-24	Current	Diversion Works - Pumps	100mm Centrifugal Pump	1	Active

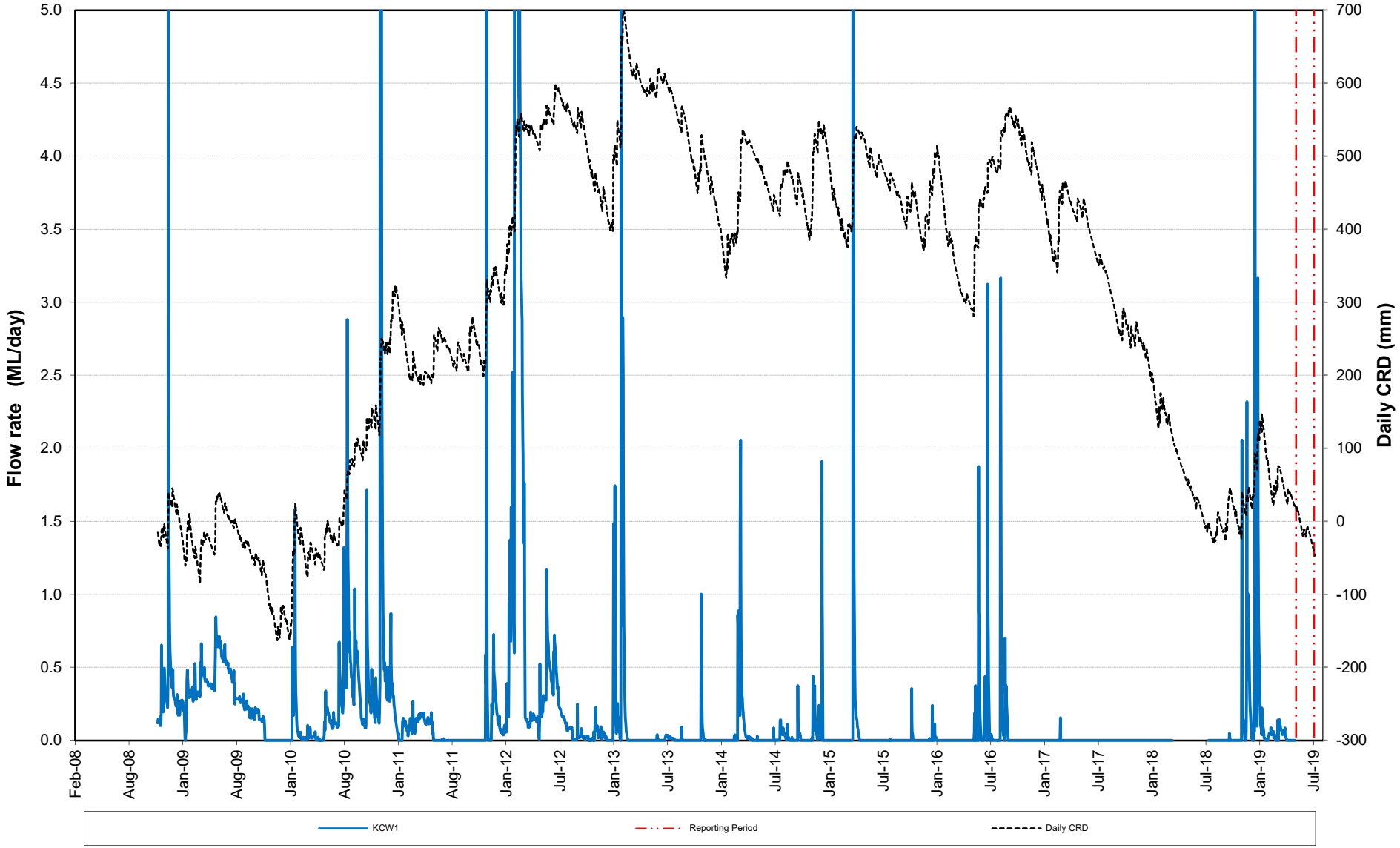
Appendix B. Flow and Water Quality Plots


Wolgan River Downstream
EC (us/cm)
Electrical conductivity (us/cm)
0
200
400
600
Iron (filt) mg/L
Iron (filt) mg/L
0.0
0.5
1.0
Manganese (filt) mg/L
Manganese (filt) (mg/L)
0.00
0.02
0.04
0.06
0.08
pH
pH
5
6
7
8
9
Adjusted flow rate (kL/day)
Adjusted flow rate (kL/day)
0
10000
20000
30000
Jan-2008
Jan-2010
Jan-2012
Jan-2014
Jan-2016
Jan-2018


Wolgan River Upstream
EC (us/cm)
Electrical conductivity (us/cm)
70
60
50
40
30
Iron (filt) mg/L
Iron (filt) mg/L
1.50
1.25
1.00
0.75
0.50
0.25
Manganese (filt) mg/L
Manganese (filt) (mg/L)
0.012
0.010
0.008
0.006
0.004
pH
pH
8.0
7.5
7.0
6.5
6.0
5.5
Adjusted flow rate (kL/day)
Adjusted flow rate (kL/day)
3000
2000
1000
0
Jan-2010
Jul-2010
Jan-2011
Jul-2011
Jan-2012
Jul-2012
Jan-2013
Jul-2013


East Wolgan Downstream Junction
EC (us/cm)
Electrical conductivity (us/cm)
0
50
100
150
Iron (filt) mg/L
Iron (filt) mg/L
0.0
0.5
1.0
1.5
Manganese (filt) mg/L
Manganese (filt) (mg/L)
0.00
0.05
0.10
0.15
pH
pH
4
6
8
10
Adjusted flow rate (kL/day)
Adjusted flow rate (kL/day)
0
2000
4000
6000
Jan-2008
Jan-2010
Jan-2012
Jan-2014
Jan-2016
Jan-2018


Water depth (mm)
Daily CRD (mm)
400
350
300
250
200
150
100
50
0
700
600
500
400
300
200
100
0
-100
-200
-300
Oct-08
Apr-09
Sep-09
Mar-10
Sep-10
Mar-11
Sep-11
Mar-12
Aug-12
Feb-13
Aug-13
Feb-14
Aug-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Dec-17
Jun-18
Dec-18
Jun-19
Water Depth
Reporting Period
Daily CRD



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KCW1 Flow Rate - Appendix B

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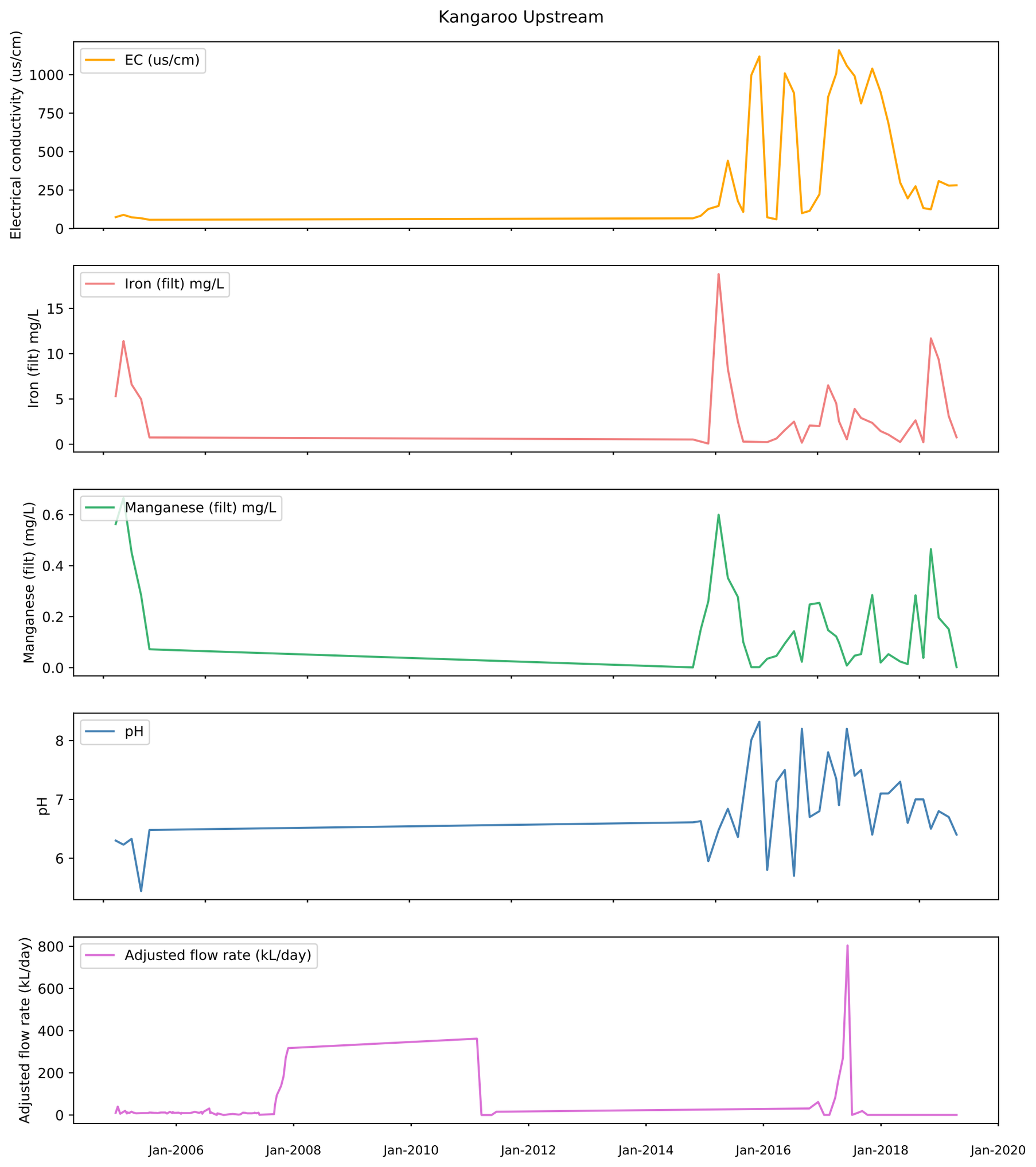
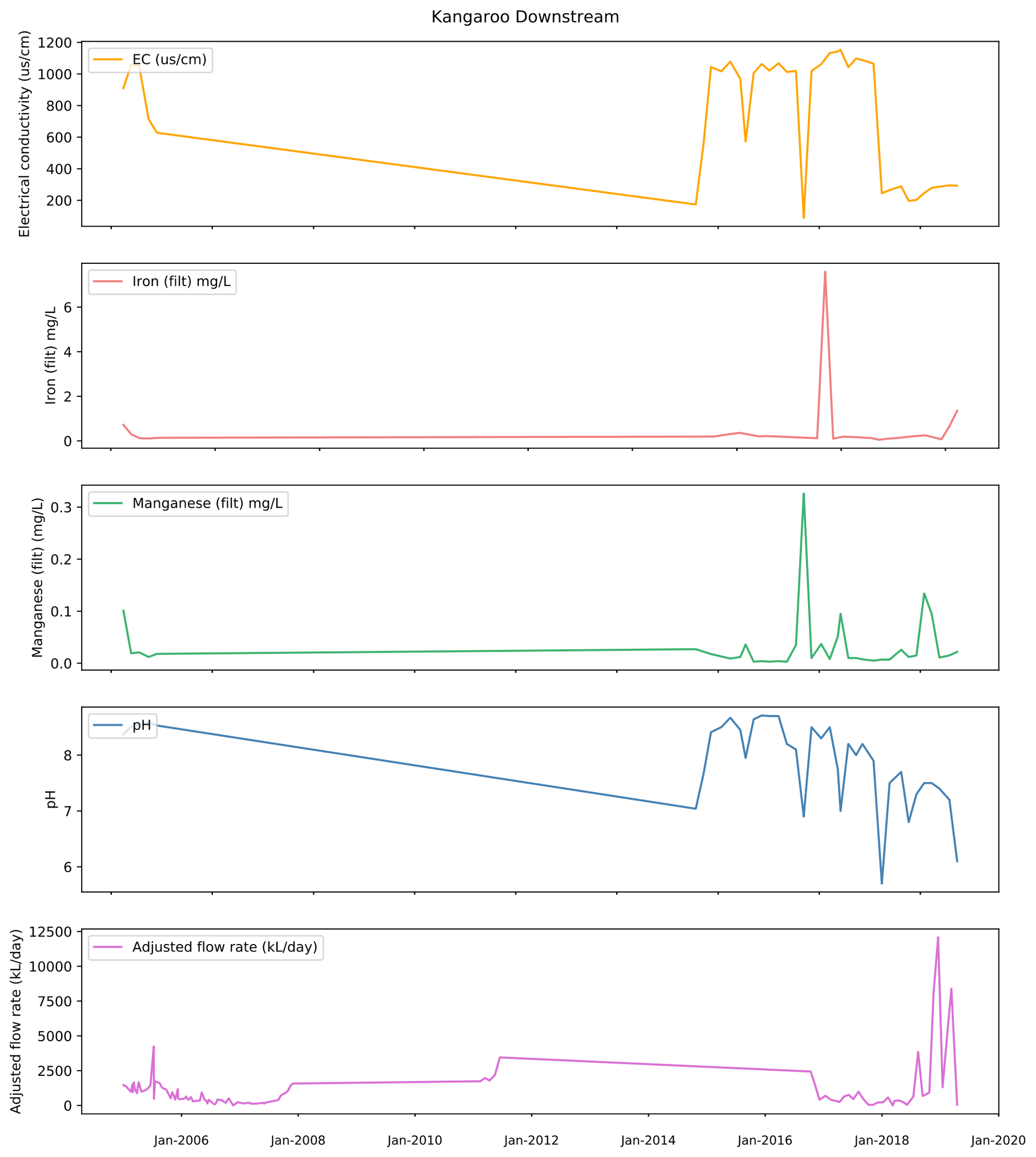

Kangaroo Upstream
EC (us/cm)
Electrical conductivity (us/cm)
0
250
500
750
1000
Iron (filt) mg/L
0
5
10
15
Manganese (filt) mg/L
0.0
0.2
0.4
0.6
pH
6
7
8
Adjusted flow rate (kL/day)
0
200
400
600
800
Jan-2006
Jan-2008
Jan-2010
Jan-2012
Jan-2014
Jan-2016
Jan-2018
Jan-2020


Kangaroo Downstream
Electrical conductivity (us/cm)
EC (us/cm)
1200
1000
800
600
400
200
Iron (filt) mg/L
Iron (filt) mg/L
6
4
2
0
Manganese (filt) (mg/L)
Manganese (filt) mg/L
0.3
0.2
0.1
0.0
pH
pH
8
7
6
Adjusted flow rate (kL/day)
Adjusted flow rate (kL/day)
12500
10000
7500
5000
2500
0
Jan-2006
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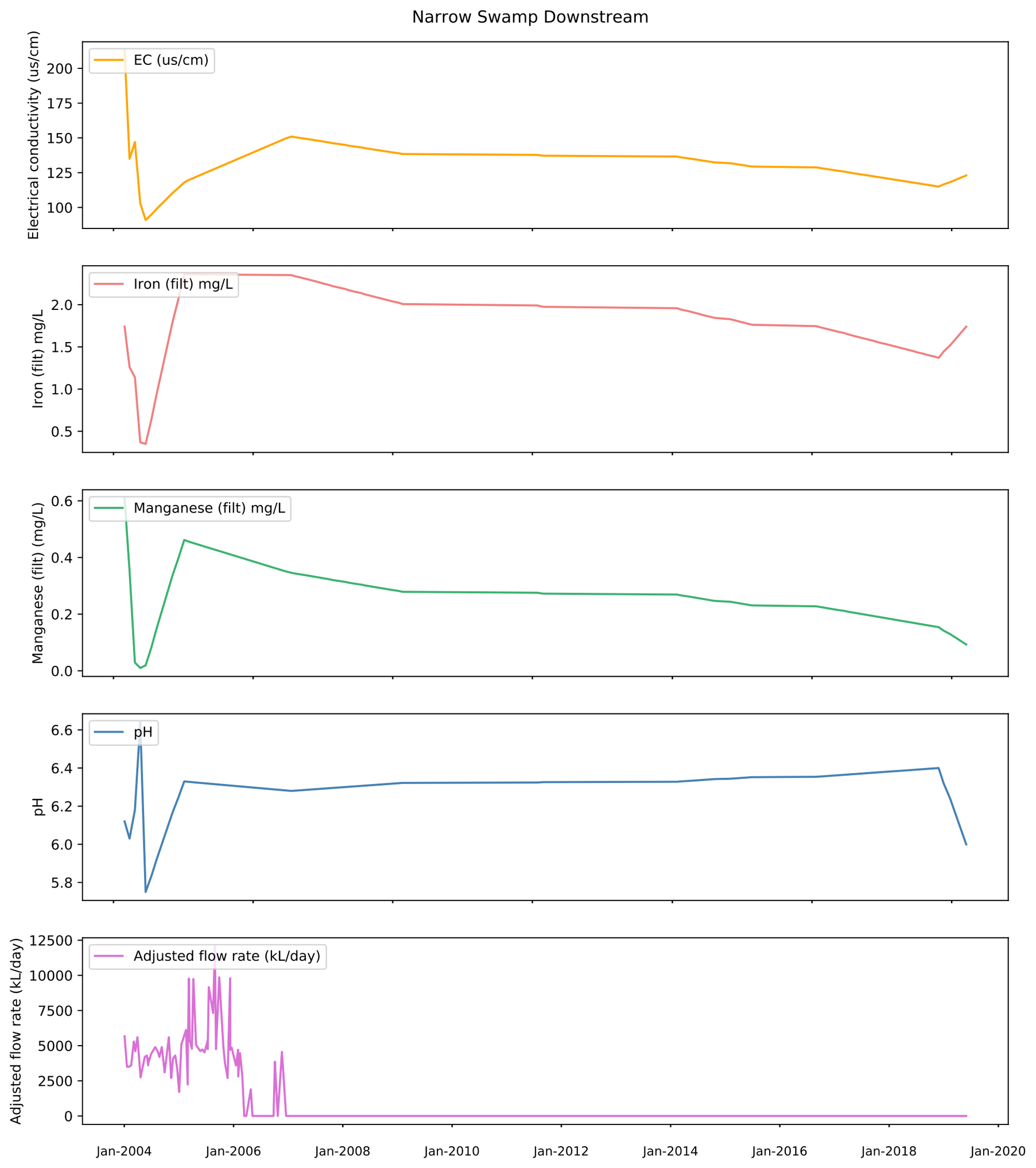
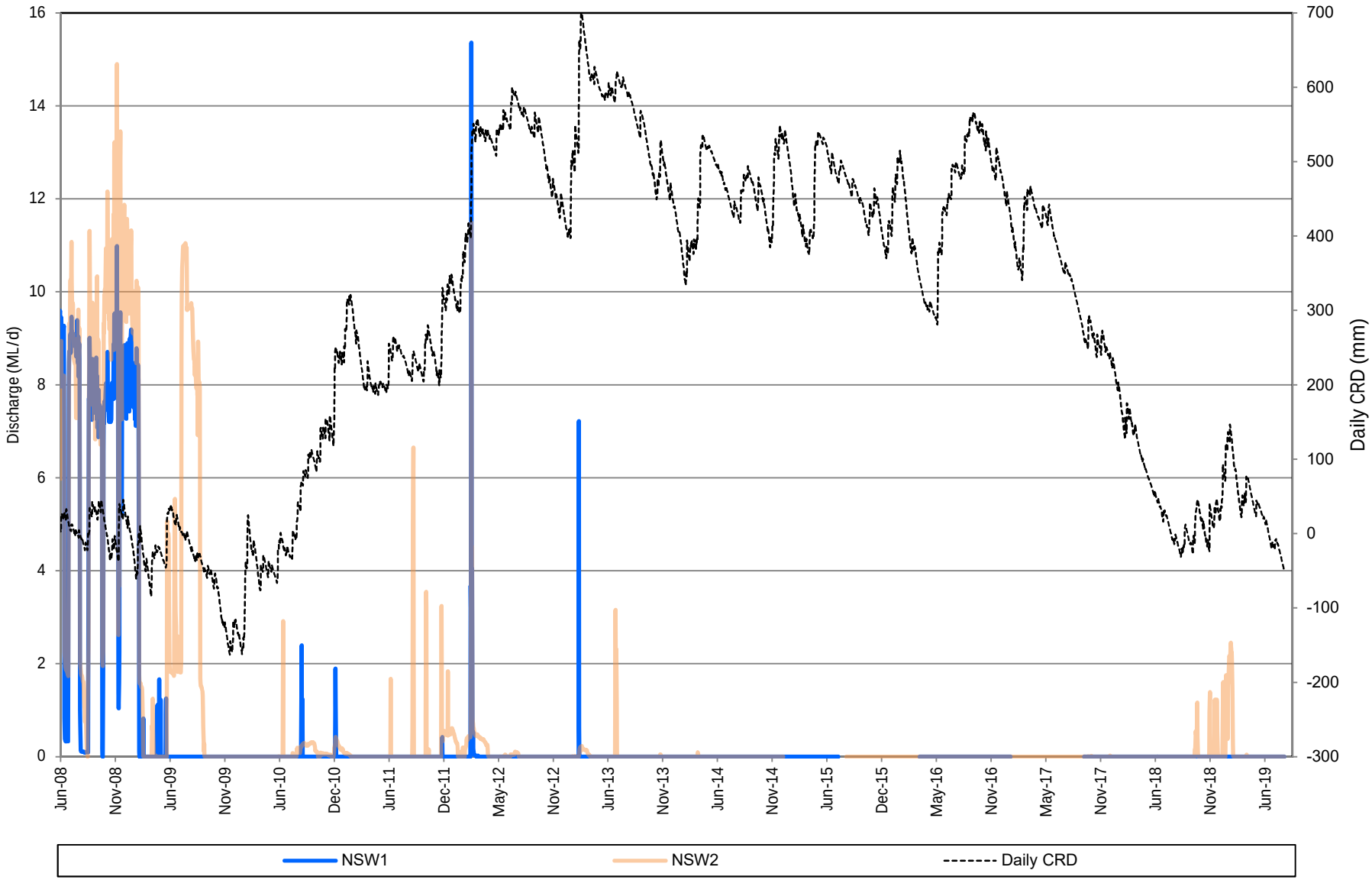
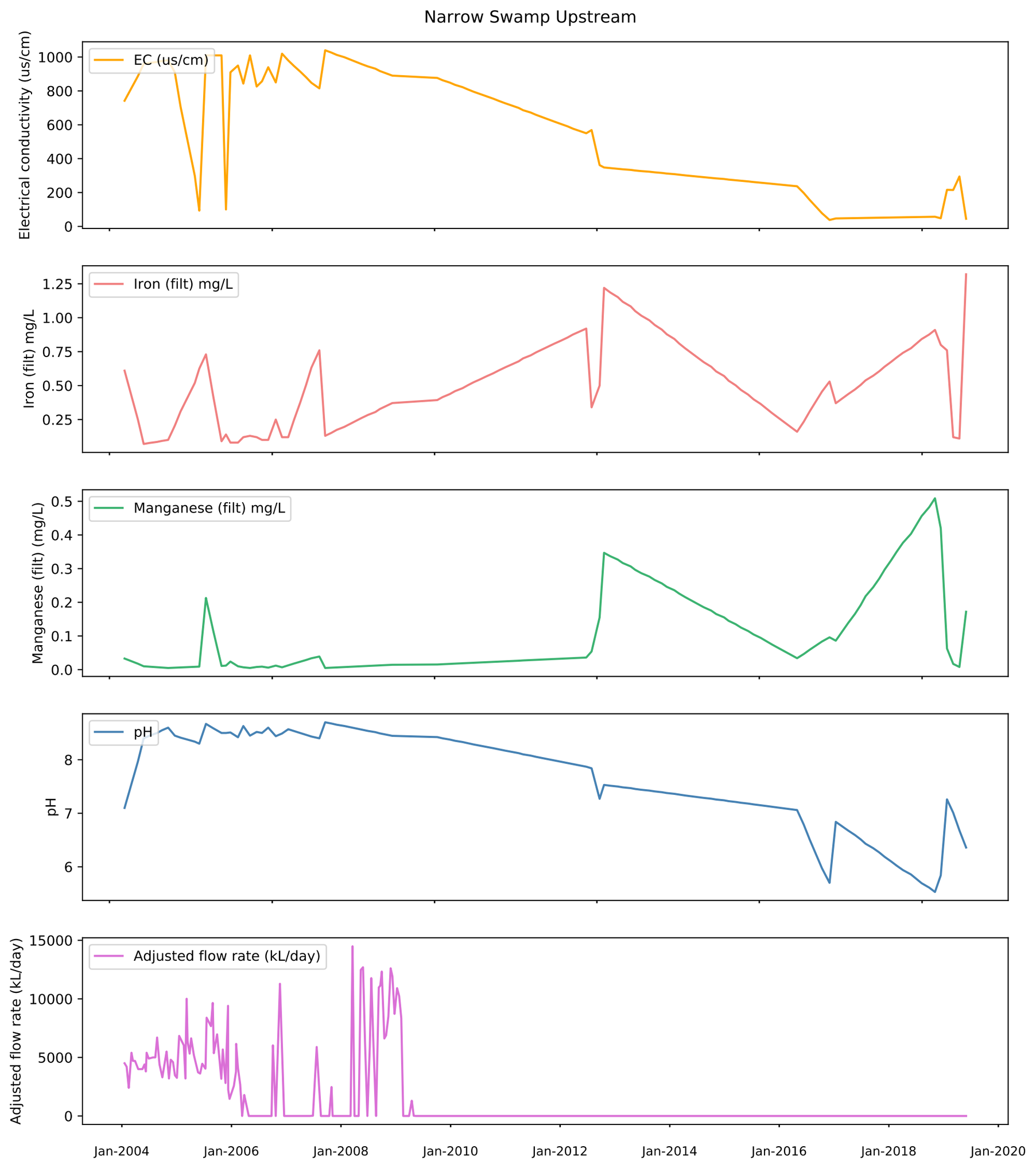
Jan-2010
Jan-2012
Jan-2014
Jan-2016
Jan-2018
Jan-2020


Narrow Swamp Downstream
EC (us/cm)
Electrical conductivity (us/cm)
200
175
150
125
100
Iron (filt) mg/L
Iron (filt) mg/L
2.0
1.5
1.0
0.5
Manganese (filt) mg/L
Manganese (filt) (mg/L)
0.6
0.4
0.2
0.0
pH
pH
6.6
6.4
6.2
6.0
5.8
Adjusted flow rate (kL/day)
Adjusted flow rate (kL/day)
12500
10000
7500
5000
2500
0
Jan-2004
Jan-2006
Jan-2008
Jan-2010
Jan-2012
Jan-2014
Jan-2016
Jan-2018
Jan-2020

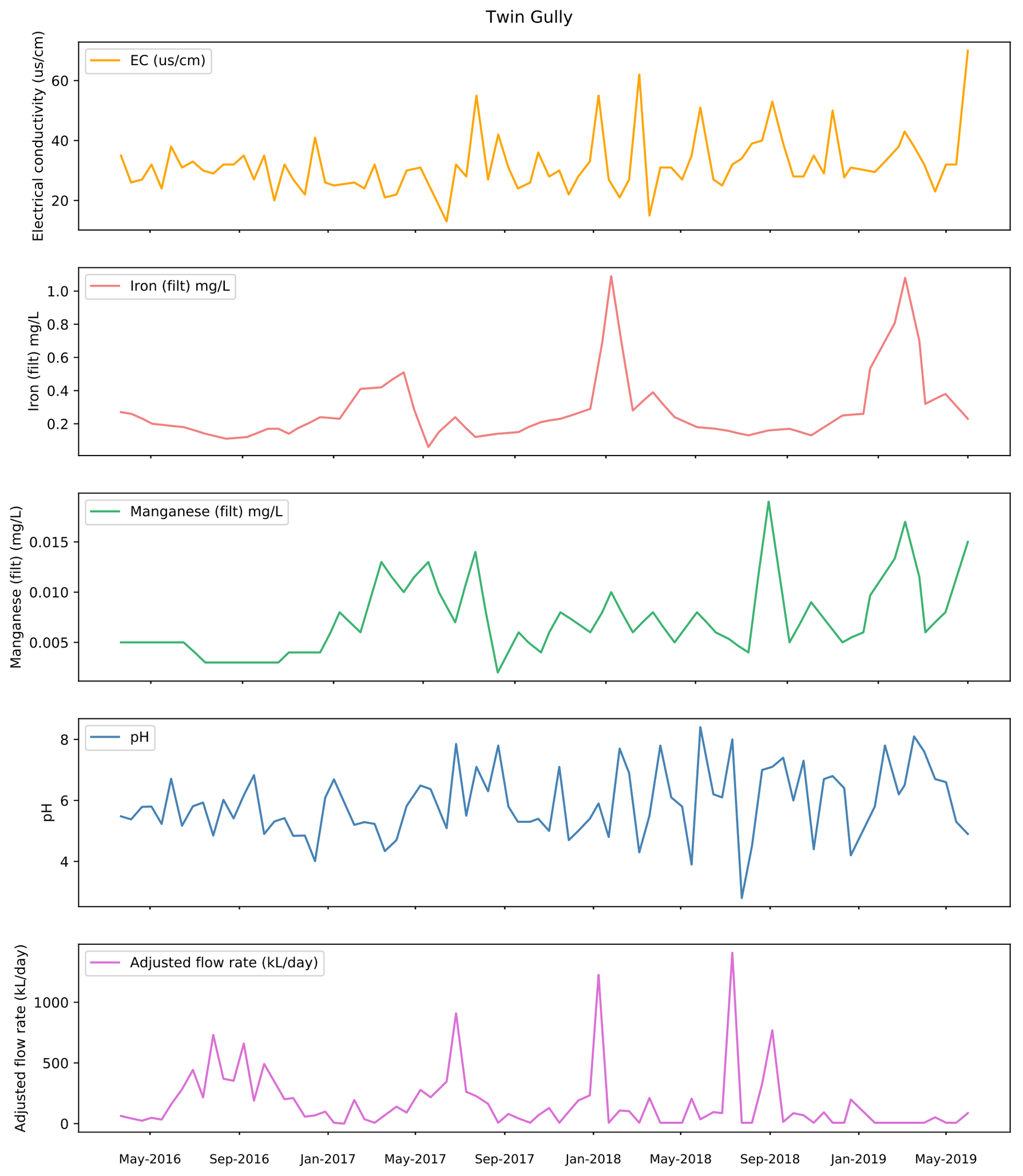

Discharge (ML/d)
Daily CRD (mm)
16
14
12
10
8
6
4
2
0
700
600
500
400
300
200
100
0
-100
-200
-300
Jun-08
Nov-08
Jun-09
Nov-09
Jun-10
Dec-10
Jun-11
Dec-11
May-12
Nov-12
Jun-13
Nov-13
Jun-14
Nov-14
Jun-15
Dec-15
May-16
Nov-16
May-17
Nov-17
Jun-18
Nov-18
Jun-19
NSW1
NSW2
Daily CRD

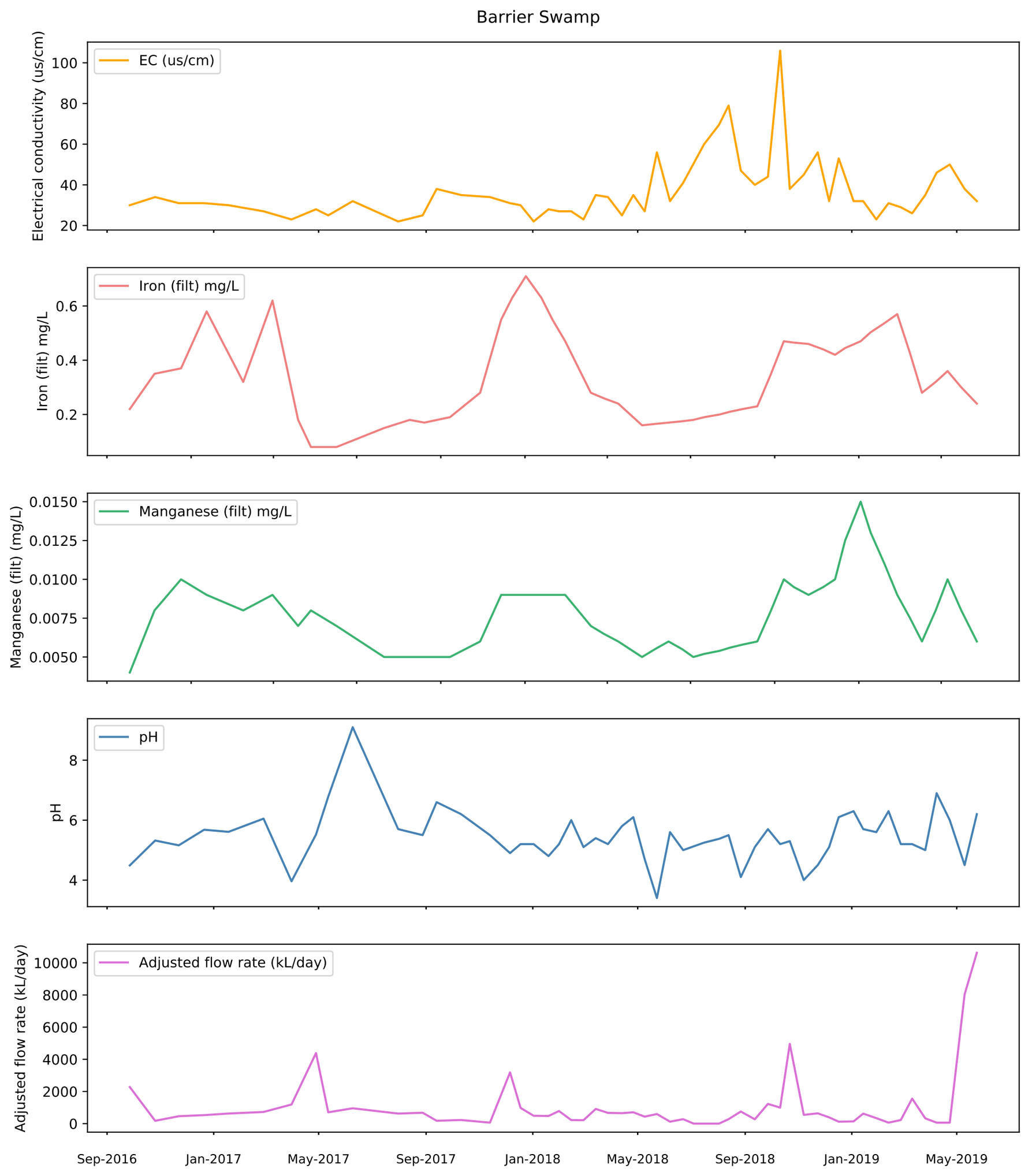

Narrow Swamp Upstream
EC (us/cm)
Electrical conductivity (us/cm)
0
200
400
600
800
1000
Iron (filt) mg/L
0.25
0.50
0.75
1.00
1.25
Manganese (filt) mg/L
0.0
0.1
0.2
0.3
0.4
0.5
pH
6
7
8
Adjusted flow rate (kL/day)
0
5000
10000
15000
Jan-2004
Jan-2006
Jan-2008
Jan-2010
Jan-2012
Jan-2014
Jan-2016
Jan-2018
Jan-2020


Tri Star Swamp
EC (us/cm)
Electrical conductivity (us/cm)
150
100
50
Iron (filt) mg/L
0.8
0.6
0.4
0.2
Manganese (filt) mg/L
0.025
0.020
0.015
0.010
0.005
pH
9
8
7
6
5
Adjusted flow rate (kL/day)
1250
1000
750
500
250
0
Jan-2011
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019

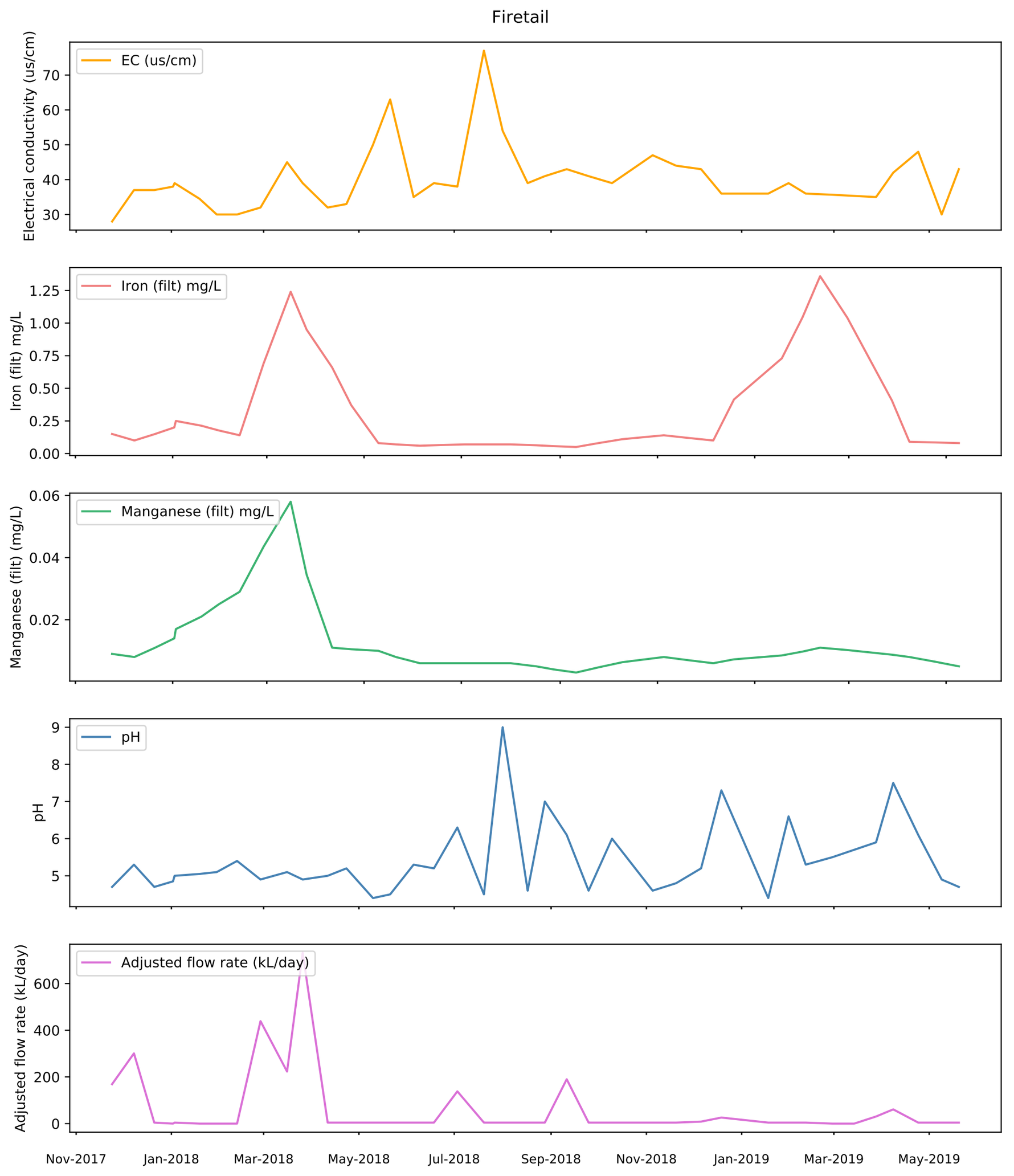

Tri Star
EC (us/cm)
Electrical conductivity (us/cm)
200
150
100
50
Iron (filt) mg/L
Iron (filt) mg/L
0.6
0.4
0.2
Manganese (filt) mg/L
Manganese (filt) (mg/L)
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
pH
pH
8
7
6
5
4
Adjusted flow rate (kL/day)
Adjusted flow rate (kL/day)
2500
2000
1500
1000
500
0
May-2016
Sep-2016
Jan-2017
May-2017
Sep-2017
Jan-2018
May-2018
Sep-2018
Jan-2019
May-2019


Twin Gully Swamp
EC (us/cm)
Electrical conductivity (us/cm)
150
100
50
Iron (filt) mg/L
0.8
0.6
0.4
0.2
Manganese (filt) mg/L
0.03
0.02
0.01
0.00
pH
8
7
6
5
4
Adjusted flow rate (kL/day)
2500
2000
1500
1000
500
0
Jan-2012
Jan-2013
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019


Twin Gully
EC (us/cm)
Electrical conductivity (us/cm)
60
40
20
Iron (filt) mg/L
Iron (filt) mg/L
1.0
0.8
0.6
0.4
0.2
Manganese (filt) mg/L
Manganese (filt) (mg/L)
0.015
0.010
0.005
pH
pH
8
6
4
Adjusted flow rate (kL/day)
Adjusted flow rate (kL/day)
1000
500
0
May-2016
Sep-2016
Jan-2017
May-2017
Sep-2017
Jan-2018
May-2018
Sep-2018
Jan-2019
May-2019


Barrier Swamp
EC (us/cm)
Electrical conductivity (us/cm)
20
40
60
80
100
Iron (filt) mg/L
0.2
0.4
0.6
Manganese (filt) mg/L
0.0050
0.0075
0.0100
0.0125
0.0150
pH
4
6
8
Adjusted flow rate (kL/day)
0
2000
4000
6000
8000
10000
Sep-2016
Jan-2017
May-2017
Sep-2017
Jan-2018
May-2018
Sep-2018
Jan-2019
May-2019


Best Creek
EC (us/cm)
Electrical conductivity (us/cm)
20
40
60
80
Iron (filt) mg/L
0.1
0.2
0.3
0.4
Manganese (filt) mg/L
0.0075
0.0100
0.0125
0.0150
0.0175
pH
4
5
6
7
8
9
Adjusted flow rate (kL/day)
0
500
1000
1500
Nov-2017
Jan-2018
Mar-2018
May-2018
Jul-2018
Sep-2018
Nov-2018
Jan-2019
Mar-2019
May-2019


Firetail
EC (us/cm)
Electrical conductivity (us/cm)
30
40
50
60
70
Iron (filt) mg/L
Iron (filt) mg/L
0.00
0.25
0.50
0.75
1.00
1.25
Manganese (filt) mg/L
Manganese (filt) (mg/L)
0.02
0.04
0.06
pH
pH
5
6
7
8
9
Adjusted flow rate (kL/day)
Adjusted flow rate (kL/day)
0
200
400
600
Nov-2017
Jan-2018
Mar-2018
May-2018
Jul-2018
Sep-2018
Nov-2018
Jan-2019
Mar-2019
May-2019

Appendix C. Water Chemistry Data

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) mg/L	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L	
Barrier Swamp	27/09/2016	High Flow	Clear		8.3	30	4.49												2273													<5								
Barrier Swamp	26/10/2016	High Flow	Clear		10.4	34	5.32	0.004	0.22										173													6								
Barrier Swamp	22/11/2016	Mod flow	Clear		15.1	31	5.16	0.008	0.35										460													<5								
Barrier Swamp	21/12/2016	Mod Flow	Clear		15.9	31	5.68	0.01	0.37										528													<5								
Barrier Swamp	18/01/2017	Mod Flow	Slightly Cloudy		20	30	5.61	0.009	0.58										627												627	55							
Barrier Swamp	11/10/2017	Mod Flow	Clear		10.2	35	6.2	0.005	0.19										224													11								
Barrier Swamp	13/11/2017	Low Flow	Clear	Too low for flow mon	10.8	34	5.5	0.006	0.28																							10								
Barrier Swamp	6/12/2017	High Flow	Clear		11.2	31	4.9	0.009	0.55	0.27	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	7.8	3188		<0.001	<1		<0.0001	<0.001	<0.01	<1		4	<1	24	14	<1	0.2	0.01	9	<0.005		
Barrier Swamp	18/12/2017	High Flow	Clear		24	30	5.2											7.3	977									368								21			
Barrier Swamp	27/02/2017	High Flow	Clear		16.4	27	6.05	0.008	0.32										724													<5								
Barrier Swamp	31/03/2017	Mod Flow	Clear		13.3	23	3.96	0.009	0.62										1188													7								
Barrier Swamp	28/04/2017	Mod Flow	Clear		11.7	28	5.52	0.007	0.18										4389													<5								
Barrier Swamp	12/05/2017	Low Flow	Clear		11.2	25	6.78	0.008	0.08										703													<5								
Barrier Swamp	9/06/2017	Low Flow	Clear		8.9	32	9.1	0.007	0.08										954													7								
Barrier Swamp	31/07/2017	Mod Flow	Clear		6.9	22	5.7	0.005	0.15										624													6								
Barrier Swamp	28/08/2017	Mod Flow	Clear		4.2	25	5.5	0.005	0.18										677													<5								
Barrier Swamp	13/09/2017	Low Flow	Clear		6.9	38	6.6	0.005	0.17										177													6								
Barrier Swamp	2/01/2018	Mod Flow	Clear		14.3	22	5.2	0.216	0.71	0.44	<0.001	<0.05	<0.0001	<1	6	<0.001	0.001	7.4	487		<0.001	<1		<0.0001	<0.001	0.03	<1	477	4	<1	70	15	<1	0.2	0.02	9.1	<0.005		
Barrier Swamp	19/01/2018	Low Flow	Clear		12.8	28	4.8												475										341								8.1			
Barrier Swamp	31/01/2018	Mod Flow	Clear		16.6	27	5.2												783										411											
Barrier Swamp	14/02/2018	Low Flow	Clear		15.3	27	6	0.009	0.47	0.17	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	6.8	220		<0.001	<1		<0.0001	<0.001	0.02	<1	210	3	<1	32	13	2	0.5	0.02		0.006		
Barrier Swamp	28/02/2018	Mod Flow	Clear		18.8	23	5.1											9	212										220								4.6			
Barrier Swamp	14/03/2018	High Flow	Clear		12.5	35	5.4	0.007	0.28	0.11	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	9.3	912		<0.001	<1		<0.0001	<0.001	0.06	<1	315	4	<1	40	16	<1	0.3	<0.01		<0.005		
Barrier Swamp	28/03/2018	Mod Flow	Clear		14.5	34	5.2											6.8	669										245								6.4			
Barrier Swamp	13/04/2018	Mod Flow	Clear		10.7	25	5.8	0.006	0.24	0.08	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	7.9	650		<0.001	<1		<0.0001	<0.001	0.06	<1	210	3	3	14	10	1	0.2	0.02		<0.005		
Barrier Swamp	26/04/2018	High flow	Clear		12.2	35	6.1											8.1	705										373								4.6			
Barrier Swamp	9/05/2018	Mod Flow	Clear		5.9	27	4.7	0.005	0.16	0.06	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	9.8	433		<0.001	<1		<0.0001	<0.001	0.04	<1	355	4	<1	20	<5	<1	0.4	<0.01		<0.005		
Barrier Swamp	23/05/2018	Mod Flow	Clear		6	56	3.4											10.5	596										335								1.7			
Barrier Swamp	7/06/2018	Mod Flow	Clear		7.1	32	5.6	0.006	0.17	0.08	<0.001	<0.05	<0.0001	<1	6	<0.001	0.002	9	120		<0.001	<1		<0.0001	<0.001	0.04	<1	473	4	<1	35	26	5	0.2	0.02		0.007		
Barrier Swamp	22/06/2018	Mod Flow	Clear		2.9	41	5											9.4	276.48										319								2.3			
Barrier Swamp	4/07/2018			Dry				0.005	0.18	0.1	<0.001	<0.05	<0.0001	<1	8	<0.001	<0.001				<0.001	<1		<0.0001	<0.001	0.05	<1		3	<1			<1	0.2	0.02		<0.005		
Barrier Swamp	16/07/2018			Dry																																			
Barrier Swamp	2/08/2018			Dry																																			
Barrier Swamp	13/08/2018	Mod Flow	Clear		5.3	79	5.5											9.4	276.48										366								3.2			
Barrier Swamp	27/08/2018	Mod Flow	Clear		4.1	47	4.1											8.7	752										334								4.6			
Barrier Swamp	12/09/2018	Mod flow	Clear		6.8	40	5.1	0.006	0.23	0.09	<0.001	<0.05	<0.0001	<1	8	<0.001	0.001	8.8	267.84	<0.1	<0.001	<1		<0.0001	<0.001	0.07	2	377	4	2	32	<5	<1	0.5	0.1	4.5	0.012		
Barrier Swamp	27/09/2018	Mod Flow	Clear		5.5	44	5.7											8.5	1226										555								2.6			
Barrier Swamp	11/10/2018	High Flow	Clear		6.2	106	5.2		0.47	0.28	<0.001	<0.05	<0.0001	<1	7	<0.001	<0.001	8.1	994	<0.1	<0.001	<1		<0.0001	<0.001	<0.01	<1	437	4	2	49	5		0.2	<0.01	4.7	<0.005		
Barrier Swamp	22/10/2018	Mod Flow	Clear		10.4	38	5.3											7.8	4959										460								3			
Barrier Swamp	7/11/2018	Mod Flow	Clear		12	45	4		0.46	0.17	<0.001	<0.05	<0.0001	<1	8	<0.001	0.002	10.4	544	<0.1	<0.001	<1		<0.0001	<0.001	0.03	<1	375	5	<1	38	12		0.3	<0.01	8.3	0.013		
Barrier Swamp	23/11/2018	Mod flow	Clear		8.7	56	4.5											7	639										500								6			
Barrier Swamp	6/12/2018	Mod flow	Clear		11.6	32	5.1		0.42	0.2	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	7.2	388	<0.1	<0.001	<1		<0.0001	<0.001	0.04	<1	370	4	<1	47	10		0.2	<0.01	4.6	<0.005		
Barrier Swamp	17/12/2018	Mod flow	Clear	Depth too low to reco	13.1	53	6.1											7.1	120										489								4.9			
Barrier Swamp	3/01/2019	Low flow	Clear		18.6	32	6.3		0.47	0.13	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	5.1	138	<0.1	<0.001	<1		<0.0001	<0.001	<0.01	<1	301	4	<1	56	10		0.1	<0.01	2.1	<0.005		
Barrier Swamp	14/01/2019	Mod flow	Clear		15.4	32	5.7											5.7	622										357								5.1			
Barrier Swamp	29/01/2019	Low Flow	Clear		20.1	23	5.6											5.2											326								2.8			
Barrier Swamp	12/02/2019	Mod flow	Clear	Depth too low to reco	13	31	6.3		0.57	0.2	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	6.5		<0.1	<0.001	<1		<0.0001	<0.001	<0.01	<1	395	4	<1	46	<5		0.3	0.03	4.9	0.006		
Barrier Swamp	26/02/2019	Mod flow	Clear	Depth too low to reco	12.2	29	5.2											18	224										385								13			
Barrier Swamp	11/03/2019	Low flow	Clear		12.3	26	5.2		0.28	0.1	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	109	1555	<0.1	<0.001	<1		<0.0001	<0.001	0.03	<1	360	3	<1	18	<5		0.3	0.02	3.6	<0.005		
Barrier Swamp	26/03/2019	Low Flow	Clear		14.5	35	5											7.8	328										139								2.4			
Barrier Swamp	8/04/2019	Mod flow	Clear	Depth too low for flo	12.4	46	6.9		0.36	0.12	<0.001	<0.05	<0.0001	<1	8	<0.001	0.002	5.5		<0.1	0.001	<1		<0.0001	0.002	0.02	<1	380	5	4	37	<5		0.4	0.02	4	0.035		
Barrier Swamp	23/04/2019	Low flow	Clear	Depth too low for flo	13.2	50	6											7											503								2.5			
Barrier Swamp	10/05/2019	Low Flow	Clear		7.5	38	4.5		0.24	0.08	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	8.8	8035	<0.1	<0.001	<1		<0.0001	<0.001	0.06	<1	421	3	<1	26	<5		0.2	0.01	3.2	0.005		
Barrier Swamp	24/05/2019	Low flow	Clear		7.9	32	6.2											8.6	10627										291								5.1			
Best Creek	24/11/2017	Low Flow	Clear		11.9	23	4.8	0.012	0.13										586													9								
Best Creek	8/12/2017	Mod Flow	Clear		12.6	32	5.3	0.008	0.13	0.1	<0.001	<0.05	<0.0001	<1	7	<0.001	<0.001	8.3	729		<0.001	<1		<0.0001	<0.001	<0.01	<1	283	3	<1	36	<5	<1	0.2	0.05	2.8	<0.005		
Best Creek	21/12/2017	Mod Flow	Clear		12.9	34	4.6											6.8	465										431								3.2			
Best Creek	3/01/2018	Mod Flow	Clear		13.6	38	6.2	0.01	0.16	0.12	<0.001	<0.05	<0.0001	<1	7	<0.001	<0.001	7.4	232		<0.001	<1		<0.0001	<0.001	<0.01	<1	420	4	<1	38	8	3	0.9	0.02	2.7	<0.005		
Best Creek	19/01/2018	Low Flow	Clear		15.1	25	4.3												92										253								5.9			
Best Creek	30/01/2018	Mod Flow	Clear		17.4	24	5.6											6.5	306										260								3.62			
Best Creek	16/03/2018	Mod Flow	Clear		13.6	33	5	0.01	0.16	0.1	<0.001	<0.05	<0.0001	<1	7	0.002	<0.001	8	347		<0.001	<1		<0.0001	<0.001	<0.01	<1	219	4	<1	31		<1	<0.1	<0.01	3.5	<0.005		
Best Creek	26/03/2018	Mod Flow	Clear		12.9	32	5											8	591										256								3.5			
Best Creek	11/04/2018	Mod Flow	Clear		18.7	32	4.7	0.009	0.09	0.09	<0.001	<0.05	<0.0001	<1	7	<0.001	<0.001	7.3	450		<0.001	<1		<0.0001	<0.001	0.03	<1	377	3	<1	<10	11	<1	0.2	<0.01		<0.005		
Best Creek	23/04/2018	Low Flow	Clear		13	29	4.9											7	181										491								0.5			
Best Creek	10/05/2018	Low flow	Clear		7.1	43	4.9	0.011	0.17	0.05	<0.001	<0.05	<0.0001	<1	9	<0.001	<0.001	7	314		<0.001	<1		<0.0001	0.002	0.05	<1	414	4	<1			<1	0.4	0.05		0.009		
Best Creek	21/05/2018	Mod Flow	Clear		7.1	36	4.1											8.6	315										223								1.4			
Best Creek	5/06/2018	Mod Flow	Clear		6.4	34	5	0.007	0.05	0.04	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	9.9	23		<0.001	<1		<0.0001	<0.001	0.03	<1	327	4	<1	12	<5	1	<0.1	<0.01		<0.005		
Best Creek	18/06/2018	Mod flow	Clear		8.1	38	5.5											9.2	414.72										357								1.4			
Best Creek	3/07/2018	Mod Flow	Clear		7.1	34	6.3	0.011	0.12	0.11	<0.001	<0.05	<0.0001	<1	7	<0.001	<0.001	8.5	777.6		<0.001	<1		<0.0001	<0.001	0.03	<1	389	4	<1	17	<5	<1	0.2	<0.01		0.011		
Best Creek	20/07/2018	Mod flow	Clear		3	69	4.9											8.4	1857.6										275								4.6			
Best Creek	1/08/2018	Mod Flow	Clear		4.4	38	8.8	0.009	0.09	0.07	<0.001	<0.05	<0.0001	<1	7	<0.001	<0.001	8.7	280		<0.001	<1		<0.0001	0.001	0.01	<1	321	4	<1	33	<5	<1	0.6	0.03		0.011		
Best Creek	17/08/2018	Mod Flow	Clear		5.9	41	4											8.9	302.4										437								1.9			
Best Creek	28/08/2018	Mod Flow	Clear		5.8	39	6.5											8.2	717										252								2.4			
Best Creek	11/09/2018	Mod Flow	Clear		7.4	74	6.3	0.009	0.08	0.1	<0.001	<0.05	<0.0001	<1	7	<0.001	<0.001	9.2	656.64	<0.1	<0.001	<1		<0.0001	<0.001	<0.01	<1	315	4	<1	12	6	<1	<0.1	<0.01	2.9	<0.005		
Best Creek	25/09/2018	Mod Flow	Clear		5.2	39	4.1											8.87	311										427								3.8			
Best Creek	10/10/2018	Low Flow	Clear	Depth too low for flo	8.7	39	5.7											7.6											354								23			
Best Creek	5/11/2018	Low Flow	Clear	Depth too low for flo	12	37	4.3		0.2	0.17	<0.001	<0.05	<0.0001	<1	11	<0.001	0.001	5.9		<0.1	<0.001	<1		<0.0001	0.001	<0.01	<1	380	5	<1	34	6		0.4	0.02	1.6	0.016		
Best Creek	20/11/2018	Low flow	Clear	Depth too low to reco	14.2	38	4.5											6											422								3.2			
Best Creek	6/12/2018	Mod flow	Clear		10.9	51	5		0.41	0.19	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	7.1	414	<0.1	<0.001	<1		<0.0001	<0.001	0.02	<1	333	4	8	53	<5		0.2	<0.01	1.7	0.005		
Best Creek	19/12/2018	Mod flow	Clear	Redox meter malfunc	17	47	5.9											7.4	457.92										1.1											
Best Creek	2/01/2018	Low flow	Clear		21.3	36.5	5.2		0.45	0.12	0.002	<0.05	<0.0001	<1	6	<0.001	<0.001	6.1	8	<0.1	<0.001	<1		<0.0001	0.001	0.02	<1	383	3	<1	14	44		<0.1	0.01	3	<0.005		
Best Creek	18/01/2019	Mod flow	Clear		22	28	4.4											6	241										311								2.5			
Best Creek	31/01/2019	Mod Flow	Clear	Depth too low to reco	17.9	81	5.1											4.9											469								23			
Best Creek	11/02/2019	Low flow		Depth too low to reco	14.6	33	5.1		0.24	0.17	<0.001	<0.05	<0.0001	<1	7	<0.001	<0.001	65		<0.1	<0.001	<1		<0.0001	<0.001	0.01	<1	334	3	<1	38	46		<0.1	0.05	2.9	<0.005		

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) mg/L	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
Best Creek	28/02/2019	Mod flow	Clear		14.4	32	5.8											6.9	276									240								21		
Best Creek	14/03/2019	Low flow	Slightly Cloudy	Depth too low to reco	16.3	37	5		0.16	0.12	<0.001	<0.05	<0.0001	<1	9	<0.001	<0.001	3.6		<0.1	<0.001	<1		<0.0001	<0.001	<0.01	<1	300	6	<1	22	87		1.2	<0.01	10.5	<0.005	
Best Creek	28/03/2019	Mod flow	Clear		13.5	36	5.9											8.8	501									243								1.6		
Best Creek	8/04/2019	Mod flow	Clear		11.5	52	7.9		0.15	0.13	<0.001	<0.05	<0.0001	<1	8	<0.001	<0.001	6.9	273	<0.1	<0.001	<1		<0.0001	<0.001	0.04	<1	378	4	1	29	4		<0.1	0.01	1.4	<0.005	
Best Creek	24/04/2019	Low flow	Clear		12.3	29	6.1											15.8	691									441								1.6		
Best Creek	9/05/2019	Low Flow	Clear		12.8	30	5		0.1	0.08	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	8.5	269	<0.1	<0.001	<1		<0.0001	<0.001	<0.01	<1	299	4	<1	22	6		<0.1	<0.01	0.9	<0.005	
Best Creek	20/05/2019	Low flow	Slightly cloudy		10.4	58	5.9											7.4	302									398			27	41				10.6		
Best Creek	12/02/2018	Mod Flow	Clear		17.8	23	5.4	0.01	0.15	0.1	<0.001	<0.05	<0.0001	<1	7	<0.001	<0.001	7.7	318		<0.001	<1		<0.0001	<0.001	0.01	<1	302	4	<1	23	7	<1	0.1	<0.01		<0.005	
Best Creek	27/02/2018	Mod Flow	Clear		12.3	45	4.2											7.3	877									234								3.7		
Downstream Wolgan River	30/01/2008				17.6	62	7.1																															
Downstream Wolgan River	4/02/2008				16	46	6.2																															
Downstream Wolgan River	15/02/2008				14.2	48	6.4																															
Downstream Wolgan River	19/02/2008				14.8	56	6.8																															
Downstream Wolgan River	26/02/2008				15.3	60	7.3																															
Downstream Wolgan River	3/03/2008				12	57	6.8																															
Downstream Wolgan River	10/03/2008				14	55	6.8																															
Downstream Wolgan River	18/03/2008				14.9	409	7.9																															
Downstream Wolgan River	26/03/2008				13.6	30	7.2																															
Downstream Wolgan River	2/04/2008				11	63	7	0.005	0.52																														
Downstream Wolgan River	8/04/2008				10.9	59	7.1																															
Downstream Wolgan River	15/04/2008				10.5	55	6.8																															
Downstream Wolgan River	23/04/2008				10.4	49	6.8																															
Downstream Wolgan River	28/04/2008				7	50	7																															
Downstream Wolgan River	28/04/2008				7	50	7																															
Downstream Wolgan River	6/05/2008				6	51	7.1																									2						
Downstream Wolgan River	13/05/2008				11.2	465	7.8																															
Downstream Wolgan River	20/05/2008				8.8	655	7.1																															
Downstream Wolgan River	28/05/2008					677	8.3																															
Downstream Wolgan River	5/06/2008				10.9	451	7.8																															
Downstream Wolgan River	11/06/2008					554	8																															
Downstream Wolgan River	17/06/2008				9	125	7.1																															
Downstream Wolgan River	24/06/2008				6.9	83	7.2																															
Downstream Wolgan River	5/06/2008				10.9	451	7.8																															
Downstream Wolgan River	11/06/2008					554	8																															
Downstream Wolgan River	17/06/2008				9	125	7.1																															
Downstream Wolgan River	24/06/2008				6.9	83	7.2																															
Downstream Wolgan River	3/07/2008				7.6	651	8.2																															
Downstream Wolgan River	8/07/2008				9.2	625	8.2																															
Downstream Wolgan River	16/07/2008				6.8	665	8.3																															
Downstream Wolgan River	22/07/2008				7.2	594	7.8																															
Downstream Wolgan River	29/07/2008				7.3	678	8.4																															
East Wolgan D/S Junction	6/07/2012					37	6.22	0.006	0.59																														
East Wolgan D/S Junction	18/07/2012					34	6.63	0.004	0.6																														
East Wolgan D/S Junction	31/07/2012					39	7.06	0.005	0.55																														
East Wolgan D/S Junction	13/08/2012					37	6.82	0.003	0.55																														
East Wolgan D/S Junction	30/08/2012					36	6.93	0.003	0.59																														
East Wolgan D/S Junction	10/09/2012				6.8	36	7.15	0.005	0.57																														
East Wolgan D/S Junction	25/09/2012				7.3	37	6.63	0.007	0.78																														
East Wolgan D/S Junction	8/10/2012				9.9	38	6.93	0.006	0.72																														
East Wolgan D/S Junction	24/10/2012				12.2	161	3.66	0.009	0.39																														
East Wolgan D/S Junction	7/11/2012				13.4	37	7.2	0.006	0.64																														
East Wolgan D/S Junction	22/11/2012				13.1	33	6.6	0.004	0.52																														
East Wolgan D/S Junction	3/12/2012				16.7	33	7.04	0.012	0.68																														
East Wolgan D/S Junction	17/12/2012				12.8	32	7.43	0.008	0.36																														
East Wolgan D/S Junction	3/01/2013				14.9	46	6.15	0.01	0.51																														
East Wolgan D/S Junction	16/01/2013				15.5	30	6.7	0.011	0.43																														
East Wolgan D/S Junction	29/01/2013				18	82	5.92	0.02	1.28																														
East Wolgan D/S Junction	11/02/2013				16.2	33	6.85	0.01	0.89																														
East Wolgan D/S Junction	25/02/2013				16.1	43	7.09	0.005	0.06																														
East Wolgan D/S Junction	11/03/2013				14.4	36	6.5	0.008	0.45																														
East Wolgan D/S Junction	25/03/2013				17.8	34	7.43																														
East Wolgan D/S Junction	9/04/2013				13.1	35	5.79	0.011	0.45																														
East Wolgan D/S Junction	22/04/2013				10.7	79	5.93	0.176	0.4																														
East Wolgan D/S Junction	6/05/2013				8.8	31	7.34	0.005	0.32																														
East Wolgan D/S Junction	20/05/2013				8.3	28	6.94	0.005	0.38																														
East Wolgan D/S Junction	3/06/2013				7.7	33	7.01	0.006	0.54																														
East Wolgan D/S Junction	18/06/2013				6	33	6.46	0.006	0.47																														
East Wolgan D/S Junction	1/07/2013				7.7	30	6.6	0.004	0.35																														
East Wolgan D/S Junction	19/07/2013				9.2	30	7.06	0.004	0.24																														
East Wolgan D/S Junction	30/07/2013				5.8	29	6.2	0.004	0.31																														
East Wolgan D/S Junction	13/08/2013				6.5	27	6.63	0.005	0.36																														
East Wolgan D/S Junction	30/08/2013				9.6	30	7.13	0.004	0.34																														
East Wolgan D/S Junction	13/09/2013				8.1	27	6.54	0.003	0.17																														
East Wolgan D/S Junction	25/09/2013				12.9	40	6.98	0.004	0.4																														
East Wolgan D/S Junction	9/10/2013				12.5	35	6.78	0.003	0.31										265																			
East Wolgan D/S Junction	24/10/2013																																					
East Wolgan D/S Junction	4/11/2013				13.2	36	6.79	0.004	0.35										262																			
East Wolgan D/S Junction	18/11/2013				11.6	28	6.73	0.002	0.36										680																			
East Wolgan D/S Junction	3/12/2013				15.4	35	6.45	0.004	0.41										300																			
East Wolgan D/S Junction	20/12/2013				14.5	29	6.75	0.005	0.29										218																			
East Wolgan D/S Junction	31/12/2013				13.8	28	6.63	0.005	0.32										465																			
East Wolgan D/S Junction	17/01/2014				14.7	25	7.32	0.008	0.3										93																			
East Wolgan D/S Junction	30/01/2014				13	22	6.52	0.006	0.3	0.05				<1	5	<0.001	<0.001	8.43	52				<1			0.03	<1		4			<5					0.006	<0.005
East Wolgan D/S Junction	11/02/2014				16	21	6.42	0.009	0.23	0.03				<1	3	<0.001	0.001	8.87	46			<1				0.02	<1		5			<5	3				0.005	<0.005

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) (mg/L)	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
East Wolgan D/S Junction	27/02/2014				15	24	7.03	0.006	0.32	0.05				<1	4	<0.001	0.002	8.71	132			<1				<0.01	<1		5			<5	3				0.007	0.006
East Wolgan D/S Junction	12/03/2014				13.5	24	6.67	0.005	0.32	0.06				<1	4	<0.001	<0.001	9.6	290				<1			0.01	<1		5			<5	4				0.005	<0.005
East Wolgan D/S Junction	26/03/2014				13.7	23	6.72	0.472	0.86	0.12				1	9	<0.001	<0.001		303				<1			<0.01	8		6			<5	6				0.012	0.017
East Wolgan D/S Junction	8/04/2014				13.3	27	6.71	0.003	0.45	0.11				<1	5	0.001	<0.001	9.34	629				<1			<0.01	<1		5			<5	5				0.006	
East Wolgan D/S Junction	22/04/2014				10.3	36	7.78	0.003	0.31	0.05				<1	4	<0.001	<0.001	14.44	324				<1			<0.01	5		<1			<5	5				0.013	
East Wolgan D/S Junction	5/05/2014				7.9	23	7.68	0.002	0.32	0.05				<1	5	<0.001	<0.001	11.5	204				<1			<0.01	<1		4			<5	4				0.007	
East Wolgan D/S Junction	21/05/2014				9.25	21	6.31	0.048	0.22	0.06				<1	4	<0.001	0.002	10.3	350				<1			<0.01	<1		5			<5	4				0.007	
East Wolgan D/S Junction	4/06/2014				8.5	26	6.82	0.002	0.28	0.04				<1	5	<0.001	<0.001	11.19	361				<1			<0.01	<1		4			<10	4				<0.005	
East Wolgan D/S Junction	16/06/2014				7.1	41	6.8	0.002	0.25	0.05				<1	5	<0.001	<0.001	12.97	208				<1			<0.01	<1		4			<10	3				<0.005	
East Wolgan D/S Junction	1/07/2014				5.5	24	6.36	0.002	0.3	0.07				<1	5	<0.001	<0.001	12.55	225				<1			<0.01	<1		5			<10	3				0.006	
East Wolgan D/S Junction	15/07/2014				4.8	230	6.36	<0.001	0.2	0.04				<1	5	0.002	<0.001	12.32	196				<1			0.01	<1		5			<10	5				<0.005	
East Wolgan D/S Junction	29/07/2014				6.3	24	6.66	0.002	0.28	0.06				<1	5	<0.001	<0.001	11.58	241				<1			<0.01	<1		4			<10	3				0.005	
East Wolgan D/S Junction	12/08/2014				4.4	43	7.39	0.002	0.2	0.03				<1	5	<0.001	0.001	10.8	165				<1			0.01	<1		5			<10	3				<0.005	
East Wolgan D/S Junction	28/08/2014				8.5	39	5.85	0.003	0.25	0.08				<1	5	<0.001	0.003	11.84	989				<1			0.01	<1		5			<10	2				0.022	
East Wolgan D/S Junction	10/09/2014				9	<100	6.3	0.004	0.49	0.28				<1	4	<0.001	0.001	9.68	1868				<1			<0.01	<1		4			42	2				0.019	
East Wolgan D/S Junction	24/09/2014				7	<10	5.69	0.007	0.3	0.06				<1	5	<0.001	<0.001	0.05	278				<1			<0.01	<1		4			<10	4				0.01	
East Wolgan d/s junction	4/02/2008																																					
East Wolgan d/s junction	21/02/2008				15.1	57	6.6	0.008	1.55										1214																			
East Wolgan d/s junction	3/03/2008				11.8	54	7.2	0.004	1.1										1585																			
East Wolgan d/s junction	19/03/2008				13.9	44	7.3	0.005	0.84										588																			
East Wolgan d/s junction	2/04/2008				10.4	41	7.2	0.004	0.68										511																			
East Wolgan d/s junction	15/04/2008				10.4	40	7.1	0.005	0.77										470																			
East Wolgan d/s junction	29/04/2008																																					
East Wolgan d/s junction	13/05/2008				10	38	7.1	0.005	1.14										7799																			
East Wolgan d/s junction	28/05/2008				7.7	34	7	0	0.81										416																			
East Wolgan d/s junction	10/06/2008																																					
East Wolgan d/s junction	24/06/2008				5.7	43	6.8	0.004	1.02										846																			
East Wolgan d/s junction	10/06/2008																																					
East Wolgan d/s junction	24/06/2008				5.7	43	6.8	0.004	1.02										846																			
East Wolgan d/s junction	10/07/2008				5.2	42	7.1	0.004	0.98										687																			
East Wolgan d/s junction	22/04/1978				4.5	40	7.4	0.004	0.91										No flow rate due to																			
East Wolgan d/s Junction	15/08/2008				5	37	6.5	0.004	0.73										710																			
East Wolgan d/s Junction	20/08/2008				4.4	35	6.7	0.003	0.65										No flow rate measu																			
East Wolgan d/s Junction	2/09/2008	Mod flow			6.6	42	7.1	0.005	1.15										840																			
East Wolgan d/s Junction	18/09/2008	High flow			8.6	48	7.7	0.004	0.73										1089																			
East Wolgan d/s Junction	2/10/2008	Mod flow			10.7	40	6.9	0.006	0.98										637																			
East Wolgan d/s Junction	15/10/2008	Mod flow			11	47	7.5	0.006	1.19										1664																			
East Wolgan d/s Junction	27/10/2008	Mod flow			12.3	30	7.2	0.006	0.9										866																			
East Wolgan d/s Junction	11/11/2008	Mod flow			13.3	34	7.7	0.006	0.68										489																			
East Wolgan d/s Junction	26/11/2008	Mod flow			11.8	33	7.5	0.006	0.93										977																			
East Wolgan d/s Junction	8/12/2008	Mod flow			15.4	29	7.5	0.007	0.86										564																			
East Wolgan d/s Junction	22/12/2008	Mod flow			15.4	350	7.4	0.006	1.07										1002																			
East Wolgan d/s Junction	8/01/2009	Mod flow			16.5	30	7.3	0.007	0.77										523																			
East Wolgan d/s Junction	21/01/2009	Low flow			17.2	26	7.5	0.007	0.54										493																			
East Wolgan d/s Junction	3/02/2009	Low flow			17.6	86	7.3	0.009	0.51										303																			
East Wolgan d/s Junction	19/02/2009	Mod flow			15.4	45	7	0.013	1.78										713																			
East Wolgan d/s Junction	3/03/2009	Mod flow			15.2	29	7.1	0.007	0.91										492																			
East Wolgan d/s Junction	17/03/2009	Low flow			11.5	28	7.3	0.006	0.96										456																			
East Wolgan d/s Junction	8/04/2009	Low flow			13.4	34	7.9	0.007	1.32										347																			
East Wolgan d/s Junction	16/04/2009	Mod flow			11.5	33	7.4	0.005	1.66										750																			
East Wolgan d/s Junction	28/04/2009	Mod flow			10.4	31	7.8	0.005	1.36										655																			
East Wolgan d/s Junction	12/05/2009	Low flow			7.5	28	7.5	0.004	0.79										492																			
East Wolgan d/s Junction	NS																																					
East Wolgan d/s Junction	11/06/2009				5.7	38	7	0.004	1										1263																			
East Wolgan d/s Junction	23/06/2009				6	41	7	0.005	0.88										1192																			
East Wolgan d/s Junction	7/07/2009				5.6	39	7.7	0.003	0.81										784																			
East Wolgan d/s Junction	22/07/2009				5.2	36	7.2	0.003	0.84										649																			
East Wolgan d/s Junction	6/08/2009				5	33	7.6	0.006	0.99										578																			
East Wolgan d/s Junction	22/08/2009				7.5	36	7.9	0.008	1.26										679																			
East Wolgan d/s Junction	4/09/2009				8.1	37	7.7	0.005	1.04										919																			
East Wolgan d/s Junction	15/09/2009				9.7	30	7.17	0.006	0.99										1163																			
East Wolgan d/s Junction	29/09/2009				8.2	30	7.12	0.007	0.75										161																			
East Wolgan d/s Junction	14/10/2009				9.5	30	6.93	0.005	0.79										106																			
East Wolgan d/s Junction	28/10/2009				11.6	47	6.37	0.007	1.11										271																			
East Wolgan d/s Junction	9/11/2009				13.4	27	6.74	0.008	0.74										126																			
East Wolgan d/s Junction	24/11/2009				13.2	23	7.4	0.011	0.44										15																			
East Wolgan d/s Junction	7/12/2009				15.4	23	6.83	0.011	0.4										0																			
East Wolgan d/s Junction	23/12/2009				14.6	21	7.07	0.012	0.39										0																			
East Wolgan d/s Junction	6/01/2010				15.5	26	7.41	0.009	0.73										12																			
East Wolgan d/s Junction	18/01/2010				12.9	21	6.26	0.012	0.56										0																			
East Wolgan d/s Junction	3/02/2010				15.7	21	7.39	0.015	0.5										168																			
East Wolgan d/s Junction	19/02/2010				15.1	35	6.75	0.008	1.38										271																			
East Wolgan d/s Junction	3/03/2010				13.5	25	7.12	0.008	0.71										48																			
East Wolgan d/s Junction	20/03/2010				11.7	22	5.79	0.011	0.35										0																			
East Wolgan d/s Junction	29/03/2010				14.1	19	6.23	0.011	0.31										0																			
East Wolgan d/s Junction	12/04/2010				10.8	22	6.53	0.008	0.48										0																			
East Wolgan d/s Junction	27/04/2010					20	6.62	0.007	0.53										0																			
East Wolgan d/s Junction	12/05/2010				7	18	7.28	0.007	0.28										0																			
East Wolgan d/s Junction	24/05/2010				9.7	17	6.36	0.006	0.15										0																			
East Wolgan d/s Junction	10/06/2010				6.9	24	7.44	0.006	0.95										63																			
East Wolgan d/s Junction	23/06/2010				8.5	22	7.04	0.005	0.62										19																			
East Wolgan d/s Junction	6/07/2010				6.6	22	7.08	0.005	0.62										74																			
East Wolgan d/s Junction	20/07/2010				5.5	30	6.69	0.005	0.68										279																			
East Wolgan d/s Junction	4/08/2010				5.9	34	6.71	0.052	1.27										488																			

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) (mg/L)	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
East Wolgan d/s Junction	16/08/2010				6.8	36	5.56	0.003	0.53										788																			
East Wolgan d/s Junction	3/09/2010				9.4	32	7.55	0.005	0.84										546																			
East Wolgan d/s Junction	13/09/2010				8.3	36	7.09	0.004	0.7										988																			
East Wolgan d/s Junction	29/09/2010				8.9	47	6.84	0.006	0.73										399																			
East Wolgan d/s Junction	14/10/2010				12.2	51	7.25	0.007	1.05										907																			
East Wolgan d/s Junction	25/10/2010				10.7	35	6.86	0.005	0.78										1259																			
East Wolgan d/s Junction	9/11/2010				14.6	37	6.94	0.006	0.89										635																			
East Wolgan d/s Junction	25/11/2010				15.1	38	7.08	0.009	1.29										510																			
East Wolgan d/s Junction	7/12/2010				15.2	32	6.86	0.005	0.42										5357																			
East Wolgan d/s Junction	21/12/2010				12.6	55	7.21	0.005	0.68										1167																			
East Wolgan d/s Junction	5/01/2011				16	35	7.09	0.006	0.99										911																			
East Wolgan d/s Junction	18/01/2011				17.5	39	7.19	0.008	1.5										1375																			
East Wolgan d/s Junction	2/02/2011				17.5	38	7.21	0.01	1.19										301																			
East Wolgan d/s Junction	18/02/2011				16.4	38	7.01	0.009	1.55										307																			
East Wolgan d/s Junction	2/03/2011				14.5	34	7.14	0.1	1										16																			
East Wolgan d/s Junction	17/03/2011				15.1	36	7.06	0.009	1.22																													
East Wolgan d/s Junction	29/03/2011				13.3	36	7.16	0.008	1.25										116																			
East Wolgan d/s Junction	2/03/2011				14.5	34	7.14	0.1	1										16																			
East Wolgan d/s Junction	17/03/2011				15.1	36	7.06	0.009	1.22																													
East Wolgan d/s Junction	29/03/2011				13.3	36	7.16	0.008	1.25										116																			
East Wolgan d/s Junction	15/04/2011				10.1	30	7.06	0.006	0.84										13																			
East Wolgan d/s Junction	27/04/2011				11.2	36	7.45	0.008	1.09										29																			
East Wolgan d/s Junction	15/04/2011				10.1	30	7.06	0.006	0.84										13																			
East Wolgan d/s Junction	27/04/2011				11.2	36	7.45	0.008	1.09										29																			
East Wolgan d/s Junction	9/05/2011				7.5	29	6.15	0.005	0.97										0																			
East Wolgan d/s Junction	25/05/2011				7.6	28	7.46	0.008	0.87										125																			
East Wolgan d/s Junction	9/05/2011				7.5	29	6.15	0.005	0.97										0																			
East Wolgan d/s Junction	25/05/2011				7.6	28	7.46	0.008	0.87										125																			
East Wolgan d/s Junction	10/06/2011				5.7	28	6.9	0.004	0.91										152																			
East Wolgan d/s Junction	22/06/2011																																					
East Wolgan d/s Junction	10/06/2011				5.7	28	6.9	0.004	0.91										152																			
East Wolgan d/s Junction	22/06/2011																																					
East Wolgan d/s Junction	6/07/2011				6	30	6.87	0.005	1.06										385																			
East Wolgan d/s Junction	20/07/2011				6.5	42	6.92	0.005	1.09										542																			
East Wolgan d/s Junction	6/07/2011				6	30	6.87	0.005	1.06										385																			
East Wolgan d/s Junction	20/07/2011				6.5	42	6.92	0.005	1.09										542																			
East Wolgan d/s Junction	5/08/2011				4.9	42	6.84	0.005	1.12										380																			
East Wolgan d/s Junction	17/08/2011				6.4	40	6.75	0.005	0.96										567																			
East Wolgan d/s Junction	31/08/2011				7.1	40	6.58	0.005	1										722																			
East Wolgan d/s Junction	5/08/2011				4.9	42	6.84	0.005	1.12										380																			
East Wolgan d/s Junction	17/08/2011				6.4	40	6.75	0.005	0.96										567																			
East Wolgan d/s Junction	31/08/2011				7.1	40	6.58	0.005	1										722																			
East Wolgan d/s Junction	14/09/2011				6.7	40	6.42	0.005	0.79										269																			
East Wolgan d/s Junction	28/09/2011				9	41	6.59	0.005	0.96										692																			
East Wolgan d/s Junction	14/09/2011				6.7	40	6.42	0.005	0.79										269																			
East Wolgan d/s Junction	28/09/2011				9	41	6.59	0.005	0.96										692																			
East Wolgan d/s Junction	12/10/2011				10	31	6.2	0.004	0.56										762																			
East Wolgan d/s Junction	26/10/2011				10.7	32	7.11	0.159	3.13										356																			
East Wolgan d/s Junction	12/10/2011				10	31	6.2	0.004	0.56										762																			
East Wolgan d/s Junction	26/10/2011				10.7	32	7.11	0.159	3.13										356																			
East Wolgan d/s Junction	10/11/2011				13.7	44	6.8	0.008	0.92										748																			
East Wolgan d/s Junction	23/11/2011				11.3	27	6.61	0.013	0.62										2343																			
East Wolgan d/s Junction	10/11/2011				13.7	44	6.8	0.008	0.92										748																			
East Wolgan d/s Junction	23/11/2011				11.3	27	6.61	0.013	0.62										2343																			
East Wolgan d/s Junction	5/12/2011				11.1	30	7.04	0.011	0.72										659																			
East Wolgan d/s Junction	28/12/2011				13.5	46	6.89	0.006	0.73										821																			
East Wolgan d/s Junction	5/12/2011				11.1	30	7.04	0.011	0.72										659																			
East Wolgan d/s Junction	28/12/2011				13.5	46	6.89	0.006	0.73										821																			
East Wolgan d/s Junction	5/01/2012				15.1	49	6.81	0.007	1.08										485																			
East Wolgan d/s Junction	18/01/2012				15	43	7.17	0.006	0.99										222																			
East Wolgan d/s Junction	31/01/2012				16.4	49	7.01	0.006	1.2										688																			
East Wolgan d/s Junction	15/02/2012				15.4	31	6.8	0.008	0.64										1724																			
East Wolgan d/s Junction	13/03/2012				14	26	6.95	0.006	0.62										3392																			
East Wolgan d/s Junction	28/03/2012				13	37	6.89	0.009	0.9										1802																			
East Wolgan d/s Junction	11/04/2012				10.6	26	6.83	0.008	1.26										1334																			
East Wolgan d/s Junction	24/04/2012				12.2	37	6.58	0.009	0.87										2957																			
East Wolgan D/S Junction	9/05/2012				8	27	6.81	0.006	0.74										1107																			
East Wolgan D/S Junction	24/05/2012				7.7	30	6.09	0.008	0.56										12668																			
East Wolgan D/S Junction	6/06/2012				7.7	32	6.75	0.009	0.68										1111																			
East Wolgan D/S Junction	20/06/2012				6.8	35	6.08	0.004	0.57										134																			
East Wolgan D/S Junction	6/07/2012				6.7	37	6.22	0.006	0.59										1477																			
East Wolgan D/S Junction	18/07/2012				5.5	34	6.63	0.004	0.6										1473																			
East Wolgan D/S Junction	31/07/2012				4.4	39	7.06	0.005	0.55										1162																			
East Wolgan D/S Junction	13/08/2012				5.6	37	6.82	0.003	0.55										807																			
East Wolgan D/S Junction	30/08/2012				6.4	36	6.93	0.003	0.59										1262																			
East Wolgan D/S Junction	10/09/2012				6.8	36	7.15	0.005	0.57										654																			
East Wolgan D/S Junction	25/09/2012				7.3	37	6.63	0.007	0.78										528																			
East Wolgan D/S Junction	8/10/2012				9.9	38	6.93	0.006	0.72										554																			
East Wolgan D/S Junction	24/10/2012				12.2	161	3.66	0.009	0.39										387																			
East Wolgan D/S Junction	7/11/2012					37	7.2	0.006	0.64																													
East Wolgan D/S Junction	22/11/2012				13.1	33	6.6	0.004	0.52										183																			
East Wolgan D/S Junction	3/12/2012				16.7	33	7.04	0.012	0.68										449																			
East Wolgan D/S Junction	17/12/2012				12.8	32	7.43	0.008	0.36										276																			
East Wolgan D/S Junction	3/01/2013				14.9	46	6.15	0.01	0.51										48																			

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) mg/L	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
East Wolgan D/S Junction	16/01/2013				15.5	30	6.7	0.011	0.43										134																				
East Wolgan D/S Junction	29/01/2013				18	82	5.92	0.02	1.28										2063																				
East Wolgan D/S Junction																																						
East Wolgan D/S Junction	11/02/2013				16.2	33	6.85	0.01	0.89										2268																				
East Wolgan D/S Junction	25/02/2013				16.1	43	7.09	0.005	0.06										7458																				
East Wolgan D/S Junction																																						
East Wolgan D/S Junction	11/03/2013				14.4	36	6.5	0.008	0.45										844																				
East Wolgan D/S Junction	25/03/2013				17.8	34	7.43	0.006	0.45										1120																				
East Wolgan D/S Junction	9/04/2013				13.1	35	5.79	0.011	0.45										646																				
East Wolgan D/S Junction	22/04/2013				10.7	79	5.93	0.176	0.4										810																				
East Wolgan D/S Junction	6/05/2013				8.8	31	7.34	0.005	0.32										393																				
East Wolgan D/S Junction	20/05/2013					28	6.94	0.005	0.38										437																				
East Wolgan D/S Junction	3/06/2013				7.7	33	7.01	0.006	0.54										1130																				
East Wolgan D/S Junction	18/06/2013				6	33	6.46	0.006	0.47										190																				
East Wolgan D/S Junction	1/07/2013				7.7	30	6.6	0.004	0.35										1695																				
East Wolgan D/S Junction	19/07/2013				9.2	30	7.06	0.004	0.24										2801																				
East Wolgan D/S Junction	30/07/2013				5.8	29	6.2	0.004	0.31										680																				
East Wolgan D/S Junction	13/08/2013				6.5	27	6.63	0.005	0.36										710																				
East Wolgan D/S Junction	30/08/2013				9.6	30	7.13	0.004	0.34										533																				
East Wolgan D/S Junction	13/09/2013				8.1	27	6.54	0.003	0.17										391																				
East Wolgan D/S Junction	25/09/2013				12.9	40	6.98	0.004	0.4										365																				
East Wolgan D/S Junction	9/10/2013				12.5	35	6.78	0.003	0.31										265																				
East Wolgan D/S Junction	24/10/2013																																					
East Wolgan D/S Junction	4/11/2013				13.2	36	6.79	0.004	0.35										262																				
East Wolgan D/S Junction	18/11/2013				11.6	28	6.73	0.002	0.36										680																				
East Wolgan D/S Junction	3/12/2013				15.4	35	6.45	0.004	0.41										300																				
East Wolgan D/S Junction	20/12/2013				14.5	29	6.75	0.005	0.29										218																				
East Wolgan D/S Junction	31/12/2013				13.8	28	6.63	0.005	0.32										465																				
East Wolgan D/S Junction	17/01/2014				14.7	25	7.32	0.008	0.3										93																				
East Wolgan D/S Junction	30/01/2014				13	22	6.52	0.006	0.3	0.05					5	<0.001	<0.001	8.43	52				<1			0.03	<1		4			<5					0.006	<0.005
East Wolgan D/S Junction	11/02/2014				16	21	6.42	0.009	0.23	0.03					3	<0.001	0.001	8.87	46			<1				0.02	<1		5			<5	3				0.005	<0.005
East Wolgan D/S Junction	27/02/2014				15	24	7.03	0.006	0.32	0.05					4	<0.001	0.002	8.71	132			<1				<0.01	<1		5			<5	3				0.007	0.006
East Wolgan D/S Junction	12/03/2014				13.5	24	6.67	0.005	0.32	0.06					4	<0.001	<0.001	9.6	290				<1			0.01	<1		5			<5	4				0.005	<0.005
East Wolgan D/S Junction	26/03/2014				13.7	23	6.72	0.472	0.86	0.12					9	<0.001	<0.001		303				<1			<0.01	8		6			<5	6				0.012	0.017
East Wolgan D/S Junction	8/04/2014				13.3	27	6.71	0.003	0.45	0.11					5	0.001	<0.001	9.34	629				<1			<0.01	<1		5			<5	5				0.006	
East Wolgan D/S Junction	22/04/2014				10.3	36	7.78	0.003	0.31	0.05					4	<0.001	<0.001	14.44	324				<1			<0.01	5		<1			<5	5				0.013	
East Wolgan D/S Junction	5/05/2014				7.9	23	7.68	0.002	0.32	0.05					5	<0.001	<0.001	11.5	204				<1			<0.01	<1		4			<5	4				0.007	
East Wolgan D/S Junction	21/05/2014				9.25	21	6.31	0.048	0.22	0.06					4	<0.001	0.002	10.3	350				<1			<0.01	<1		5			<5	4				0.007	
East Wolgan D/S Junction	4/06/2014				8.5	26	6.82	0.002	0.28	0.04					5	<0.001	<0.001	11.19	361				<1			<0.01	<1		4			<10	4				<0.005	
East Wolgan D/S Junction	16/06/2014				7.1	41	6.8	0.002	0.25	0.05					5	<0.001	<0.001	12.97	208				<1			<0.01	<1		4			<10	3				<0.005	
East Wolgan D/S Junction	1/07/2014				5.5	24	6.36	0.002	0.3	0.07					5	<0.001	<0.001	12.55	225				<1			<0.01	<1		5			<10	3				0.006	
East Wolgan D/S Junction	15/07/2014				4.8	23	6.36	<0.001	0.2	0.04					5	0.002	<0.001	12.32	196				<1			0.01	<1		5			<10	5				<0.005	
East Wolgan D/S Junction	29/07/2014				6.3	24	6.66	0.002	0.28	0.06					5	<0.001	<0.001	11.58	241				<1			<0.01	<1		4			<10	3				0.005	
East Wolgan D/S Junction	12/08/2014				4.4	43	7.39	0.002	0.2	0.03					5	<0.001	0.001	10.8	165				<1			0.01	<1		5			<10	3				<0.005	
East Wolgan D/S Junction	28/08/2014				8.5	39	5.85	0.003	0.25	0.08					5	<0.001	0.003	11.84	989				<1			0.01	<1		5			<10	2				0.022	
East Wolgan D/S Junction	10/09/2014				9		6.3	0.004	0.49	0.28					4	<0.001	0.001	9.68	1868				<1			<0.01	<1		4			42	2				0.019	
East Wolgan D/S Junction	24/09/2014				7		5.69	0.007	0.3	0.06					5	<0.001	<0.001	0.05	278				<1			<0.01	<1		4			<10	4				0.01	
East Wolgan D/S Junction	9/10/2014	Mod flow	Clear		9.6	25	6.31	0.004	0.38	0.08				<1		<0.001	<0.001	10.96	213			<1				<0.01	<1		4	5		<10	<1	<0.1			0.016	
East Wolgan D/S Junction	20/10/2014			Inaccessable due to fl																																		
East Wolgan D/S Junction	5/11/2014			No Access																																		
East Wolgan D/S Junction	19/11/2014	Low Flow	Clear		13.9	11	6.49	0.002	0.37	0.06				5		<0.001	0.002	9.86	239			<1				0.04	6		<1	<1		<5	4	0.2			0.007	
East Wolgan D/S Junction	3/12/2014	Low Flow	Clear		15.5	4	6.4	0.006	0.43	0.13				5		0.001	0.002	9.4	191			<1				0.04	5		<1	<1		<5	4	<0.1			0.016	
East Wolgan D/S Junction	17/12/2014	Mod Flow	Clear		15.7	31	6.41	0.006	0.42	0.08				4		<0.001	0.002	8.1	127			<1				<0.01	5		<1	1		<5	4	<0.1			0.011	
East Wolgan D/S Junction	31/12/2014	Low Flow	Clear		13.8	24	5.69	0.006	0.49	0.1				5		<0.001	0.001	9.98				<1				<0.01	5		<1	<1		<5	5	0.1			0.012	
East Wolgan D/S Junction	12/01/2015	Mod Flow	Clear		16.2	31.8	6.87	0.005	0.48	0.12				4		<0.001	0.001	9.46	353			<1				<0.01	4		<1	<1		<5	4	0.2			0.008	
East Wolgan D/S Junction	28/01/2015	Mod Flow	Clear		14.4	33	7.7	0.004	0.44	0.18				4		<0.001	0.002	10.14	488			<1				0.02	7		<1	<1		<5	4	0.1			0.014	
East Wolgan D/S Junction	12/02/2015	Low Flow	Clear		15.2	28	6.56	0.028	0.42	0.08				5		<0.001	<0.001	11.02	174			<1				0.06	7		<1	<1		<5	4	0.3			0.058	
East Wolgan D/S Junction	26/02/2015	Mod Flow	Clear		16.3	32	6.9	0.006	0.4	0.06				5		<0.001	0.01	7.72	194			<1				<0.01	6		<1	<1		<5	5	<0.1			0.037	
East Wolgan D/S Junction	11/03/2015	Low Flow	Clear		15.4	31	6.78	0.006	0.43	0.08				5		<0.001	0.002	4.46	163			<1				<0.01	4		<1	<1		<5	4	<0.1			0.019	
East Wolgan D/S Junction	26/03/2015	Mod Flow	Clear		12.7	3	6.83	0.003	0.46	0.09				5		<0.001	<0.001	10.6	194			<1				<0.01	4		<1	<1		<5	4	0.1			0.009	
East Wolgan D/S Junction	9/04/2015	Mod Flow	Clear		10.8	30	7.39	0.004	0.41	0.07				5		<0.001	<0.001	10.92	264			<1				0.01	4		<1	<1		<5	4	<0.1			0.008	
East Wolgan D/S Junction	22/04/2015	High Flow	Slightly Cloudy		10.7	32	6.4	0.025	0.05	0.02				<1		0.002	<0.001	10.49	6488			<1				0.04	<1		<1	<1		5	<10	4.4			0.011	
East Wolgan D/S Junction	6/05/2015	High Flow	Clear		9.7	36	6.75	0.003	0.51	0.15				<1	4	<0.001	<0.001	10.31	1338			<1				<0.01	<1		6	1		<5	6	0.2			0.009	
East Wolgan D/S Junction	20/05/2015	Mod Flow	Clear		9.9	34	6.84	0.003	0.56	0.12				<1	5	<0.001	0.001	11.72	466			<1				<0.01	<1		6	<1		<5	5	0.2			0.013	
East Wolgan D/S Junction	3/06/2015	Mod Flow	Clear		5.6	35	7.63	0.002	0.36	0.08				4		<0.001	<0.001	11.88	368			<1				0.01	4		<1	<1		<5	5	<0.1			0.009	
East Wolgan D/S Junction	17/06/2015	Mod Flow	Clear		9.5	41	6.97	0.002	0.49	0.09				5		<0.001	<0.001	9.13	763			<1				<0.01	5		<1	<1		<5	4	0.1			0.01	
East Wolgan D/S Junction	30/06/2015	Mod Flow	Clear		5.6	34	7.4	0.002	0.27	0.05				4		<0.001	<0.001	10.86	296			<1				0.05	5		<1	<1		<5	4	0.2			0.009	
East Wolgan D/S Junction	15/07/2015	Mod Flow	Clear		4.3	32	7.34	0.002	0.44	0.11				5	5	<0.001	<0.001	12.24	276			<1				0.01	2		<1	1		<5	3	<0.1			0.006	
East Wolgan D/S Junction	29/07/2015	Mod Flow	Clear		3.9	32	7.01	0.002	0.41	0.1				<1	5	<0.001	<0.001	12.66	285			<1				0.05	<1		5	<1		<5	4	<0.1			0.01	
East Wolgan D/S Junction	12/08/2015	Low Flow	Clear		4.9	38	8.14	0.002	0.34	0.06				<1	4	<0.001	0.001	12.01	419			<1				0.12	<1		5	<1		<5	4	0.8			0.005	
East Wolgan D/S Junction	18/08/2015	Mod Flow	Clear		8	32	7.6	0.003	0.43	0.09				<1	3	<0.001	<0.001	11.28	654			<1				<0.01	<1		5	1		<5	3	0.2			<0.005	
East Wolgan D/S Junction	9/09/2015	Mod flow	Clear		7.6	38	7.74	0.002	0.32	0.05				<1	5	<0.001	<0.001	11.38	258			<1				0.03	<1		4	<1		<5	3	<0.1			<0.005	
East Wolgan D/S Junction	23/09/2015	Mod flow	Clear		6.9	34	7.46	0.003	0.52	0.11				<1	5	<0.001	<0.001	10.76	372			<1				0.04	<1		5	<1		<5	4	<0.1			<0.005	
East Wolgan D/S Junction	7/10/2015	Low Flow	Clear		10.1	24	7.29	0.003	0.34	0.04				<1	5	<0.001	<0.001	10.17	103			<1				0.05	<1		4	<1		<5	3	<0.1			<0.005	
East Wolgan D/S Junction	21/10/2015	Mod Flow	Clear		12.2	35	7.4	0.005	0.59	0.14				<1	5	0.004	<0.001	9	266			<1				0.02	<1		4	<1		<5	3	<0.1			0.011	
East Wolgan D/S Junction	4/11/2015	Low Flow	Clear		13.6	36	6.75	0.005	0.48	0.22				<1	5	<0.001	<0.001	9.78	266			<1				0.01	<1		8	<1		<5	4	0.2			0.014	
East Wolgan D/S Junction	18/11/2015	Mod Flow	Clear		14.4	29	7.32	0.005	0.5	0.09				<1	5	<0.001	<0.001	9.47	283			<1				0.08	<1		5	<1		<5	5	<0.1			<0.005	
East Wolgan D/S Junction	30/11/2015	Low Flow	Clear		13.6	35	7.61	0.005	0.49	0.06				<1	5	<0.001	<0.001	9.39	257			<1				<0.01	<1		4	<1		<5	5	0.8			<0.005	
East Wolgan D/S Junction	16/12/2015	Low Flow	Clear		14.7	31	6.86	0.006	0.48	0.12				<1	5	<0.001	0.001	9.34	110			<1				<0.01	<1		4	<1		<5	4	0.2			<0.005	
East Wolgan D/S Junction	30/12/2015	Low flow	Clear		13	44	7.04	0.005	0.45	0.06				<1	5	<0.001	<0.001	9.45	145			<1				0.05	<1		4	<1		<5	4	<0.1			<0.005	
East Wolgan D/S Junction	13/01/2016	Mod Flow	Clear		16	31	6.62	0.006	0.42	0.05				<1	5	<0.001	<0.001	7.88	259			<1				<0.01	<1		4	8		<5	1	0.2			<0.005	
East Wolgan D/S Junction	28/01/2016	Mod Flow	Clear		15.7	35	7.5	0.005	0.49	0.08				<1	4	<0.001	<0.001	8.01	643			<1				<0.01	<1		5	<1		<5	4	0.2			<0.005	
East Wolgan D/S Junction	10/02/2016	Mod Flow	Clear		15.2	32	8.02	0.005	0.44	0.06				<1	4	<0.001	<0.001	8.34	267			<1				<0.01	<1		5	<1		<5	4	0.1			<0.005	
East Wolgan D/S Junction	22/02/2016	Low Flow	Clear		15.8	31	6.76	0.009	0.9	0.16				<1	6	<0.001	<0.001	7.81	128			<1				0.01	<1		4	<1		<5	6	<0.1			<0.005	

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) mg/L	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
East Wolgan D/S Junction	8/03/2016	Low Flow	Clear		15.7	30	6.31	0.008	0.53	0.07				<1	6	<0.001	<0.001	8.89	74			<1				0.02	<1		4	<1		<5	3	<0.1			<0.005	
East Wolgan D/S Junction	21/03/2016	Low Flow	Clear		14.2	31	6.41	0.004	0.32	0.04				<1	5	<0.001	<0.001	9.53	98			<1				<0.01	<1		4	<1		<5	4	0.1			<0.005	
East Wolgan D/S Junction	6/04/2016	Low Flow	Clear		14.2	33	6.7	0.005	0.34	0.04				<1	4	<0.001	<0.001	8.19	37			<1				0.02	<1		4	<1		<5	3	<0.1			<0.005	
East Wolgan D/S Junction	19/04/2016	Low Flow	Clear		13.5	25	6.79	0.005	0.26	0.15				<1	5	<0.001	<0.001	9.72	76			<1				<0.01	<1		6	<1		<5	6	<0.1			0.014	
East Wolgan D/S Junction	2/05/2016	Low Flow	Clear		11.2	27	5.94	0.004	0.36	0.04				<1	5	<0.001	<0.001	10.24	113			<1				0.04	<1		4	1		<5	1	<0.1			<0.005	
East Wolgan D/S Junction	16/05/2016	Low Flow	Clear		8.8	28	7.33	0.003	0.21	0.02				<1	5	<0.001	<0.001	10.01	23			<1				<0.01	<1		4	<1		<5	3	<0.1			<0.005	
East Wolgan D/S Junction	30/05/2016	Low Flow	Clear		6.4	28	7.39	0.003	0.21	0.04				<1	4	<0.001	<0.001	10.57	66			<1				<0.01	<1		3	<1		<5	2	<0.1			<0.005	
East Wolgan D/S Junction	15/06/2016	Mod Flow	Clear		6.3	31	6.31	0.003	0.21	0.06				<1	4	<0.001	<0.001	11.35	267			<1				<0.01	<1		5	<1		<5	2	<0.1			0.006	
East Wolgan D/S Junction	29/06/2016	Mod Flow	Clear		5.6	30	6.18	0.003	0.29	0.09				<1	3	<0.001	<0.001	11.93	367			<1				0.02	<1		4	<1		<5	3	<0.1			<0.005	
East Wolgan D/S Junction	11/07/2016	Mod Flow	Clear		7.3	31	6.26	0.004	0.42	0.12				<1	4	<0.001	<0.001	10.35	591			<1				<0.01	<1		4	1		<5	3	0.1			0.005	
East Wolgan D/S Junction	27/07/2016	Mod Flow	Clear		7.7	36	7.04	0.003	0.3	0.15				<1	3	<0.001	<0.001	10.46	845			<1				0.02	<1		4	<1		<5	6	<0.1			0.007	
East Wolgan D/S Junction	10/08/2016	Mod Flow	Clear		7.1	34	7.53	0.002	0.34	0.12				<1	3	<0.001	<0.001	10.63	824			<1				0.02	<1		5	1		<5	4	0.2			0.005	
East Wolgan D/S Junction	24/08/2016	Mod Flow	Clear		7.3	31	7.56	0.002	0.31	0.08				<1	6	<0.001	<0.001	10.58	292			<1				<0.01	<1		4	<1		<5	3	<0.1			0.005	
East Wolgan D/S Junction	7/09/2016	Mod flow	Clear		7.7	34	7.65	0.004	0.28	0.11				<1	5	<0.001	0.001	11.12	620			<1				<0.01	<1		5	2		<5	4	0.1			<0.005	
East Wolgan D/S Junction	21/09/2016	Mod flow	Clear		93	34	7.85	0.002	0.3	0.12				<1	4	<0.001	<0.001	10.27	474			<1				<0.01	<1		5	1		<5	4	0.2			0.006	
East Wolgan D/S Junction	5/10/2016	Mod Flow	Clear		8.6	31.5	7.58	0.003	0.41	0.09				<1	4	<0.001	<0.001	11.39	413			<1				<0.01	<1		5	1		<5	3	<0.1			<0.005	
East Wolgan D/S Junction	20/10/2016	Mod Flow	Clear		10.4	40	8.13	0.001	0.38	0.06				<1	4	<0.001	<0.001	10.5	313			<1				<0.01	<1		4	<1		<5	4	0.1			<0.005	
East Wolgan D/S Junction	2/11/2016	Low Flow	Clear		9.6	30	6.02	0.004	0.37	0.06				<1	5	<0.001	<0.001	10.75	101			<1				<0.01	<1		4	<1		<5	4	<0.1			<0.005	
East Wolgan D/S Junction	17/11/2016	Mod Flow	Clear		12.9	29	6.45	0.004	0.4	0.06				<1	4	<0.001	<0.001	10.25	101			<1				0.02	<1		5	<1		<5	5	<0.1			<0.005	
East Wolgan D/S Junction	28/11/2016	Mod Flow	Clear		15.1	51	8.12	0.003	0.38	0.06				<1	4	<0.001	<0.001	8.72	268			<1				0.02	<1		5	<1		<5	4	0.1			<0.005	
East Wolgan D/S Junction	12/12/2016	Mod Flow	Clear		14.8	29	5.86	0.005	0.41	0.06				<1	5	<0.001	<0.001	10.83	106			<1				0.05	<1		5	<1		<5	4	<0.1			<0.005	
East Wolgan D/S Junction	29/12/2016	Low Flow	Clear		16.9	31	6.97	0.01	0.41	0.05				<1	4	<0.001	<0.001	8.57	221			<1				0.01	<1		6	<1			5	0.2			<0.005	
East Wolgan D/S Junction	10/01/2017	Low Flow	Clear		17.2	31	6.9	0.009	0.32	0.05				<1	4	<0.001	<0.001	8.74	135			<1				0.02	<1		5	<1		12	4	0.2			<0.005	
East Wolgan D/S Junction	25/01/2017	Low Flow	Clear		16.4	23	6.18	0.007	0.44	0.05				<1	5	<0.001	<0.001	8.9	152			<1				<0.01	4		6	<1		<5	4	0.2			<0.005	
East Wolgan D/S Junction	5/10/2017	Low Flow	Clear	Flow too low for flow	7.1	39	6.7	0.003	0.5	0.05				<1	5	<0.001	0.001	9.7				<1				0.04	<1		6	1		<5	6	0.5			0.006	
East Wolgan D/S Junction	19/10/2017		Clear	Flow too low for flow	13.5	22	5.8	0.009	0.28	0.03				<1	5	<0.001	<0.001	8.7				<1				0.02	<1		5	<1		<5	6	1			<0.005	
East Wolgan D/S Junction	30/10/2017		Clear	Flow too low for flow	11.8	45	6.8	0.005	0.41	0.05				<1	6	<0.001	<0.001	7.3				<1				0.11	<1		5	1		<5	6	0.3			<0.005	
East Wolgan D/S Junction	14/11/2017	Low Flow	Clear		10	29	6	0.005	0.29	0.07				<1	4	<0.001	<0.001	8.7	154			<1				0.01	<1		4	<1		<5	2	<0.1			<0.005	
East Wolgan D/S Junction	30/11/2017	Mod Flow	Clear		12.6	29	6.1	0.01	0.33	0.04				<1	5	<0.001	<0.001	8.7	122			<1				<0.01	<1		4	<1		<5	3	<0.1			<0.005	
East Wolgan D/S Junction	14/12/2017	Low Flow	Clear	Too low for flow mon	12	39	6.7	0.007	0.28	0.04				<1	5	<0.001	<0.001					<1				0.04	<1		<1	<1		22	5	0.2			<0.005	
East Wolgan D/S Junction	28/12/2017	Low Flow	Clear		12.9	28	7	0.005	0.32	0.04				<1	4	<0.001	<0.001	8.1	156			<1				<0.01	<1		4	<1		<5	6	<0.1			<0.005	
East Wolgan D/S Junction	9/02/2017	Mod Flow	Clear		17.7	29	6.75	0.01	0.57	0.1				<1	5	<0.001	<0.001	9.42	284			<1				0.02	<1		5	1		<5	3	0.2			<0.005	
East Wolgan D/S Junction	21/02/2017	Low Flow	Clear		12.7	35	6.71	0.006	0.36	0.06				<1	4	<0.001	<0.001	8.43	189			<1				<0.01	<1		5	<1		<5	6	0.5			<0.005	
East Wolgan D/S Junction	9/03/2017	Mod flow	Clear		14.4	24	5.7	0.004	0.53	0.07				<1	5	<0.001	<0.001	8.98	183			<1				<0.01	<1		6	<1		<5	5	0.1			<0.005	
East Wolgan D/S Junction	21/03/2016	Low flow	Clear	Flow too low for flow	15.2	23	5.68	0.007	0.81	0.14				<1	5	<0.001	<0.001	8.23				<1				<0.01	<1		5	<1		6	4	0.3			<0.005	
East Wolgan D/S Junction	6/04/2017	Low Flow	Clear		11.4	22	6.07	0.005	0.59	0.09				<1	5	<0.001	<0.001	9.56	230			<1				0.02	<1		5	3		8	<1	0.3			<0.005	
East Wolgan D/S Junction	20/04/2017	Low Flow	Clear		11.5	35	6.84	0.003	0.32	0.03				<1	4	<0.001	<0.001	9.26	221			<1				<0.01	<1		5	<1		<5	3	<0.1			<0.005	
East Wolgan D/S Junction	11/05/2017	Low Flow	Clear		11.9	39	6.97	0.003	0.34	0.03				<1	5	<0.001	<0.001	9.43	1057			<1				0.01	<1		4	1		5	2	<0.1			<0.005	
East Wolgan D/S Junction	25/05/2017	Low Flow	Cloudy		11.2	28	6.78	0.004	0.4	0.05				<1	5	<0.001	<0.001	10.14	284			<1				<0.01	<1		4	<1		86	4	0.4			<0.005	
East Wolgan D/S Junction	15/06/2017	Low Flow	Clear		9.9	33	6.99	0.005	0.48	0.05				<1	4	<0.001	<0.001	10.07	1038			<1				<0.01	<1		4	<1		<5	4	0.4			<0.005	
East Wolgan D/S Junction	27/06/2017	Low Flow	Clear		5	31	7.9	0.003	0.3	0.04				<1	5	<0.001	<0.001	9.5	298			<1				0.04	<1		4	<1			3	<0.1			<0.005	
East Wolgan D/S Junction	13/07/2017	Low Flow	Clear		4.5	19	6.5	0.002	0.12	0.02				<1	3	<0.001	<0.001	10.4	202			<1				<0.01	<1		4	4		<5	2	0.1			<0.005	
East Wolgan D/S Junction	25/07/2017	Low Flow	Clear		4.9	21	6	0.002	0.29	0.03				<1	4	<0.001	<0.001	9.9	257			<1				0.03	<1		4	<1			3	<0.1			<0.005	
East Wolgan D/S Junction	10/08/2017	Low Flow	Clear		5.2	22	6.9	0.002	0.28	0.03				<1	6	<0.001	<0.001	10.5	118			<1				<0.01	<1		4	<1		<5	2	<0.1			<0.005	
East Wolgan D/S Junction	25/08/2017	Low Flow	Clear		5.5	35	9.74	0.002	0.25	0.03				<1	5	<0.001	<0.001	9.6	285			<1				0.01	<1		4	<1		<5	2	<0.1			<0.005	
East Wolgan D/S Junction	7/09/2017	Low Flow	Clear		6.8	26	7	0.001	0.21	0.02				<1	5	<0.001	<0.001	10.5	271			<1				0.02	<1		7	<1		<5	2	0.6			<0.005	
East Wolgan D/S Junction	18/09/2017	Low Flow	Clear	Flow too low for flow	6.5	28	7.4	0.002	0.22	0.02				<1	5	<0.001	<0.001	9.8				<1				0.02	<1		4	<1		<5	6	<0.1			<0.005	
East Wolgan D/S Junction	10/01/2018	Low Flow	Clear		13.7	29	6.4	0.005	0.51	0.09				<1	4	<0.001	<0.001		42			<1				<0.01	<1		4	<1		18	4	0.4			<0.005	
East Wolgan D/S Junction	23/01/2018	Low Flow	Clear		13.9	28	6.1	0.009	0.26	0.03				<1	2	<0.001	<0.001	9.2				<1				<0.01	<1		4	<1		6	3	<0.1			0.011	
East Wolgan D/S Junction	7/02/2018		Clear	Too Low For Flow Mo	13.2	22	5.9	0.008	0.26	0.03				<1	4	<0.001	<0.001	7.9				<1				0.02	<1		3	<1		8	2	0.1			<0.005	
East Wolgan D/S Junction	19/02/2018	Low Flow	Clear	Too Low For Flow Mo	13.7	22	6.1	0.008	0.33	0.03				<1	5	<0.001	<0.001	8.2				<1				0.02	<1		3	<1		20	3	0.2			<0.005	
East Wolgan D/S Junction	7/03/2018	Low Flow	Clear	Too Low For Flow	14	45	5.6	0.007	0.34	0.08				<1	4	<0.001	<0.001	6.7				<1				<0.01	<1		5	2		9	<1	0.3			<0.005	
East Wolgan D/S Junction	21/03/2018	Low Flow	Clear	Too Low For Flow	13.8	27	4.9	0.008	0.29	0.11				<1	6	<0.001	<0.001	8.5	90			<1				<0.01	<1		3	<1		13	<1	0.4			<0.005	
East Wolgan D/S Junction	4/04/2018	Low Flow	Clear	Too low for flow mon	12.1	28	6.3	0.006	0.24	0.03				<1	5	<0.001	<0.001	8.4				<1				<0.01	<1		3	<1		8	2	0.1			<0.005	
East Wolgan D/S Junction	17/04/2018	Low Flow	Clear	Too low for flow mon	12	34	7.6	0.008	0.28	0.1				<1	7	<0.001	0.001	8.1				<1				0.02	<1		4	<1		12	<1	0.3			0.005	
East Wolgan D/S Junction	2/05/2018	Low Flow	Clear	Too low for flow mon	8.4	26	5.7	0.005	0.15	0.02				<1	4	<0.001	<0.001	8.8				<1				0.01	<1		4	<1		22	<1	<0.1			<0.005	
East Wolgan D/S Junction	17/05/2018	Low Flow	Clear	Too Low For Flow Mo	5.1	27	6.1	0.004	0.1	0.01				<1	5	<0.001	<0.001	8				<1				0.04	<1		3	<1		<5	<1	<0.1			<0.005	
East Wolgan D/S Junction	30/05/2018	Low Flow	Clear	Too Low For Flow Mo	5.9	32	4.3	0.007	0.2	0.08				<1	7	<0.001	0.001	9.6				<1				0.07	<1		5	<1		14	<1	0.3			<0.005	
East Wolgan D/S Junction	12/06/2018	Low Flow	Clear	Too low for flow mon	6.5	27	5.3	0.004	0.16	0.02				<1	5	<0.001	<0.001	9.9				<1				0.02	<1		4	<1		<5	2	<0.1			<0.005	
East Wolgan D/S Junction	29/06/2018	Low flow	Clear		4.5	31	5.6	0.007	0.36	0.12				<1	5	<0.001	<0.001	9.5	173			<1				<0.01	<1		4	2		<5	2	0.2			0.008	
East Wolgan D/S Junction	12/07/2018	low Flow	Clear	Too low for flow mon	1.9	35	5.3	0.002	0.12	0.04				<1	6	<0.001	0.001	9.5				<1				0.01	<1		7	2		<5	<1	0.1			0.016	
East Wolgan D/S Junction	26/07/2018		Clear	Too low for flow mon	2.6	51	8.4	0.003	0.16	0.04				<1	5	<0.001	<0.001	8.3				<1				0.04	4		5	2		<5	<1	0.1			<0.005	
East Wolgan D/S Junction	9/08/2018	Low Flow	Clear	Too Low for flow Mon	5.9	28	5.3	0.003	0.1	0.02				<1	5	<0.001	<0.001	8.9				<1				<0.01	<1		3	1		<5	<1	<0.1			0.005	
East Wolgan D/S Junction	23/08/2018	low flow	Clear	Too Low for flow Mon	4.4	28	5.7	0.004	0.11	0.02				<1	4	<0.001	<0.001	8.3				<1				<0.01	<1		4	<1		<5	<1	<0.1			<0.005	
East Wolgan D/S Junction	6/09/2018	Low Flow	Clear	Depth too low for flo	7.1	35	4		0.19	0.05				<1	5	<0.001	<0.001	9.13		<0.1		<1				<0.01	<1		4	1	41	<5	<1	<0.1	<0.01	3.2	<0.005	
East Wolgan D/S Junction	17/09/2018	Low flow	Clear	Depth too low for flo	3.2	30	5.7		0.2	0.07				<1	6	<0.001	<0.001	9.6		<0.1		<1				<0.01	<1	404	4	1		<5	<1	0.1	<0.01		<0.005	
East Wolgan D/S Junction	4/10/2018	Low Flow	Clear	Depth too low for flo	4.9	30	5.6		0.18	0.06				<1	6	<0.001	<0.001	8.7		<0.1		<1				0.02	<1	397	4	2	60	5		0.2	<0.01	3.1	<0.005	
East Wolgan D/S Junction	15/10/2018	Low Flow	Clear	Depth too low for flo	7.7	39	5.4		0.26	0.07				<1	5	<0.001	<0.001	8.6				<1				0.04	<1	197	4	2		<5		<0.1		2.5	<0.005	
East Wolgan D/S Junction	1/11/2018	Low Flow	Clear	Depth too low for flo	9.9	35	5.3		0.19	0.06				<1	5	<0.001	<0.001	7.5		<0.1		<1				0.06	<1	391	5	2		17		0.4	0.03	11	0.011	
East Wolgan D/S Junction	15/11/2018	Low Flow	Clear	Depth too low for flo	16.7	41	4.7		0.37	0.06				<1	6	<0.001	<0.001	9.1		<0.1		<1				<0.01	<1	287	4	<1	19	10		0.2	0.05	30	<0.005	
East Wolgan D/S Junction	29/11/2018				10.8	31	5.4		0.28	0.18				<1	4	<0.001	0.001	8.3	613			<1				0.02	<1	251	13	3	<5			0.3		5.9	0.016	
East Wolgan D/S Junction	13/12/2018	Low flow	Clear	Depth too low for flo	14.9	40	6.8		0.34	0.09				<1	5	<0.001	<0.001	7		<0.1		<1				<0.01	<1	467	7	2	38	<5		0.2	<0.01	3.1	<0.005	
East Wolgan D/S Junction	27/12/2018	Low flow	Clear	Depth too low for flo	16.1	31	7.7		0.28	0.07				<1	5	<0.001	0.002	6.7				<1				<0.01	<1	293	4	2	16	<5		0.3		2.6	0.019	
East Wolgan D/S Junction	10/01/2019	Low flow	Clear	Depth too low for flo	16.1	27	6.7		0.29	0.07				<1	4	<0.001	<0.001	11		<0.1		<1				0.01	<1	244	5	1	14	<5		<0.1	<0.01	3.6	0.008	
East Wolgan D/S Junction	24/01/2019	Mod flow	Clear		15.9	33	6		0.36	0.16				<1	3	<0.001	<0.001	14.5	1460			<1				<0.01	<1	338	4	1		<5		0.2		3.6	0.009	
East Wolgan D/S Junction	6/02/2019	Low flow	Clear	Depth too low to reco	19	37	6.4		0.41	0.07				<1	4	<0.001	<0.001	8.9		<0.1		<1				0.04	<1	326	3	3	23	5		<0.1	<0.01	4.2	0.006	
East Wolgan D/S Junction	20/02/2019	Low flow	Clear	Depth too low to reco	14.6	27	6.7		0.45	0.05				<1	4	<0.001	0.008	7.9				<1				<0.01	<1	263	5	<1		6		<0.1		2.2	0.005	
East Wolgan D/S Junction	4/03/2019	Low flow	Clear	Depth too low to reco	13.6	53	5.8		1.1	0.18				<1	5	<0.001	<0.001	5.1		<0.1		<1				0.01	<1	466	5	2	44	<5		0.4	<0.01	2.5	0.014	
East Wolgan D/S Junction	21/03/2019	Low flow	Clear	Depth too low to reco	14.8	46	4.9		0.38	0.08				<1	8	<0.001	<0.001	6.5				<1				0.02	1	138	5	<1		8		0.2		4.2	0.013	
East Wolgan D/S Junction	1/04/2019	Mod Flow	Clear		11.8	51	6.6		0.3	0.05				<1	5	<0.001	<0.001	8.7	296	<0.1		<1				0.05	<1	177	3	<1	<10	<5		0.2	<0.01	2.6	<0.005	
East Wolgan D/S Junction	17/04/2019	Low flow	Clear	Depth too low for flo	11.9	25	7.4		0.22	0.02				<1	4	<0.001	<0.001	8.4				<1				0.01	<1	327	4	<1		<5		<0.1		1.8	<0.005	
East Wolgan D/S Junction	1/05/2019	Low Flow	Clear	Depth too low for flo	12.5	27	5.8		0.21	0.03				<1	6	<0.001	<0.001	8.2		<0.1		<1				<0.01	<1	277	3	3	24	<5		<0.1	<0.01	2.3	0.01	
East Wolgan D/S Junction	15/05/2019	Low flow	Clear	Depth too low for flo	8.7	33	4.7		0.17	0.02				<1	5	<0.001	<0.001	8.9				<1				0.01	<1	265	3	<1		<5		<0.1		1.2	<0.005	
East Wolgan D/S Junction	29/05/2019	Low flow	Clear	Depth too low for flo	8	312	7.1		0.11	0.02				<1	5	<0.001	<0.001	9				<1				0.01	<1	373	2	<1		12		0.2		6.6	<0.005	

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) (mg/L)	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
East Wolgan Downstream	6/07/2012					42	5.49	0.046	0.24																													
East Wolgan Downstream	18/07/2012					18	6.21	0.018	0.2																													
East Wolgan Downstream	31/07/2012					33	6.21	0.035	0.15																													
East Wolgan Downstream	13/08/2012																																					
East Wolgan Downstream	30/08/2012																																					
East Wolgan Downstream	10/09/2012																																					
East Wolgan Downstream	25/09/2012																																					
East Wolgan Downstream	8/10/2012																																					
East Wolgan Downstream	24/10/2012																																					
East Wolgan Downstream	7/11/2012																																					
East Wolgan Downstream	22/11/2012																																					
East Wolgan Downstream	3/12/2012																																					
East Wolgan Downstream	17/12/2012																																					
East Wolgan Downstream	3/01/2013																																					
East Wolgan Downstream	16/01/2013																																					
East Wolgan Downstream	29/01/2013				19.2	34	5.36	0.396	0.62																													
East Wolgan Downstream	11/02/2013				19.3	25	6.3	0.194	0.29																													
East Wolgan Downstream	25/02/2013				16.5	53	6.2	0.014	0.3																													
East Wolgan Downstream	11/03/2013				16.2	55	6.07	0.054	0.42																													
East Wolgan Downstream	25/03/2013																																					
East Wolgan Downstream	9/04/2013				13.7	97	4.97	0.225	0.34																													
East Wolgan Downstream	22/04/2013				12.9	81	6.09	0.005	0.56																													
East Wolgan Downstream	6/05/2013																																					
East Wolgan Downstream	20/05/2013				9.9	157	5.91	0.455	0.74																													
East Wolgan Downstream	3/06/2013				8.1	13	6.12	0.012	<0.05																													
East Wolgan Downstream	18/06/2013				4.1	33	5.75	0.029	0.14																													
East Wolgan Downstream	1/07/2013				9.1	19	5.58	0.038	0.07																													
East Wolgan Downstream	19/07/2013				9.8	18	6.57	0.026	0.06																													
East Wolgan Downstream	30/07/2013				7	62	5.79	0.135	0.2																													
East Wolgan Downstream	13/08/2013				10.1	47	6.01	0.083	0.13																													
East Wolgan Downstream	30/08/2013																																					
East Wolgan Downstream	13/09/2013																																					
East Wolgan Downstream	25/09/2013																																					
East Wolgan Downstream	9/10/2013																																					
East Wolgan Downstream	24/10/2013																																					
East Wolgan Downstream	4/11/2013																																					
East Wolgan Downstream	18/11/2013				13.3	59	5.86	0.187	0.25										0																			
East Wolgan Downstream	3/12/2013																																					
East Wolgan Downstream	20/12/2013																																					
East Wolgan Downstream	31/12/2013																																					
East Wolgan Downstream	17/01/2014																																					
East Wolgan Downstream	30/01/2014																																					
East Wolgan Downstream	11/02/2014																																					
East Wolgan Downstream	27/02/2014																																					
East Wolgan Downstream	12/03/2014																																					
East Wolgan Downstream	26/03/2014				15.5	58	6.01	0.005	0.39	0.08				<1	5	<0.001	<0.001							<1			0.01	<1		4			20	5			<0.005	0.007
East Wolgan Downstream	8/04/2014				14.6	39	6.38	0.051	0.67	0.53				<1	2	<0.001	0.001	5.27	0					<1			<0.01	2		9			20	10			0.009	
East Wolgan Downstream	22/04/2014																																					
East Wolgan Downstream	5/05/2014																																					
East Wolgan Downstream	21/05/2014																																					
East Wolgan Downstream	4/06/2014																																					
East Wolgan Downstream	16/06/2014																																					
East Wolgan Downstream	1/07/2014																																					
East Wolgan Downstream	15/07/2014																																					
East Wolgan Downstream	29/07/2014																																					
East Wolgan Downstream	12/08/2014																																					
East Wolgan Downstream	28/08/2014																																					
East Wolgan Downstream	10/09/2014																																					
East Wolgan Downstream	24/09/2014																																					
East Wolgan Downstream	4/02/2008																																					
East Wolgan Downstream	21/02/2008																		0																			
East Wolgan Downstream	3/03/2008																		0																			
East Wolgan Downstream	19/03/2008																		0																			
East Wolgan Downstream	2/04/2008																		0																			
East Wolgan Downstream	15/04/2008																		0																			
East Wolgan Downstream	29/04/2008																																					
East Wolgan Downstream	13/05/2008																		0																			
East Wolgan Downstream	28/05/2008																		0																			
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East Wolgan Downstream	24/06/2008																		0																			
East Wolgan Downstream	10/07/2008																		0																			
East Wolgan Downstream	22/07/2008																		0																			
East Wolgan Downstream	15/08/2008																																					
East Wolgan Downstream	20/08/2008																																					
East Wolgan Downstream	2/09/2008	No flow, no s																	0																			
East Wolgan Downstream	18/09/2008	No flow, no s																																				
East Wolgan Downstream	2/10/2008	Dry, no flow,																																				
East Wolgan Downstream	15/10/2008	Dry, no flow,																																				
East Wolgan Downstream	27/10/2008	Dry, no flow,																																				
East Wolgan Downstream	11/11/2008	Dry, no flow,																																				
East Wolgan Downstream	26/11/2008	No flow																																				
East Wolgan Downstream	8/12/2008	No flow																																				

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) mg/L	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
East Wolgan Downstream	22/12/2008	No flow																																			
East Wolgan Downstream	8/01/2009	No flow, no s																																			
East Wolgan Downstream	21/01/2009	No flow, no s																																			
East Wolgan Downstream	3/02/2009	No flow																																			
East Wolgan Downstream	19/02/2009	No flow																	0																		
East Wolgan Downstream	3/03/2009	No flow																																			
East Wolgan Downstream	17/03/2009	No flow																																			
East Wolgan Downstream	8/04/2009	No flow																																			
East Wolgan Downstream	16/04/2009	No flow																																			
East Wolgan Downstream	28/04/2009	No flow																																			
East Wolgan Downstream	12/05/2009	No flow																																			
East Wolgan Downstream	NS																																				
East Wolgan Downstream	11/06/2009																																				
East Wolgan Downstream	23/06/2009																																				
East Wolgan Downstream	7/07/2009																																				
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East Wolgan Downstream	14/10/2009																																				
East Wolgan Downstream	28/10/2009																																				
East Wolgan Downstream	9/11/2009																																				
East Wolgan Downstream	24/11/2009																																				
East Wolgan Downstream	7/12/2009																		0																		
East Wolgan Downstream	23/12/2009																		0																		
East Wolgan Downstream	6/01/2010																																				
East Wolgan Downstream	18/01/2010																																				
East Wolgan Downstream	3/02/2010																																				
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East Wolgan Downstream	27/04/2010																																				
East Wolgan Downstream	12/05/2010																																				
East Wolgan Downstream	24/05/2010																																				
East Wolgan Downstream	10/06/2010																																				
East Wolgan Downstream	23/06/2010																																				
East Wolgan Downstream	6/07/2010																																				
East Wolgan Downstream	20/07/2010																																				
East Wolgan Downstream	4/08/2010					4.8	85	6.71	0.004	0.57																												
East Wolgan Downstream	16/08/2010					6.5	70	5.21	0.023	0.46																												
East Wolgan Downstream	3/09/2010					9.6	106	7.27	0.147	2.17									0																		
East Wolgan Downstream	13/09/2010					11.2	94	6.76	0.077	1.42									0																		
East Wolgan Downstream	29/09/2010																																				
East Wolgan Downstream	14/10/2010																																				
East Wolgan Downstream	25/10/2010					11.5	93	6.79	0.1	1.61																												
East Wolgan Downstream	9/11/2010					15.4	111	6.81	0.176	3.54									0																		
East Wolgan Downstream	9/11/2010								0.164	3.33																												
East Wolgan Downstream	25/11/2010					15.9	120	6.87	0.19	4.79									0																		
East Wolgan Downstream	7/12/2010					15.2	57	6.57	0.018	0.23																												
East Wolgan Downstream	21/12/2010																																				
East Wolgan Downstream	5/01/2011																																				
East Wolgan Downstream	18/01/2011					17.2	107	6.73	0.008	0.74																												
East Wolgan Downstream	2/02/2011																																				
East Wolgan Downstream	18/02/2011																																				
East Wolgan Downstream	2/03/2011																																				
East Wolgan Downstream	17/03/2011																																				
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East Wolgan Downstream	17/03/2011																																				
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East Wolgan Downstream	9/05/2011																																				
East Wolgan Downstream	25/05/2011																																				
East Wolgan Downstream	9/05/2011																																				
East Wolgan Downstream	25/05/2011																																				
East Wolgan Downstream	10/06/2011																																				
East Wolgan Downstream	22/06/2011																																				
East Wolgan Downstream	10/06/2011																																				
East Wolgan Downstream	22/06/2011																																				
East Wolgan Downstream	6/07/2011					6.6	76	6.73	0.133	1.89																												
East Wolgan Downstream	20/07/2011					7	98	6.37	0.131	2.06																												
East Wolgan Downstream	6/07/2011					6.6	76	6.73	0.133	1.89																												
East Wolgan Downstream	20/07/2011					7	98	6.37	0.131	2.06																												
East Wolgan Downstream	5/08/2011																																				
East Wolgan Downstream	17/08/2011																																				
East Wolgan Downstream	31/08/2011																																				
East Wolgan Downstream	5/08/2011																																				

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) mg/L	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
East Wolgan Downstream	17/08/2011																																				
East Wolgan Downstream	31/08/2011																																				
East Wolgan Downstream	14/09/2011				6.9	162	6.5	0.166	4.31																												
East Wolgan Downstream	28/09/2011																																				
East Wolgan Downstream	14/09/2011				6.9	162	6.5	0.166	4.31																												
East Wolgan Downstream	28/09/2011																																				
East Wolgan Downstream	12/10/2011																																				
East Wolgan Downstream	26/10/2011				10.6	104	6.92	0.007	0.58										0																		
East Wolgan Downstream	12/10/2011																																				
East Wolgan Downstream	26/10/2011				10.6	104	6.92	0.007	0.58										0																		
East Wolgan Downstream	10/11/2011																																				
East Wolgan Downstream	23/11/2011																																				
East Wolgan Downstream	10/11/2011																																				
East Wolgan Downstream	23/11/2011																																				
East Wolgan Downstream	5/12/2011																																				
East Wolgan Downstream	28/12/2011																																				
East Wolgan Downstream	5/12/2011																																				
East Wolgan Downstream	28/12/2011																																				
East Wolgan Downstream	5/01/2012																																				
East Wolgan Downstream	18/01/2012																																				
East Wolgan Downstream	31/01/2012				16.5	34	6.09	0.018	0.19										BD																		
East Wolgan Downstream	15/02/2012				13.8	54	6.72	0.02	0.17										BD																		
East Wolgan Downstream	13/03/2012				14	27	6.45	0.005	0.09																												
East Wolgan Downstream	28/03/2012																																				
East Wolgan Downstream	11/04/2012																																				
East Wolgan Downstream	24/04/2012																																				
East Wolgan Downstream	9/05/2012																																				
East Wolgan Downstream	25/05/2012				7.2	16	5.13																														
East Wolgan Downstream	6/06/2012				8.4	18	5.98	0.029	0.11																												
East Wolgan Downstream	20/06/2012				7.3	22	5.33	0.036	0.23																												
East Wolgan Downstream	6/07/2012				6.7	42	5.49	0.046	0.24																												
East Wolgan Downstream	18/07/2012				5.7	18	6.21	0.018	0.2																												
East Wolgan Downstream	31/07/2012				1.6	33	6.21	0.035	0.15																												
East Wolgan Downstream	13/08/2012																																				
East Wolgan Downstream	30/08/2012																																				
East Wolgan Downstream	10/09/2012																																				
East Wolgan Downstream	25/09/2012																																				
East Wolgan Downstream	8/10/2012																																				
East Wolgan Downstream	24/10/2012																																				
East Wolgan Downstream	7/11/2012				13.4														117																		
East Wolgan Downstream	22/11/2012																																				
East Wolgan Downstream	3/12/2012																																				
East Wolgan Downstream	17/12/2012																																				
East Wolgan Downstream	3/01/2013																																				
East Wolgan Downstream	16/01/2013																																				
East Wolgan Downstream	29/01/2013				19.2	34	5.36	0.396	0.62										0																		
East Wolgan Downstream																																					
East Wolgan Downstream	11/02/2013				19.3	25	6.3	0.194	0.29										0																		
East Wolgan Downstream	25/02/2013				16.5	53	6.2	0.014	0.3																												
East Wolgan Downstream																																					
East Wolgan Downstream	11/03/2013				16.2	55	6.07	0.054	0.42										0																		
East Wolgan Downstream	25/03/2013																																				
East Wolgan Downstream	9/04/2013				13.7	97	4.97	0.225	0.34																												
East Wolgan Downstream	22/04/2013				12.9	81	6.09	0.005	0.56																												
East Wolgan Downstream	6/05/2013																																				
East Wolgan Downstream	20/05/2013				8	157	5.91	0.455	0.74										0																		
East Wolgan Downstream	3/06/2013				8.1	13	6.12	0.012	<0.05										0																		
East Wolgan Downstream	18/06/2013				4.1	33	5.75	0.029	0.14										0																		
East Wolgan Downstream	1/07/2013				9.1	19	5.58	0.038	0.07										0																		
East Wolgan Downstream	19/07/2013				9.8	18	6.57	0.026	0.06										0																		
East Wolgan Downstream	30/07/2013				7	62	5.79	0.135	0.2										0																		
East Wolgan Downstream	13/08/2013				10.1	47	6.01	0.083	0.13																												
East Wolgan Downstream	30/08/2013																																				
East Wolgan Downstream	13/09/2013																																				
East Wolgan Downstream	25/09/2013																																				
East Wolgan Downstream	9/10/2013																																				
East Wolgan Downstream	24/10/2013																																				
East Wolgan Downstream	4/11/2013																																				
East Wolgan Downstream	18/11/2013				13.3	59	5.86	0.187	0.25										0																		
East Wolgan Downstream	3/12/2013																																				
East Wolgan Downstream	20/12/2013																																				
East Wolgan Downstream	31/12/2013																																				
East Wolgan Downstream	17/01/2014																																				
East Wolgan Downstream	30/01/2014																																				
East Wolgan Downstream	11/02/2014																																				
East Wolgan Downstream	27/02/2014																																				
East Wolgan Downstream	12/03/2014																																				
East Wolgan Downstream	26/03/2014				15.5	58	6.01	0.005	0.39	0.08					5	<0.001	<0.001						<1			0.01	<1		4			20	5				<0.005	0.007
East Wolgan Downstream	8/04/2014				14.6	39	6.38	0.051	0.67	0.53					2	<0.001	0.001	5.27	0				<1			<0.01	2		9			20	10				0.009	
East Wolgan Downstream	22/04/2014																																				
East Wolgan Downstream	5/05/2014																																				
East Wolgan Downstream	21/05/2014																																				
East Wolgan Downstream	4/06/2014																																				
East Wolgan Downstream	16/06/2014																																				

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) (mg/L)	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
East Wolgan Downstream	1/07/2014																																					
East Wolgan Downstream	15/07/2014																																					
East Wolgan Downstream	29/07/2014																																					
East Wolgan Downstream	12/08/2014																																					
East Wolgan Downstream	28/08/2014																																					
East Wolgan Downstream	10/09/2014																																					
East Wolgan Downstream	24/09/2014																																					
East Wolgan Downstream	9/10/2014			Dry																																		
East Wolgan Downstream	20/10/2014			Dry																																		
East Wolgan Downstream	5/11/2014			No Access																																		
East Wolgan Downstream	19/11/2014			Dry																																		
East Wolgan Downstream	3/12/2014			Dry																																		
East Wolgan Downstream	17/12/2014			Dry																																		
East Wolgan Downstream	31/12/2014			Dry																																		
East Wolgan Downstream	12/01/2015																																					
East Wolgan Downstream	28/01/2015																																					
East Wolgan Downstream	12/02/2015			Dry																																		
East Wolgan Downstream	26/02/2015			Dry																																		
East Wolgan Downstream	11/03/2015			Dry																																		
East Wolgan Downstream	26/03/2015			Dry																																		
East Wolgan Downstream	9/04/2015			Dry																																		
East Wolgan Downstream	22/04/2015	Low Flow	Clear	Flow too low for flow	10	7	5.87	0.007	0.48	0.32				<1		0.002	<0.001	9.55				<1				0.01	<1		4	4		85	1	0.4			0.038	
East Wolgan Downstream	6/05/2015			Dry																																		
East Wolgan Downstream	20/05/2015			Dry																																		
East Wolgan Downstream	3/06/2015			Dry																																		
East Wolgan Downstream	17/06/2015			Dry																																		
East Wolgan Downstream	30/06/2015			Dry																																		
East Wolgan Downstream	15/07/2015			Dry																																		
East Wolgan Downstream	29/07/2015			Dry																																		
East Wolgan Downstream	12/08/2015			Dry																																		
East Wolgan Downstream	18/08/2015			Dry																																		
East Wolgan Downstream	9/09/2015			Dry																																		
East Wolgan Downstream	23/09/2015			Dry																																		
East Wolgan Downstream	7/10/2015			Dry																																		
East Wolgan Downstream	21/10/2015			Dry																																		
East Wolgan Downstream	4/11/2015			Dry																																		
East Wolgan Downstream	18/11/2015			Dry																																		
East Wolgan Downstream	30/11/2015			Dry																																		
East Wolgan Downstream	16/12/2015			Dry																																		
East Wolgan Downstream	30/12/2015			Dry																																		
East Wolgan Downstream	13/01/2016			Dry																																		
East Wolgan Downstream	28/01/2016			Dry																																		
East Wolgan Downstream	10/02/2016			Dry																																		
East Wolgan Downstream	22/02/2016			Dry																																		
East Wolgan Downstream	8/03/2016			Dry																																		
East Wolgan Downstream	21/03/2016			Dry																																		
East Wolgan Downstream	6/04/2016			Dry																																		
East Wolgan Downstream	19/04/2016			Dry																																		
East Wolgan Downstream	2/05/2016			Dry																																		
East Wolgan Downstream	16/05/2016			Dry																																		
East Wolgan Downstream	30/05/2016			Dry																																		
East Wolgan Downstream	15/06/2016			Dry																																		
East Wolgan Downstream	29/06/2016			Dry																																		
East Wolgan Downstream	11/07/2016			Dry																																		
East Wolgan Downstream	27/07/2016			Dry																																		
East Wolgan Downstream	10/08/2016			Dry																																		
East Wolgan Downstream	24/08/2016			Dry																																		
East Wolgan Downstream	7/09/2016			Dry																																		
East Wolgan Downstream	21/09/2016			Dry																																		
East Wolgan Downstream	5/10/2016			Dry																																		
East Wolgan Downstream	20/10/2016			Dry																																		
East Wolgan Downstream	2/11/2016			Dry																																		
East Wolgan Downstream	17/11/2016			Dry																																		
East Wolgan Downstream	28/11/2016			Dry																																		
East Wolgan Downstream	12/12/2016			Dry																																		
East Wolgan Downstream	29/12/2016			Dry																																		
East Wolgan Downstream	10/01/2017			Dry																																		
East Wolgan Downstream	25/01/2017			Dry																																		
East Wolgan Downstream	5/10/2017		Dry																																		
East Wolgan Downstream	19/10/2017		Dry																																		
East Wolgan Downstream	30/10/2017		Dry																																		
East Wolgan Downstream	14/11/2017			Dry																																		
East Wolgan Downstream	30/11/2017			Dry																																		
East Wolgan Downstream	14/12/2017			Dry																																		
East Wolgan Downstream	28/12/2017			Dry																																		
East Wolgan Downstream	9/02/2017			Dry																																		
East Wolgan Downstream	21/02/2017			Dry																																		
East Wolgan Downstream	9/03/2017			Dry																																		
East Wolgan Downstream	21/03/2016			Dry																																		
East Wolgan Downstream	6/04/2017			Dry																																		
East Wolgan Downstream	20/04/2017			Dry																																		
East Wolgan Downstream	11/05/2017			Dry																																		
East Wolgan Downstream	25/05/2017			Dry																																		
East Wolgan Downstream	15/06/2017			Dry																																		

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) (mg/L)	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
East Wolgan Downstream	27/06/2017			Dry																																		
East Wolgan Downstream	13/07/2017			Dry																																		
East Wolgan Downstream	25/07/2017			Dry																																		
East Wolgan Downstream	10/08/2017			Dry																																		
East Wolgan Downstream	25/08/2017			Dry																																		
East Wolgan Downstream	7/09/2017			Dry																																		
East Wolgan Downstream	18/09/2017			Dry																																		
East Wolgan Downstream	10/01/2018			Dry																																		
East Wolgan Downstream	23/01/2018			Dry																																		
East Wolgan Downstream	7/02/2018			Dry																																		
East Wolgan Downstream	19/02/2018			Dry																																		
East Wolgan Downstream	7/03/2018			Dry																																		
East Wolgan Downstream	21/03/2018			Dry																																		
East Wolgan Downstream	4/04/2018			Dry																																		
East Wolgan Downstream	17/04/2018			Dry																																		
East Wolgan Downstream	2/05/2018			Dry																																		
East Wolgan Downstream	17/05/2018			Dry																																		
East Wolgan Downstream	30/05/2018			Dry																																		
East Wolgan Downstream	12/06/2018			Dry																																		
East Wolgan Downstream	29/06/2018			Dry																																		
East Wolgan Downstream	12/07/2018			Dry																																		
East Wolgan Downstream	26/07/2018			Dry																																		
East Wolgan Downstream	9/08/2018			Dry																																		
East Wolgan Downstream	23/08/2018			Dry																																		
East Wolgan Downstream	6/09/2018			Dry																																		
East Wolgan Downstream	17/09/2018			Dry																																		
East Wolgan Downstream	4/10/2018			Dry																																		
East Wolgan Downstream	15/10/2018			Dry																																		
East Wolgan Downstream	1/11/2018			Dry																																		
East Wolgan Downstream	15/11/2018			Dry																																		
East Wolgan Downstream	29/11/2018		Dry																																		
East Wolgan Downstream	13/12/2018		Dry																																		
East Wolgan Downstream	27/12/2018		Dry																																		
East Wolgan Downstream	10/01/2019			Dry																																		
East Wolgan Downstream	24/01/2019			Dry																																		
East Wolgan Downstream	6/02/2019			Dry																																		
East Wolgan Downstream	20/02/2019			Dry																																		
East Wolgan Downstream	4/03/2019			Dry																																		
East Wolgan Downstream	21/03/2019			Dry																																		
East Wolgan Downstream	1/04/2019			Dry																																		
East Wolgan Downstream	17/04/2019			Dry																																		
East Wolgan Downstream	1/05/2019			Dry																																		
East Wolgan Downstream	15/05/2019			Dry																																		
East Wolgan Downstream	29/05/2019			Dry																																		
East Wolgan Upstream	6/07/2012																																					
East Wolgan Upstream	18/07/2012																																					
East Wolgan Upstream	31/07/2012																																					
East Wolgan Upstream	13/08/2012																																					
East Wolgan Upstream	30/08/2012																																					
East Wolgan Upstream	10/09/2012																																					
East Wolgan Upstream	25/09/2012																																					
East Wolgan Upstream	8/10/2012																																					
East Wolgan Upstream	24/10/2012																																					
East Wolgan Upstream	7/11/2012																																					
East Wolgan Upstream	22/11/2012																																					
East Wolgan Upstream	3/12/2012																																					
East Wolgan Upstream	17/12/2012																																					
East Wolgan Upstream	3/01/2013																																					
East Wolgan Upstream	16/01/2013																																					
East Wolgan Upstream	29/01/2013																																					
East Wolgan Upstream	11/02/2013																																					
East Wolgan Upstream	25/02/2013																																					
East Wolgan Upstream	11/03/2013																																					
East Wolgan Upstream	25/03/2013																																					
East Wolgan Upstream	9/04/2013																																					
East Wolgan Upstream	22/04/2013																																					
East Wolgan Upstream	6/05/2013																																					
East Wolgan Upstream	20/05/2013																																					
East Wolgan Upstream	3/06/2016																																					
East Wolgan Upstream	18/06/2013																																					
East Wolgan Upstream	1/07/2013																																					
East Wolgan Upstream	19/07/2013																																					
East Wolgan Upstream	30/07/2013																																					
East Wolgan Upstream	13/08/2013																																					
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East Wolgan Upstream	13/09/2013																																					
East Wolgan Upstream	25/09/2013																																					
East Wolgan Upstream	9/10/2013																																					
East Wolgan Upstream	24/10/2013																																					
East Wolgan Upstream	4/11/2013																																					
East Wolgan Upstream	18/11/2013																																					
East Wolgan Upstream	3/12/2013																																					
East Wolgan Upstream	20/12/2013																																					
East Wolgan Upstream	31/12/2013																																					

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) (mg/L)	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
East Wolgan Upstream	17/01/2014																																				
East Wolgan Upstream	30/01/2014																																				
East Wolgan Upstream	11/02/2014																																				
East Wolgan Upstream	27/02/2014																																				
East Wolgan Upstream	12/03/2014																																				
East Wolgan Upstream	26/03/2014																																				
East Wolgan Upstream	8/04/2014																																				
East Wolgan Upstream	22/04/2014																																				
East Wolgan Upstream	5/05/2014																																				
East Wolgan Upstream	21/05/2014																																				
East Wolgan Upstream	4/06/2014																																				
East Wolgan Upstream	16/06/2014																																				
East Wolgan Upstream	1/07/2014																																				
East Wolgan Upstream	15/07/2014																																				
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East Wolgan Upstream	12/08/2014																																				
East Wolgan Upstream	28/08/2014																																				
East Wolgan Upstream	10/09/2014																																				
East Wolgan Upstream	24/09/2014																																				
East Wolgan Upstream	4/02/2008																																				
East Wolgan Upstream	21/02/2008																		0																		
East Wolgan Upstream	3/03/2008																		0																		
East Wolgan Upstream	19/03/2008																		0																		
East Wolgan Upstream	2/04/2008																		0																		
East Wolgan Upstream	15/04/2008																		0																		
East Wolgan Upstream	29/04/2008																																				
East Wolgan Upstream	13/05/2008					19.1	907	8.4	0.003	0.16									9933																		
East Wolgan Upstream	27/05/2008					20.7	1000	8.4	0.002	0.21									13979																		
East Wolgan Upstream	10/06/2008																																				
East Wolgan Upstream	24/06/2008																		0																		
East Wolgan Upstream	10/06/2008																																				
East Wolgan Upstream	24/06/2008																		0																		
East Wolgan Upstream	8/07/2008					17.8	1040	8.4	0.002	0.11									5467																		
East Wolgan Upstream	22/07/2008					16.3	987	8.4	0.002	0									4988																		
East Wolgan Upstream	6/08/2008					11.3	912	7.8	0.004	0.2									66																		
East Wolgan Upstream	20/08/2008																																				
East Wolgan Upstream	2/09/2008	Mod flow				17.2	1030	8.4	0.002	0.12									11332																		
East Wolgan Upstream	18/09/2008	High flow				19.5	950	8.6	0.003	0.06									10204																		
East Wolgan Upstream	2/10/2008	Mod flow				21.7	990	8.5	0.005	0.11									3750																		
East Wolgan Upstream	15/10/2008	High flow				20.6	960	8.5	0.005	0.12									4417																		
East Wolgan Upstream	27/10/2008	High flow				20.8	970	8.5	0.004	0.13									8489																		
East Wolgan Upstream	11/11/2008	High flow				21.2	864	8.3	0.005	0.11									8698																		
East Wolgan Upstream	26/11/2008	High flow				21.1	857	8.4	0.005	0.11									9525																		
East Wolgan Upstream	8/12/2008	Mod flow				21.6	664	8.7	0.007	0.12									4969																		
East Wolgan Upstream	22/12/2008	High flow				21.7	848	8.7	0.005	0.13									10325																		
East Wolgan Upstream	8/01/2009	High flow				23.5	930	8.7	0.005	0.14									10567																		
East Wolgan Upstream	21/01/2009	High flow				23.6	835	8.7	0.005	0.24									17096																		
East Wolgan Upstream	3/02/2009	High flow				24.3	823	8.6	0.003	0.14									16589																		
East Wolgan Upstream	19/02/2009	No flow																	0																		
East Wolgan Upstream	3/03/2009	No flow																																			
East Wolgan Upstream	17/03/2009	No flow																																			
East Wolgan Upstream	8/04/2009	No flow, insu																																			
East Wolgan Upstream	16/04/2009	No flow																																			
East Wolgan Upstream	28/04/2009	Low flow				15.8	779	7.9	0.008	0.29									367																		
East Wolgan Upstream	12/05/2009	No flow																																			
East Wolgan Upstream	NS																																				
East Wolgan Upstream	11/06/2009																																				
East Wolgan Upstream	23/06/2009																																				
East Wolgan Upstream	7/07/2009																																				
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East Wolgan Upstream	7/12/2009																		0																		
East Wolgan Upstream	23/12/2009																		0																		
East Wolgan Upstream	6/01/2010																																				
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East Wolgan Upstream	10/06/2010																																				
East Wolgan Upstream	23/06/2010																																				

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) (mg/L)	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
East Wolgan Upstream	6/07/2010																																					
East Wolgan Upstream	20/07/2010																																					
East Wolgan Upstream	4/08/2010																		0																			
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East Wolgan Upstream	21/12/2010																																					
East Wolgan Upstream	5/01/2011																																					
East Wolgan Upstream	18/01/2011																																					
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East Wolgan Upstream	29/03/2011																																					
East Wolgan Upstream	15/04/2011																																					
East Wolgan Upstream	27/04/2011																																					
East Wolgan Upstream	15/04/2011																																					
East Wolgan Upstream	27/04/2011																																					
East Wolgan Upstream	9/05/2011																																					
East Wolgan Upstream	25/05/2011						5.49																															
East Wolgan Upstream	9/05/2011																																					
East Wolgan Upstream	25/05/2011						5.49																															
East Wolgan Upstream	10/06/2011																																					
East Wolgan Upstream	22/06/2011																																					
East Wolgan Upstream	10/06/2011																																					
East Wolgan Upstream	22/06/2011																																					
East Wolgan Upstream	6/07/2011																																					
East Wolgan Upstream	20/07/2011																																					
East Wolgan Upstream	6/07/2011																																					
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East Wolgan Upstream	23/11/2011																																					
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East Wolgan Upstream	28/12/2011																																					
East Wolgan Upstream	5/12/2011																																					
East Wolgan Upstream	28/12/2011																																					
East Wolgan Upstream	5/01/2012																																					
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East Wolgan Upstream	20/06/2012																																					
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East Wolgan Upstream	18/07/2012																																					
East Wolgan Upstream	31/07/2012																																					
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East Wolgan Upstream	30/08/2012																																					
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East Wolgan Upstream	24/10/2012																																					
East Wolgan Upstream	7/11/2012																																					
East Wolgan Upstream	22/11/2012																																					

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) (mg/L)	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
East Wolgan Upstream	3/12/2012																																					
East Wolgan Upstream	17/12/2012																																					
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East Wolgan Upstream	25/03/2013																																					
East Wolgan Upstream	9/04/2013																																					
East Wolgan Upstream	22/04/2013																																					
East Wolgan Upstream	6/05/2013																																					
East Wolgan Upstream	20/05/2013				9.9																																	
East Wolgan Upstream	3/06/2013																																					
East Wolgan Upstream	18/06/2013																																					
East Wolgan Upstream	1/07/2013																																					
East Wolgan Upstream	19/07/2013																																					
East Wolgan Upstream	30/07/2013																																					
East Wolgan Upstream	13/08/2013																																					
East Wolgan Upstream	30/08/2013																																					
East Wolgan Upstream	13/09/2013																																					
East Wolgan Upstream	25/09/2013																																					
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East Wolgan Upstream	24/10/2013																																					
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East Wolgan Upstream	31/12/2013																																					
East Wolgan Upstream	17/01/2014																																					
East Wolgan Upstream	30/01/2014																																					
East Wolgan Upstream	11/02/2014																																					
East Wolgan Upstream	27/02/2014																																					
East Wolgan Upstream	12/03/2014																																					
East Wolgan Upstream	26/03/2014																																					
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East Wolgan Upstream	5/05/2014																																					
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East Wolgan Upstream	28/08/2014																																					
East Wolgan Upstream	10/09/2014																																					
East Wolgan Upstream	24/09/2014																																					
East Wolgan Upstream	9/10/2014			Dry																																		
East Wolgan Upstream	20/10/2014			Dry																																		
East Wolgan Upstream	5/11/2014			Dry																																		
East Wolgan Upstream	19/11/2014			Dry																																		
East Wolgan Upstream	3/12/2014			Dry																																		
East Wolgan Upstream	17/12/2014			Dry																																		
East Wolgan Upstream	31/12/2014			Dry																																		
East Wolgan Upstream	12/01/2015																																					
East Wolgan Upstream	28/01/2015																																					
East Wolgan Upstream	12/02/2015			Dry																																		
East Wolgan Upstream	26/02/2015			Dry																																		
East Wolgan Upstream	11/03/2015			Dry																																		
East Wolgan Upstream	26/03/2015			Dry																																		
East Wolgan Upstream	9/04/2015			Dry																																		
East Wolgan Upstream	22/04/2015	Mod Flow	Clear		10.4	49	4.7	0.056	0.22	0.44				<1		0.003	<0.001	9.48	369			<1					<0.01	1		2	4		<5	<5	0.5			0.008	
East Wolgan Upstream	6/05/2015			Dry																																		
East Wolgan Upstream	20/05/2015			Dry																																		
East Wolgan Upstream	3/06/2015			Dry																																		
East Wolgan Upstream	17/06/2015			Dry																																		
East Wolgan Upstream	30/06/2015			Dry																																		
East Wolgan Upstream	15/07/2015			Dry																																		
East Wolgan Upstream	29/07/2015			Dry																																		
East Wolgan Upstream	12/08/2015			Dry																																		
East Wolgan Upstream	18/08/2015			Dry																																		
East Wolgan Upstream	9/09/2015			Dry																																		
East Wolgan Upstream	23/09/2015			Dry																																		
East Wolgan Upstream	7/10/2015			Dry																																		
East Wolgan Upstream	21/10/2015			Dry																																		
East Wolgan Upstream	4/11/2015			Dry																																		
East Wolgan Upstream	18/11/2015			Dry																																		
East Wolgan Upstream	30/11/2015			Dry																																		
East Wolgan Upstream	16/12/2015			Dry																																		
East Wolgan Upstream	30/12/2015			Dry																																		
East Wolgan Upstream	13/01/2016			Dry																																		

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) (mg/L)	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
East Wolgan Upstream	28/01/2016			Dry																																		
East Wolgan Upstream	10/02/2016			Dry																																		
East Wolgan Upstream	22/02/2016			Dry																																		
East Wolgan Upstream	8/03/2016			Dry																																		
East Wolgan Upstream	21/03/2016			Dry																																		
East Wolgan Upstream	6/04/2016			Dry																																		
East Wolgan Upstream	19/04/2016			Dry																																		
East Wolgan Upstream	2/05/2016			Dry																																		
East Wolgan Upstream	16/05/2016			Dry																																		
East Wolgan Upstream	30/05/2016			Dry																																		
East Wolgan Upstream	15/06/2016			Dry																																		
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East Wolgan Upstream	7/09/2016			Dry																																		
East Wolgan Upstream	21/09/2016			Dry																																		
East Wolgan Upstream	5/10/2016			Dry																																		
East Wolgan Upstream	20/10/2016			Dry																																		
East Wolgan Upstream	2/11/2016			Dry																																		
East Wolgan Upstream	17/11/2016			Dry																																		
East Wolgan Upstream	28/11/2016			Dry																																		
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East Wolgan Upstream	29/12/2016			Dry																																		
East Wolgan Upstream	10/01/2017			Dry																																		
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East Wolgan Upstream	19/10/2017		Dry																																		
East Wolgan Upstream	30/10/2017		Dry																																		
East Wolgan Upstream	14/11/2017			Dry																																		
East Wolgan Upstream	30/11/2017			Dry																																		
East Wolgan Upstream	14/12/2017			Dry																																		
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East Wolgan Upstream	10/01/2018			Dry																																		
East Wolgan Upstream	23/01/2018			Dry																																		
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East Wolgan Upstream	19/02/2018			Dry																																		
East Wolgan Upstream	7/03/2018			Dry																																		
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East Wolgan Upstream	4/04/2018			Dry																																		
East Wolgan Upstream	17/04/2018			Dry																																		
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East Wolgan Upstream	17/09/2018			Dry																																		
East Wolgan Upstream	4/10/2018			Dry																																		
East Wolgan Upstream	15/10/2018			Dry																																		
East Wolgan Upstream	1/11/2018			Dry																																		
East Wolgan Upstream	15/11/2018			Dry																																		
East Wolgan Upstream	29/11/2018		Dry																																		
East Wolgan Upstream	13/12/2018		Dry																																		
East Wolgan Upstream	27/12/2018		Dry																																		
East Wolgan Upstream	10/01/2019			Dry																																		
East Wolgan Upstream	24/01/2019			Dry																																		
East Wolgan Upstream	6/02/2019			Dry																																		
East Wolgan Upstream	20/02/2019			Dry																																		
East Wolgan Upstream	4/03/2019			Dry																																		
East Wolgan Upstream	21/03/2019			Dry																																		
East Wolgan Upstream	1/04/2019			Dry																																		
East Wolgan Upstream	17/04/2019			Dry																																		

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) mg/L	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
East Wolgan Upstream	1/05/2019			Dry																																		
East Wolgan Upstream	15/05/2019			Dry																																		
East Wolgan Upstream	29/05/2019			Dry																																		
Firetail	24/11/2017	Low Flow	Clear		12.7	28	4.7	0.009	0.15										169													<5						
Firetail	8/12/2017	Low Flow	Clear		13.6	37	5.3	0.008	0.1	0.07	<0.001	<0.05	<0.0001	<1	9	<0.001	<0.001	7.1	301		<0.001	<1		<0.0001	<0.001	<0.01	<1	219	4	<1	32	9	<1	0.1	0.07	1.6	<0.005	
Firetail	21/12/2017	Low Flow	Clear	Too Low for Flow Mo	13.3	37	4.7											5.6										412								7.7		
Firetail	3/01/2018	Low Flow	Clear	Too low for flow mon	16.4	39	5	0.017	0.25	0.07	<0.001	<0.05	<0.0001	<1	8	<0.001	<0.001	6.3			<0.001	<1		<0.0001	<0.001	<0.01	<1	350	4	<1	33	<5	4	0.3	<0.01	1.7	0.014	
Firetail	19/01/2018			Dry																																		
Firetail	30/01/2018		Clear		19.7	30	5.1											4.7										280								4.34		
Firetail	12/02/2018		Cloudy	Stagnant No flow	16.5	30	5.4	0.029	0.14	0.07	<0.001	<0.05	<0.0001	<1	7	<0.001	<0.001	5.2			<0.001	<1		<0.0001	<0.001	0.02	<1	285	5	<1	22	223	<1	0.2	<0.01		0.006	
Firetail	27/02/2018	Mod Flow	Clear		12.7	32	4.9											7.3	439									241								1.1		
Firetail	16/03/2018	LowFlow	Cloudy		14.9	45	5.1	0.058	1.24	0.11	<0.001	<0.05	<0.0001	<1	7	<0.001	<0.001	4.8	223		<0.001	<1		<0.0001	<0.001	<0.01	<1	168	4	1	58		<1	3.6	0.68	0.7	<0.005	
Firetail	26/03/2018	Mod Flow	Clear		12.7	39	4.9											7.4	732									261								0.7		
Firetail	11/04/2018	Low Flow	Clear	Too low for flow mon	19.2	32	5	0.011	<0.05	0.05	<0.001	<0.05	<0.0001	<1	7	<0.001	<0.001	6.2			<0.001	<1		<0.0001	<0.001	0.02	<1	360	3	<1	<10	<5	<1	<0.1	<0.01		<0.005	
Firetail	23/04/2018	Low Flow	Clear	Too low for flow mon	12.9	33	5.2											6.9										511								0.6		
Firetail	10/05/2018	Low flow	Clear	Too Low For Flow	7.4	50	4.4	0.01	0.08	0.05	<0.001	<0.05	<0.0001	<1	6	<0.001	0.001	7.2			<0.001	<1		<0.0001	<0.001	0.04	<1	441	4	<1			1	<0.1	0.01		0.007	
Firetail	21/05/2018	Low flow	Clear	Too Low for flow	5.7	63	4.5											6.7										238								1.3		
Firetail	5/06/2018	Low Flow	Clear	Too low for flow mon	6.5	35	5.3	0.006	0.06	0.04	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	8.3			<0.001	<1		<0.0001	<0.001	0.03	<1	312	4	<1	16	<5	<1	<0.1	<0.01		<0.005	
Firetail	18/06/2018	Low flow	Clear	Too low for flow mon	5.2	39	5.2											9.6										340								2.5		
Firetail	3/07/2018	Mod Flow	Clear		6.3	38	6.3	0.006	0.07	0.08	<0.001	<0.05	<0.0001	<1	8	<0.001	<0.001	7.8	138.24		<0.001	<1		<0.0001	<0.001	0.02	<1	364	4	1	19	<5	<1	<0.1	<0.01		0.011	
Firetail	20/07/2018	Low flow	Clear	Too low for flow mon	2.7	77	4.5											8.3										280								3.8		
Firetail	1/08/2018	Low Flow	Clear	Too low for flow mon	4.2	54	9	0.006	0.07	0.05	<0.001	<0.05	<0.0001	<1	7	<0.001	0.002	8.6			<0.001	<1		<0.0001	<0.001	<0.01	<1	368	7	1	35	32	<1	0.4	<0.01		0.013	
Firetail	17/08/2018	Low Flow	Clear	Too low for flow mon	3.8	39	4.6											9										409								0.45		
Firetail	28/08/2018	Low Flow	Clear	Depth too low for flo	4.4	41	7											8.7										256								0.75		
Firetail	11/09/2018	Low Flow	Clear		6.8	43	6.1	0.003	0.05	0.08	<0.001	<0.05	<0.0001	<1	8	<0.001	<0.001	9.3	190.08	<0.1	<0.001	<1		<0.0001	<0.001	<0.01	<1	306	5	2	8	<5	<1	<0.1	<0.01	0.4	0.014	
Firetail	25/09/2018	Low Flow	Clear	Depth to Low for flow	4	41	4.6											9										400								3		
Firetail	10/10/2018	Low Flow	Clear	Depth too low for flo	7.5	39	6											8.2										382								23		
Firetail	5/11/2018	Low Flow	Clear	Depth too low for flo	11.8	47	4.6		0.14	0.08	<0.001	<0.05	<0.0001	<1	12	<0.001	<0.001	7		<0.1	<0.001	<1		<0.0001	<0.001	<0.01	<1	392	8	2	32	<5		<0.1	0.12	0.75	0.011	
Firetail	20/11/2018	Low flow	Clear	Depth too low to reco	11.5	44	4.8											7.3										432								2.7		
Firetail	6/12/2018	Low flow	Clear		10.4	43	5.2		0.1	0.09	<0.001	<0.05	<0.0001	<1	8	<0.001	<0.001	7.5	8.6	<0.1	<0.001	<1		<0.0001	<0.001	<0.01	<1	342	5	2	28	<5		0.2	<0.01	0.7	<0.005	
Firetail	19/12/2018	Low flow	Clear	Redox meter malfunc	13.2	36	7.3											11.1	25.92																	1.2		
Firetail	2/01/2018			Dry																																		
Firetail	18/01/2019		Stagnent	Depth too low to reco	31	36	4.4											3.6										296								20		
Firetail	31/01/2019	Low Flow	Clear	Depth too low to reco	16.2	39	6.6											6.5										413								3.2		
Firetail	11/02/2019	Low flow		Depth too low to reco	16.1	36	5.3		1.36	0.14	<0.001	<0.05	<0.0001	<1	7	<0.001	<0.001	19		<0.1	<0.001	<1		<0.0001	<0.001	<0.01	<1	289	4	<1	37	86		0.3	<0.01	2.2	0.01	
Firetail	28/02/2019			Dry																																		
Firetail	14/03/2019		Dry																																			
Firetail	28/03/2019	Low flow	Clear		13.7	35	5.9											8.3										244								0.67		
Firetail	8/04/2019	Low flow	Clear		12.3	42	7.5		0.09	0.09	<0.001	<0.05	<0.0001	<1	8	<0.001	<0.001	6.2	61	<0.1	<0.001	<1		<0.0001	<0.001	<0.01	<1	352	4	3	15	<5		<0.1	0.02	0.94	0.028	
Firetail	24/04/2019	Low flow	Clear	Depth too low for flo	13.6	48	6.1											9.2										366								0.7		
Firetail	9/05/2019	Low Flow	Clear	Depth too low for flo	12.9	30	4.9		0.08	0.06	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	8		<0.1	0.001	<1		<0.0001	<0.001	<0.01	<1	307	4	<1	27	<5		0.1	0.01	7.5	<0.005	
Firetail	20/05/2019	Low flow	Clear	Depth too low for flo	9.6	43	4.7											6										423			27	15				5.7		
Tri Star	22/03/2016	Mod Flow	Clear		13.3	26	5.95	0.01	0.28	0.05	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	9.64	185		<0.001	<1		<0.0001	<0.001	<0.01	<1	420	3	<1			<1	0.1	<0.01	8	<0.005	
Tri Star	5/04/2016	Mod Flow	Clear		12.9	23	5.89	0.011	0.24	0.04	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	9.56	199		<0.001	<1		<0.0001	<0.001	<0.01	<1	299	3	<1	12	<5	1	<0.1	<0.01	5	<0.005	
Tri Star	20/04/2016	Mod Flow	Clear		12.9	25	5.97											9.39	189									198								23		
Tri Star	3/05/2016	Low Flow	Clear		10.9	22	5.84	0.01	0.19	0.16	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	10.19	181		<0.001	<1		<0.0001	<0.001	0.02	<1	220	3	<1	26	<5	<1	0.2	<0.01	4	0.012	
Tri Star	17/05/2016	Low Flow	Clear		9.8	23	5.67											10.56	228									203								2		
Tri Star	30/05/2016	Mod Flow	Clear		6.2	24	6.04											11.26										220								2		
Tri Star	14/06/2016	Mod Flow	Clear		6.4	26	5.11	0.01	0.18	0.05	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	10.98	472		<0.001	<1		<0.0001	<0.001	<0.01	<1	221	3	<1	48	<5	<1	<0.1	0.02	3	<0.005	
Tri Star	29/06/2016	Mod Flow	Clear		5.7	31	6.21											10.76	602																	3		
Tri Star	13/07/2016	High Flow	Clear		7.9	24	5.31	0.011	0.12	0.04	<0.001	<0.05	0.0001	<1	5	<0.001	<0.001	11.28	620		<0.001	<1		<0.0001	<0.001	0.07	<1	161	3	3	40	<5	<1	<0.1	<0.01	4	<0.005	
Tri Star	27/07/2016	Mod Flow	Clear		7.8	26	5.21											11.43	673																	3		
Tri Star	10/08/2016	Low Flow	Clear		6.9	26	5.48	0.009	0.16	0.05	<0.001	<0.05	<0.0001	<1	3	<0.001	0.002	11.16	974		<0.001	<1		<0.0001	<0.001	0.04	<1	180	3	<1	39	<5	<1	<0.1	<0.01	2	<0.005	
Tri Star	24/08/2016	Mod Flow	Clear		7.3	30	7.02											10.99	539									120								1		
Tri Star	7/09/2016	Mod Flow	Clear		7.4	28	7.07	0.008	0.17	0.1	<0.001	<0.05	<0.0001	<1	5	<0.001	0.002	9.38	999		<0.001	<1		<0.0001	<0.001	<0.01	<1	179	3	2	16	<5	1	<0.1	<0.01	3	<0.005	
Tri Star	21/09/2016	Mod Flow	Clear		8.4	32	7.04											10.35	298									400								13		
Tri Star	5/10/2016	Mod Flow	Clear		8.6	29.8	5.35	0.01	0.22	0.06	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	10.09	398		<0.001	<1		<0.0001	<0.001	<0.01	<1	277	3	<1	37	<5	2	<0.1	<0.01	3	<0.005	
Tri Star	19/10/2016	Mod Flow	Clear		9.5	21	5.75	0.01	0.22	0.06	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	10.46			<0.001	<1		<0.0001	<0.001	<0.01	<1	277	3	<1			2	<0.1	<0.01		<0.005	
Tri Star	6/10/2017	Mod Flow	Clear		6.2	26	5.9	0.01	0.23	0.06	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	10.3	231		<0.001	<1		<0.0001	<0.001	0.04	<1	303	3	<1	27	<5	5	<0.1	<0.01	5.2	<0.005	
Tri Star	17/10/2017	Low Flow	Clear	Too low for flow mon	12.9	45	5.8											8.7	299									110										
Tri Star	1/11/2017	Low Flow	Clear		9.5	65	5.4	0.012	0.22	0.04	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	8.5	299		<0.001	<1		<0.0001	<0.001	0.04	<1	385	3	<1	34	5	<1	0.2	<0.01	3.9	<0.005	
Tri Star	15/11/2017	Low Flow	Clear	Too low for flow mon	10.1	33	6.9											7										269										
Tri Star	6/03/2017	Mod Flow	Clear		13.3	37	6.3	0.017	0.24	0.07	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	9.98	1285		<0.001	<1		<0.0001	<0.001	0.03	<1	230	3	<1	30	12	<1	0.2	0.05	6	<0.005	
Tri Star	20/03/2017	Low Flow	Clear		14.4	19	4.95											8.73	342									230								5		
Tri Star	5/04/2017	Mod Flow	Clear		12.2	24	6.72	0.017	0.37	0.08	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	9.86	680		<0.001	<1		<0.0001	<0.001	<0.01	<1	280	4	<1	36	<5	<1	<0.1	<0.01	3	<0.005	
Tri Star	19/04/2017	Low Flow	Clear		11.5	25	7.03											9.62	254									338								4		
Tri Star	8/05/2017	Low Flow	Clear		8.5	28	6.92	0.014	0.07	0.06	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	8.01	722		<0.001	<1		<0.0001	<0.001	<0.01	<1	302	4	8	44	<5	<1	<0.1	<0.01	3	<0.005	
Tri Star	23/05/2017	Low Flow	Clear		11.7	28	5.86											7.78	622									324								5		
Tri Star	13/06/2017	Mod Flow	Clear		8.4	33	5.09	0.007	0.08	0.04	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	10.55	1255		<0.001	<1		<0.0001	0.003	0.03	<1	255	3	<1	40	<5	<1	<0.1	0.02	2.1	<0.005	
Tri Star	26/06/2017	Low Flow	Clear		5	36	7.4											9.46	284									242								4.2		
Tri Star	10/07/2017	Mod Flow	Clear		5.5	25	5.9	0.013	0.15	0.03	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	9.9	312		<0.001	<1		<0.0001	<0.001	<0.01	<1	437	2	<1	11	<5	<1	<0.1	<0.01	1.2	<0.005	
Tri Star	24/07/2017	Mod Flow	Clear		7.2	61	7.5											10.2	410									437								1.2		
Tri Star	9/08/2017	Mod Flow	Clear		6	26	6.4	0.005	0.13	0.03	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	9.8	260		<0.001	<1		<0.0001	<0.001	0.01	<1	421	2	<1	<10	<5	1	<0.1	<0.01	1.1	<0.005	
Tri Star	23/08/2017	Mod Flow	Clear		7.8	50	7											9.9	258									498								0.78		
Tri Star	6/09/2017	Low Flow	Clear		5.5	25	7.4	0.01	0.2	0.03	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	9.9	263		<0.001	<1		<0.0001	<0.001	0.02	<1	334	3	<1	24	<5	<1	<0.1	<0.01	2.8	<0.005	
Tri Star	19/09/2017	Mod Flow	Clear		5.3	20	5.6											9.7	245									461								3.1		
Tri Star (Angus Place Site)	6/02/2018	Mod Flow	Clear		19.8	22	8.3	0.013	0.22	0.05	<0.001	<0.05	<0.0001	<1	3	<0.001	<0.001	7.3	353		<0.001	<1		<0.0001	<0.001	<0.01	<1	223	4	<1	<10	<5	1	0.1	<0.01		<0.005	
Tri Star (Angus Place Site)	19/02/2018	Low Flow	Clear		16.3	37	5.9												377																	7.9		
Tri Star (Angus Place Site)	5/03/2018	Low Flow	Clear		15	10	6.2	0.009	0.35	0.11	<0.001	<0.05	<0.0001	<1	7	<0.001	<0.001	7.1	258		<0.001	<1		0.0002	<0.001	0.05	<1	399	3	<1	36	9	3	0.6	<0.01		0.006	
Tri Star (Angus Place Site)	19/03/2018	Mod Flow	Clear		9.9	16	6.1											8.6	485									294								2.5		
Tri Star (Angus Place Site)	3/04/2018	Mod Flow	Clear		14.2	26	7	0.011	0.19	0.04	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	7.9	439		<0.001	<1		<0.0001	<0.001	0.02	<1	492	5	<1	<10	11	<1	<0.1	<0.01		<0.005	
Tri Star (Angus Place Site)	18/04/2018	Mod Flow	Clear		11.3	20	6.4											7.3	301									462								3		
Tri Star (Angus Place Site)	3/05/2018	Mod Flow	Clear		6.7	25	5.5	0.01	0.15	0.03	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	8.9	311		<0.001	<1		<0.0001	<0.001	<0.01	<1	293	3	<1	27	<5	<1	<0.1	<0.01		<0.005	
Tri Star (Angus Place Site)	16/05/2018	Mod Flow	Clear		5.8	34	5.4											8.9	286									409								2.3		

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) mg/L	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
Tri Star (Angus Place Site)	28/05/2018	Mod Flow	Clear		5	30	8.3	0.01	0.13	0.03	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	8.6	208		<0.001	<1		<0.0001	<0.001	<0.01	<1	250	3	1	16	5	<1	<0.1	<0.01		<0.005	
Tri Star (Angus Place Site)	15/06/2018	Mod Flow	Clear		5.2	25	6.1											9.2	198.12									360								1.5		
Tri Star (Angus Place Site)	27/06/2018	Mod Flow	Clear		4.9	27	5.9											9.1	241.92									322								1.6		
Tri Star (Angus Place Site)	11/07/2018	Mod Flow	Clear		1.5	28	7.5	0.008	0.13	0.03	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	9.9	3741.12		<0.001	<1		<0.0001	<0.001	0.02	<1	351	3	4	16	<5	<1	<0.1	<0.01		<0.005	
Tri Star (Angus Place Site)	24/07/2018	Low Flow	Clear	Too low for flow mon	9.3	26	3.4											7.9										402								1.3		
Tri Star (Angus Place Site)	7/08/2018	Mod Flow	Clear		2.1	31	5.3	0.018	0.16	0.07	<0.001	<0.05	<0.0001	<1	8	<0.001	<0.001	7.9	545.28		<0.001	<1		<0.0001	<0.001	<0.01	<1	330	5	2	18	<5	<1	<0.1	0.02		<0.005	
Tri Star (Angus Place Site)	21/08/2018	Low Flow	Clear		3.6	30	7.1											8.9	311									350								1.3		
Tri Star (Angus Place Site)	4/09/2018	Mod Flow	Clear		5.6	56	7.4	0.007	0.14	0.04	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	9.6	889.92	<0.1	<0.001	<1		<0.0001	<0.001	<0.01	1	248	4	<1	30	<5	<1	<0.1	<0.01	3.7	<0.005	
Tri Star (Angus Place Site)	19/09/2018	Mod Flow	Clear		10	38	7.5											9.2	397									376								0.69		
Tri Star (Angus Place Site)	3/10/2018		Clear	Depth too low for flo	6.5	23	6.2		0.13	0.03	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	87		<0.1	<0.001	<1		<0.0001	<0.001	0.03	<1	449	3	<1	33	<5		<0.1	<0.01	1.7	<0.005	
Tri Star (Angus Place Site)	17/10/2018	Mod Flow	Clear		9.1	24	7.7											12.9	679									260								4.9		
Tri Star (Angus Place Site)	31/10/2018	Low flow	Clear	Depth too low for flo	9.7	34	4.3											8.7										275								1.6		
Tri Star (Angus Place Site)	14/11/2018	Mod Flow	Clear		9.4	30	7.3		0.21	0.04	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	7.8	34	<0.1	<0.001	<1		<0.0001	<0.001	0.04	<1	431	3	<1	31	<5		<0.1	<0.01	3.6	<0.005	
Tri Star (Angus Place Site)	26/11/2018		Clear	Depth too low for flo	8.8	53	6.8											8.2										326								2.6		
Tri Star (Angus Place Site)	12/12/2018	Low flow	Clear	Depth too low to rec	10.2	23.2	5.2		0.22	0.06	<0.001	<0.05	<0.0001	<1		<0.001	<0.001	8			<0.001	<1		<0.0001	<0.001		<1	202	4		18	8		0.2	<0.01	5.8	0.006	
Tri Star (Angus Place Site)	21/12/2018	Mod flow	Clear	Redox meter malfun	13.2	27	4.4											7	267.84																	2.7		
Tri Star (Angus Place Site)	8/01/2018	Mod flow	Clear		15.3	70	7.6		0.96	0.38	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	7.1	302	<0.1	<0.001	<1		<0.0001	<0.001	0.04	<1	377	4	<1	42	5		0.3	<0.01	5.5	<0.005	
Tri Star (Angus Place Site)	23/01/2019	Low flow	Clear	Depth too low to rec	15.2	33.15	6											5.3										239								2.7		
Tri Star (Angus Place Site)	6/02/2019	Low flow	Clear	Depth too low to rec	13	32	7.6		0.32	0.1	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	7.2		<0.1	<0.001	<1		<0.0001	<0.001	0.01	<1	340	3	<1	25	<5		<0.1	<0.01	3.1	<0.005	
Tri Star (Angus Place Site)	25/02/2019	Mod flow	Clear		12.1	242	7.7											13.3	190									139								2.8		
Tri Star (Angus Place Site)	5/03/2019	Low flow	Clear		11.9	28	6		0.25	0.06	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	6.6	120	<0.1	0.011	<1		<0.0001	<0.001	<0.01	<1	266	4	<1	41	<5		<0.1	<0.01	1.8	0.009	
Tri Star (Angus Place Site)	18/03/2019	Mod flow	Clear		12.1	41	7.4											5.4	259									404								9.3		
Tri Star (Angus Place Site)	1/04/2019	Low Flow	Clear	Depth too low for flo	9.4	30	6.9		0.39	0.07	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	8.9		<0.1	0.002	<1		<0.0001	<0.001	0.05	<1	176	4	<1	21	<5		0.2	<0.01	3	0.007	
Tri Star (Angus Place Site)	16/04/2019	Mod flow	Clear		9.3	23	5.8											8.3	51									383								2		
Tri Star (Angus Place Site)	1/05/2019	Low Flow	Clear	Depth too low for flo	12	45	7.6		0.3	0.08	<0.001	<0.05	<0.0001	<1	5	<0.001	0.003	9.4		<0.1	0.002	<1		<0.0001	0.001	0.02	1	265	6	<1	23	<5		0.2	<0.01	3.6	0.052	
Tri Star (Angus Place Site)	15/05/2019	Low flow	Clear		7.8	30	5.4											9.3	864									290								1.9		
Tri Star (Angus Place Site)	31/05/2019	Low flow	Clear		6.8	32	4.8											8.6	432									351								1.4		
Tri Star (Angus Place Site)	11/12/2017	Mod Flow	Clear		10.7	24	5	0.013	0.2	0.05	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	10.3	532		<0.001	<1		<0.0001	<0.001	0.02	<1	248	3	<1	14	<5	1	0.1	<0.01	1.7	<0.005	
Tri Star (Angus Place Site)	27/12/2017	Mod Flow	Clear		10.8	24	4.9											7.9	286									194								6		
Tri Star (Angus Place Site)	8/01/2018	Low Flow	Clear	Too low for flow mon	17.1	28	5.9	0.01	0.57	0.19	<0.001	<0.05	<0.0001	<1	5	<0.001	0.001	7.8			<0.001	<1		<0.0001	0.001	0.02	2	133	4	<1	34	28	<1	0.4	<0.01	10.8	0.008	
Tri Star (Angus Place Site)	22/01/2018	Mod Flow	Clear		12.8	26	5.8											9	317									307								1.8		
Tri Star (Angus Place)	28/11/2017	Mod Flow	Clear		10.9	17	4.7											8.7										350								9.4		
Tri Star (Springvale Site)	2/11/2016	Mod Flow	Clear		10.9	32	5.76	0.01	0.17	0.04	<0.001	0.09	<0.0001	<1	5	<0.001	<0.001	10.03	316		<0.001	<1		<0.0001	<0.001	0.02	<1		3	<1	24	<5	<1	0.3	<0.01	4	<0.005	
Tri Star (Springvale Site)	14/11/2016	Mod Flow	Clear		11.3	24	5.02											10.63	501									264								4		
Tri Star (Springvale Site)	30/11/2016	Mod Flow	Clear		16.4	19	5.23											10.24	157									379								13		
Tri Star (Springvale Site)	14/12/2016	Mod Flow	Clear		15.9	23	5.31	0.007	0.23	0.06	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	8.35	212		<0.001	<1		<0.0001	<0.001	<0.01	<1	409	4	<1	18	<5	<1	0.3	<0.01	4	<0.005	
Tri Star (Springvale Site)	28/12/2016	Mod Flow	Clear			23	6.31											8.09	283									260								3		
Tri Star (Springvale Site)	9/01/2017	Mod Flow	Clear		14.8	24	5.62	0.013	0.22	0.06	0.003	<0.05	<0.0001	<1	4	<0.001	<0.001	8.01	208		<0.001	<1		<0.0001	<0.001	0.03	<1		4	<1		<5	1	<0.1	<0.01	5	<0.005	
Tri Star (Springvale Site)	23/01/2017	Low Flow	Clear		16.6	2641	5.82												433									476										
Tri Star (Springvale Site)	11/12/2017	Low Flow	Clear		10.3	27	5.7	0.012	0.22	0.04	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	14	248		<0.001	<1		<0.0001	<0.001	0.08	<1	306	3	<1	14	<5	<1	0.2	<0.01	1.7	<0.005	
Tri Star (Springvale Site)	27/12/2017	Mod Flow	Clear		11.1	26	6.2											8.1	297									187								5.1		
Tri Star (Springvale Site)	6/02/2017	Mod Flow	Clear		16.3	23	5.69	0.012	0.35	0.06	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	9.59	113		<0.001	<1		<0.0001	<0.001	<0.01	<1	343	3	<1	44	<5	<1	<0.1	<0.01	8	<0.005	
Tri Star (Springvale Site)	20/02/2017	Mod Flow	Clear		13.1	23	6.02											9.86	166									226								3		
Tri Star (Springvale Site)	8/01/2018	Low Flow	Clear	Too low for flow mon	16.3	31	6	0.007	0.59	0.17	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	7.8			<0.001	<1		<0.0001	<0.001	0.02	1	127	3	<1	32	24	<1	0.6	0.58	12.6	0.006	
Tri Star (Springvale Site)	22/01/2018	Mod Flow	Clear		12.6	30	5.9											9.1	293									297								2		
Tri Star (Springvale site)	6/02/2018	Mod Flow	Clear		20.2	21	7.7	0.011	0.26	0.05	<0.001	<0.05	<0.0001	<1	3	<0.001	<0.001	7	232		<0.001	<1		<0.0001	<0.001	0.03	<1	226	4	<1	<10	<5	2	<0.1	<0.01		<0.005	
Tri Star (Springvale site)	19/02/2018	Low Flow	Clear		16.1	41	6.1												742									359								9.8		
Tri Star (Springvale site)	5/03/2018	Low Flow	Clear		13.7	68	6.1	0.008	0.38	0.13	<0.001	<0.05	<0.0001	<1	7	<0.001	<0.001	7.3	108		<0.001	<1		0.0001	0.001	0.05	<1	411	3	2	38	12	3	0.2	<0.01		<0.005	
Tri Star (Springvale site)	21/03/2018	Low Flow	Clear		18.5	42	7.6											7.3	253									967										
Tri Star (Springvale site)	3/04/2018	Mod Flow	Clear		14	27	7.5	0.011	0.14	0.04	<0.001	<0.05	<0.0001	<1	5	0.001	<0.001	7.8	272		<0.001	<1		<0.0001	<0.001	0.03	<1	493	5	<1	<10	9	<1	<0.1	<0.01		<0.005	
Tri Star (Springvale site)	18/04/2018	Low Flow	Clear		10.9	29	6											6.1	73									471								3		
Tri Star (Springvale site)	3/05/2018	Mod Flow	Clear		7.3	25	4.6	0.008	0.24	0.03	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	9	402		<0.001	<1		<0.0001	<0.001	<0.01	<1	376	3	<1	30	<5	<1	<0.1	<0.01		<0.005	
Tri Star (Springvale site)	16/05/2018	Mod Flow	Clear		6.2	29	4.6											8.8	196									413								1.5		
Tri Star (Springvale site)	28/05/2018	Mod Flow	Clear		4.9	45	8	0.009	0.17	0.02	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	9.1	268		<0.001	<1		<0.0001	<0.001	<0.01	<1	250	3	2	14	<5	<1	<0.1	<0.01		<0.005	
Tri Star (Springvale site)	15/06/2018	Mod Flow	Clear		5	27	6.2											9.5	362.88									382								3.9		
Tri Star (Springvale site)	27/06/2018	Low Flow	Clear		4.5	27	5.7											8.9	311.04									337								1.6		
Tri Star (Springvale site)	11/07/2018	Low Flow	Clear		2.1	37	7.6	0.008	0.13	0.02	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	10.1	2678.4		<0.001	<1		<0.0001	<0.001	<0.01	<1	299	5	<1	34	<5	<1	0.1	<0.01		<0.005	
Tri Star (Springvale site)	24/07/2018	Low Flow	Clear	Too low for flow mon	8.7	28	3.6											8.2										394								1.6		
Tri Star (Springvale site)	7/08/2018	Low Flow	Clear	Too low for flow mon	1.9	34	5.1	0.018	0.2	0.09	<0.001	<0.05	<0.0001	<1	8	<0.001	<0.001	8.2			<0.001	<1		<0.0001	<0.001	0.06	<1	341	6	2	38	<5	<1	0.2	0.01		<0.005	
Tri Star (Springvale site)	21/08/2018	Low Flow	Clear		3.3	27	7.3											9.4	311									339								1.4		
Tri Star (Springvale site)	4/09/2018	Mod Flow	Clear		5.4	197	6.3	0.01	0.15	0.04	<0.001	<0.05	<0.0001	<1	5	<0.001	0.001	10.4	552.96	<0.1	<0.001	<1		<0.0001	<0.001	<0.01	<1	319	4	<1	34	<5	10	<0.1	<0.01	4.9	0.009	
Tri Star (Springvale site)	19/09/2018	Low flow	Clear		9.7	41	7.3											9	319									367								0.86		
Tri Star (Springvale site)	3/10/2018	Low Flow	Clear		6.1	31	5.8		0.12	0.03	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	8.4	207	<0.1	<0.001	<1		<0.0001	<0.001	0.02	<1	453	3	<1	41	16		<0.1	<0.01	5.5	<0.005	
Tri Star (Springvale site)	17/10/2018	Mod Flow	Clear		8.9	25	7.6											13.5	578									261								4.7		
Tri Star (Springvale site)	31/10/2018	Mod Flow	Clear		8.8	23	4.9											12.7	95									270								1.8		
Tri Star (Springvale site)	14/11/2018	Low Flow	Clear		9.4	27	8.3		0.2	0.04	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	9.8	250	<0.1	<0.001	<1		<0.0001	<0.001	0.04	<1	397	3	3	39	<5		<0.1	0.01	2.6	<0.005	
Tri Star (Springvale site)	26/11/2018		Clear	Depth too low for flo	8.6	52	6.9											8.3										289								2.1		
Tri Star (Springvale site)	12/12/2018	Low flow	Clear		11.1	26.4	6.1		0.63	0.12	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	7.4	414	<0.1	<0.001	<1		<0.0001	<0.001	<0.01	<1	194	4	<1	40	7		<0.1	<0.01	4.4	<0.005	
Tri Star (Springvale site)	21/12/2018	Mod flow	Clear	Redox meter malfun	13.6	27	4.4											7.6	984.96																	2.4		
Tri Star (Springvale site)	8/01/2018	Low flow	Clear	Depth too low to rec	15.6	72	6.9		1.13	0.4	<0.001	<0.05	<0.0001	<1	6	<0.001	0.001	7		<0.1	<0.001	<1		<0.0001	0.001	<0.01	<1	409	4	<1	36	7		0.4	0.13	4	0.011	
Tri Star (Springvale site)	23/01/2019	Low flow	Slightly cloudy	Depth too low to rec	14.8	30.54	6											5.5										241								6.8		
Tri Star (Springvale site)	6/02/2019	Low flow	Clear	Depth too low to rec	12.7	26	7.3		0.29	0.09	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	9.4		<0.1	<0.001	<1		<0.0001	<0.001	0.01	<1	316	3	<1	18	<5		0.1	<0.01	3	0.007	
Tri Star (Springvale site)	25/02/2019	Mod flow	clear		12.7	151	8.3											15.3	587									162								7.4		
Tri Star (Springvale site)	5/03/2019	Mod flow	Clear		12.2	27	6.2		0.33	0.05	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	7.6	233	<0.1	<0.001	<1		<0.0001	<0.001	0.01	<1	268	4	<1	42	<5		<0.1	<0.01	2.6	<0.005	
Tri Star (Springvale site)	18/03/2019	Mod flow	Clear		13.6	41	7.6											5.6	743									417								14		
Tri Star (Springvale site)	1/04/2019	Low Flow	Clear	Depth too low for flo	9.6	31	6.3		0.38	0.06	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	10.4		<0.1	<0.001	<1		<0.0001	<0.001	0.05	<1	169	4	<1	21	5		0.2	<0.01	3.8	0.015	
Tri Star (Springvale site)	16/04/2019	Low flow	Clear		9.7	25	7											8.1	60									343								1.5		
Tri Star (Springvale site)	1/05/2019	Low Flow	Clear		13.7	39	6.8		0.24	0.06	<0.001	<0.05	<0.0001	<1	5	<0.001	0.001	10.2	129	<0.1	<0.001	<1		<0.0001	<0.001	<0.01	<1	299	5	2	24	<5		<0.1	<0.01	3	0.022	
Tri Star (Springvale site)	15/05/2019	Low flow	Clear		7.8	30	5.4											9.1	10627									296								1.7		
Tri Star (Springvale site)	31/05/2019	Low flow	Clear	Depth too low for flo	7.2	29	4.9											9.1										280								1.9		
Tri Star (Springvale)	28/11/2017	Mod Flow	Clear		10.5	17	5.4											8.7										360								4.1		
Twin Gully	22/03/2016	Low Flow	Clear		13.5	35	5.48	0.005	0.27	0.14	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	8.1	63		<0.001	<1		<0.0001	<0.001	<0.01	<1	514	4	<1			<1	0.1	<0.01	8	<0.005	
Twin Gully	5/04/2016	Low Flow	Clear		12.2	26	5.38	0.005	0.26	0.1	<0.001	0.17	<0.0001	<1	6	<0.001	<0.001	8.55	43		<0.001	<1		<0.0001	<0.001	<0.01	<1	320	4	<1	50	8	2	<0.1	<0.01	6	<0.005	
Twin Gully	20/04/2016	Low Flow	Clear		14.3	27	5.79											8.78	24									185								6		

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) mg/L	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
Twin Gully	3/05/2016	Low Flow	Clear		11.5	32	5.8	0.005	0.2	0.07	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	8.41	48		<0.001	<1		<0.0001	<0.001	<0.01	<1	246	3	<1	10	20	<1	0.3	0.02	8	<0.005	
Twin Gully	17/05/2016	Low Flow	Clear		9.3	24	5.23											9.58	33									220								2		
Twin Gully	30/05/2016	Low Flow	Clear		5.6	38	6.71											10.33										280								2		
Twin Gully	14/06/2016	Mod Flow	Clear		5.8	31	5.17	0.005	0.18	0.08	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	9.98	283		<0.001	<1		<0.0001	<0.001	<0.01	<1	246	4	<1	48	<5	<1	0.1	0.03	2	<0.005	
Twin Gully	29/06/2016	Low Flow	Clear		5.3	33	5.81											10.62	443																	1		
Twin Gully	13/07/2016	Mod Flow	Clear		7.5	30	5.93	0.003	0.14	0.1	<0.001	<0.05	0.0002	<1	5	<0.001	<0.001	10.82	216		<0.001	<1		<0.0001	<0.001	0.05	<1	162	3	2	52	<5	<1	0.2	<0.01	2	<0.005	
Twin Gully	27/07/2016	High Flow	Clear		7.5	29	4.85											10.58	731																	2		
Twin Gully	10/08/2016	Low Flow	Clear		6.8	32	6.02	0.003	0.11	0.08	<0.001	<0.05	<0.0001	<1	3	<0.001	<0.001	10.22	370		<0.001	<1		<0.0001	<0.001	0.02	<1	147	3	2	20	<5	1	<0.1	0.05	1	<0.005	
Twin Gully	24/08/2016	High Flow	Clear		7.2	32	5.41											10.24	353									95								1		
Twin Gully	7/09/2016	Mod Flow	Clear		7.4	35	6.17	0.003	0.12	0.09	<0.001	<0.05	<0.0001	<1	6	<0.001	0.001	9.45	660		<0.001	<1		<0.0001	<0.001	<0.01	<1	151	4	7	30	<5	2	<0.1	<0.01	2	<0.005	
Twin Gully	21/09/2016	Low Flow	Clear		8.5	27	6.83											9.94	189									380								6		
Twin Gully	5/10/2016	Low Flow	Clear		8.3	35	4.9	0.003	0.17	0.09	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	9.25	492		<0.001	<1		<0.0001	<0.001	<0.01	<1	303	3	2	44	<5	<1	<0.1	<0.01	2	<0.005	
Twin Gully	19/10/2016	Low Flow	Clear		8.6	20	5.31	0.003	0.17	0.09	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	9.36			<0.001	<1		<0.0001	<0.001	<0.01	<1	303	3	2			<1	<0.1	<0.01		<0.005	
Twin Gully	6/10/2017	Low Flow	Clear	Too low for flow mon	5.6	26	5.3	0.004	0.21	0.08	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	9.2			<0.001	<1		<0.0001	<0.001	0.03	<1	419	3	<1	19	<5	5	<0.1	0.03	3.2	<0.005	
Twin Gully	17/10/2017	Low Flow	Clear		9.8	36	5.4											8										208										
Twin Gully	1/11/2017	Low Flow	Clear		7.8	28	5	0.008	0.23	0.09	<0.001	<0.05	<0.0001	<1	7	<0.001	<0.001	8.1	129		<0.001	<1		<0.0001	<0.001	0.03	<1	455	4	<1	38	<5	<1	<0.1	<0.01	2.6	0.008	
Twin Gully	15/11/2017	Low Flow	Clear	Too low for flow mon	9.9	30	7.1											6.9										273										
Twin Gully	28/11/2017	Mod Flow	Clear		10.3	22	4.7											7.6										393								3.6		
Twin Gully	6/03/2017	Low Flow	Clear	Flow too low for flow	14	32	5.23	0.013	0.42	0.12	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	8.01			<0.001	<1		<0.0001	<0.001	0.01	<1	217	3	1	20	28	<1	0.2	<0.01	6	0.008	
Twin Gully	20/03/2017	Low Flow	Clear		14.2	21	4.34											8.54	69									241								28		
Twin Gully	5/04/2017	Low Flow	Clear		12.4	22	4.7	0.01	0.51	0.1	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	7.96	140		<0.001	<1		<0.0001	<0.001	<0.01	<1	311	4	<1	38	32	1	0.5	0.02	18.2	<0.005	
Twin Gully	19/04/2017	Low Flow	Clear		17.4	30	5.82											7.87	91									374								4		
Twin Gully	8/05/2017	Low Flow	Clear		8.2	31	6.49	0.013	0.06	0.04	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	7.98	278		<0.001	<1		<0.0001	<0.001	<0.01	<1	283	4	3	46	<5	3	<0.1	<0.01	3.2	<0.005	
Twin Gully	22/05/2017	Low Flow	Clear		12.6	24	6.37											7.08	217									346								9		
Twin Gully	13/06/2017	Low Flow	Clear		7	13	5.09	0.007	0.24	0.1	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	10.2	346		<0.001	<1		<0.0001	0.003	0.05	<1	222	3	<1	42	<5	<1	<0.1	<0.01	2.6	<0.005	
Twin Gully	26/06/2017	Low Flow	Clear		4.4	32	7.85											9.73	909									230								3.4		
Twin Gully	10/07/2017	Low Flow	Clear		4.6	28	5.5	0.014	0.12	0.06	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	9.1	262		<0.001	<1		<0.0001	<0.001	<0.01	<1	451	3	<1	13	<5	<1	<0.1	<0.01	0.98	<0.005	
Twin Gully	24/07/2017	Low Flow	Clear		6.9	55	7.1											9.9	226									421								1.3		
Twin Gully	9/08/2017	Low Flow	Clear		5.6	27	6.3	0.002	0.14	0.05	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	10.2	163		<0.001	<1		<0.0001	<0.001	0.02	<1	445	3	<1	<10	<5	<1	0.1	<0.01	1.1	<0.005	
Twin Gully	23/08/2017		Clear	Flow too low for flow	6.3	42	7.8											10.1										504								1.4		
Twin Gully	6/09/2017	Low Flow	Clear		4.6	31	5.8	0.006	0.15	0.06	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	9.7	80		<0.001	<1		<0.0001	<0.001	0.01	<1	461	3	<1	<10	<5	<1	<0.1	<0.01	1.1	<0.005	
Twin Gully	19/09/2017	Low Flow	Clear		4.1	24	5.3											9.5	45									455								2		
Twin Gully (Springvale site)	6/02/2018	Low Flow	Clear		20.6	21	7.7	0.006	0.28	0.11	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	6.7	108		<0.001	<1		<0.0001	<0.001	0.02	<1	229	4	<1	<10	<5	<1	<0.1	<0.01		<0.005	
Twin Gully (Springvale site)	19/02/2018	Low Flow	Clear		15.9	27	6.9												103									401								8		
Twin Gully (Springvale site)	5/03/2018	Low Flow	Clear	Too Low for Flow	14.9	62	4.3	0.008	0.39	0.13	<0.001	<0.05	<0.0001	<1	7	<0.001	<0.001	7.8			<0.001	<1		<0.0001	0.002	0.04	<1	421	3	<1	39	16	4	0.4	0.02		0.005	
Twin Gully (Springvale site)	19/03/2018	Low Flow	Clear		9.7	15	5.5											7.5	211									398								2.5		
Twin Gully (Springvale site)	3/04/2018	Low Flow	Clear	Too low for flow mon	14.1	31	7.8	0.005	0.24	0.07	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	6.9			<0.001	<1		<0.0001	<0.001	0.03	<1	437	6	<1	<10	25	2	0.1	<0.01		<0.005	
Twin Gully (Springvale site)	18/04/2018	Low Flow	Clear	Too low for flow mon	11.1	31	6.1											5.7										443								4		
Twin Gully (Springvale site)	3/05/2018	Low Flow	Clear	Too Low For Flow	8.6	27	5.8	0.008	0.18	0.05	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	7.8			<0.001	<1		<0.0001	<0.001	<0.01	<1	264	4	<1	27	44	1	0.7	0.04		<0.005	
Twin Gully (Springvale site)	16/05/2018	Mod Flow	Clear		4.5	35	3.9											8.8	206									484								1.5		
Twin Gully (Springvale site)	28/05/2018	Low Flow	Clear		5.3	51	8.4	0.006	0.17	0.06	<0.001	<0.05	<0.0001	<1	8	<0.001	<0.001	8.7	35		<0.001	<1		<0.0001	<0.001	<0.01	8	277	4	<1	14	5	1	0.2	<0.01		<0.005	
Twin Gully (Springvale site)	15/06/2018	Low Flow	Clear		3.9	27	6.2											9.1	95.04									448								3.5		
Twin Gully (Springvale site)	27/06/2018	Low Flow	Clear		2.3	25	6.1											9.9	86.4									383								2.3		
Twin Gully (Springvale site)	11/07/2018	Low flow	Clear		0.9	32	8	0.004	0.13	0.06	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	9.8	1408.32		<0.001	<1		<0.0001	<0.001	0.07	<1	336	3	<1	28	<5	<1	<0.1	<0.01		<0.005	
Twin Gully (Springvale site)	24/07/2018	Low Flow	Clear	Too low for flow mon	10.1	34	2.8											7.4										389								0.9		
Twin Gully (Springvale site)	7/08/2018	Low Flow	Clear	Too low for flow mon	2	39	4.5	0.019	0.16	0.07	<0.001	<0.05	<0.0001	<1	8	<0.001	<0.001	8.4			<0.001	<1		<0.0001	<0.001	0.03	<1	351	6	1	<5	<5	<1	0.1	0.04		<0.005	
Twin Gully (Springvale site)	21/08/2018	Low Flow	Clear		1.7	40	7											8.4	328									436								1.2		
Twin Gully (Springvale site)	4/09/2018	Mod Flow	Clear		4.5	53	7.1	0.005	0.17	0.08	<0.001	<0.05	<0.0001	<1	5	<0.001	0.002	9.9	769	<0.1	<0.001	<1		<0.0001	<0.001	<0.01	1	248	5	<1	42	<5	8	<0.1	<0.01	28	<0.005	
Twin Gully (Springvale site)	19/09/2018	Low Flow	Clear	Depth to Low for flow	9.5	39	7.4											9.4	14									401								1.91		
Twin Gully (Springvale site)	3/10/2018	Low Flow	Clear		5.9	28	6		0.13	0.03	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	7.7	86	<0.1	<0.001	<1		<0.0001	<0.001	0.02	<1	432	3	<1	37	12		0.2	<0.01	4	<0.005	
Twin Gully (Springvale site)	17/10/2018	Mod Flow	Clear		8.6	28	7.3											12	69									234								18		
Twin Gully (Springvale site)	31/10/2018	Low flow	Clear	Depth too low for flo	13.9	35	4.4											8.3										325								3.7		
Twin Gully (Springvale site)	14/11/2018	Low Flow	Clear		9.3	29	6.7		0.25	0.08	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	8.8	93	<0.1	<0.001	<1		<0.0001	<0.001	0.04	<1	440	4	3	39	<5		<0.1	<0.01	5.6	<0.005	
Twin Gully (Springvale site)	26/11/2018		Clear	Depth too low for flo	9.1	50	6.8											8.2										298								2.4		
Twin Gully (Springvale site)	12/12/2018	Low flow	Clear	Depth too low to reco	13.1	27.7	6.4		0.26	0.09	<0.001	<0.05	<0.0001	<1		<0.001	0.002	7.6				0.078	<1		0.0001	0.001		<1	95	5		14	6		0.4	<0.01	27	0.007	
Twin Gully (Springvale site)	21/12/2018	Mod flow	Clear	Redox meter malfun	13.2	31	4.2											6.5	198.72																	2.2		
Twin Gully (Springvale site)	8/01/2018	Low flow	Clear		16	55	5.9		1.09	0.4	<0.001	<0.05	<0.0001	<1	7	<0.001	<0.001	6.9	1226	<0.1	<0.001	<1		<0.0001	<0.001	0.03	<1	401	4	<1	35	12		0.4	<0.01	6.4	0.006	
Twin Gully (Springvale site)	23/01/2019	Low flow	Clear	Depth too low to reco	18.8	29.5	5.8											5.7										277								2.3		
Twin Gully (Springvale site)	6/02/2019	Low flow	Clear	Depth too low to reco	14.9	33	7.8		1.08	0.17	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	6.8		<0.1	<0.001	<1		<0.0001	<0.001	0.01	<1	299	4	1	24	32		0.5	<0.01	12	<0.005	
Twin Gully (Springvale site)	25/02/2019	Low flow	Clear	Depth too low to reco	13.1	339	6.2											13.8										231								1.9		
Twin Gully (Springvale site)	5/03/2019	Low flow	Clear	Depth too low to reco	12.2	43	6.5		0.32	0.11	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	6.1		<0.1	<0.001	<1		<0.0001	<0.001	<0.01	<1	323	4	<1	39	8		<0.1	<0.01	2.7	<0.005	
Twin Gully (Springvale site)	18/03/2019	Low flow	Clear	Depth too low to reco	14	38	8.1											6.9										342								6.2		
Twin Gully (Springvale site)	1/04/2019	Low Flow	Clear	Depth too low for flo	9.9	32	7.6		0.38	0.07	<0.001	<0.05	<0.0001	<1	6	<0.001	<0.001	8.2		<0.1	<0.001	<1		<0.0001	<0.001	0.03	<1	152	4	<1	29	8		0.1	<0.01	5.5	<0.005	
Twin Gully (Springvale site)	16/04/2019	Low flow	Clear		9.1	23	6.7											8.2	52									328								2.7		
Twin Gully (Springvale site)	1/05/2019	Low Flow	Clear	Depth too low for flo	10.4	32	6.6		0.23	0.05	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	8.8		<0.1	0.003	<1		<0.0001	<0.001	<0.01	<1	281	4	4	22	<5		<0.1	<0.01	4	0.014	
Twin Gully (Springvale site)	15/05/2019	Low flow	Clear	Depth too low for flo	6.8	32	5.3											9.3										322								3.4		
Twin Gully (Springvale site)	31/05/2019	Low flow	Clear		6.5	70	4.9											8.7	86.4									407								1.9		
Twin Gully (Springvale Site)	2/11/2016	Low Flow	Clear		10	32	5.42	0.004	0.14	0.06	<0.001	0.1	<0.0001	<1	6	<0.001	<0.001	9.56	201		<0.001	<1		<0.0001	<0.001	<0.01	<1		4	<1	30	<5	<1	0.2	<0.01	2	<0.005	
Twin Gully (Springvale Site)	14/11/2016	Low Flow	Clear		11	27	4.84											9.3	211									311								3		
Twin Gully (Springvale Site)	30/11/2016	Low Flow	Clear		16.6	22	4.85											8.64	57									392								4		
Twin Gully (Springvale Site)	14/12/2016	Low Flow	Clear		16.3	41	4.01	0.004	0.24	0.1	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	8.46	68		<0.001	<1		<0.0001	<0.001	0.06	<1	427	4	<1	32	37	<1	0.3	<0.01	17	<0.005	
Twin Gully (Springvale Site)	28/12/2016	Low Flow	Clear			26	6.09											7.75	99									295								2		
Twin Gully (Springvale Site)	9/01/2017	Low Flow	Clear	Flow too low for flow	16.4	25	6.69	0.008	0.23	0.17	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	7.26			<0.001	<1		<0.0001	<0.001	0.04	<1		6	<1		14	1	0.2	<0.01	6	<0.005	
Twin Gully (Springvale Site)	23/01/2017			Dry																																		
Twin Gully (Springvale Site)	11/12/2017	Low Flow	Clear		10.4	28	5	0.006	0.29	0.14	<0.001	<0.05	<0.0001	<1	5	<0.001	<0.001	10.1	190		<0.001	<1		<0.0001	<0.001	0.05	<1	319	3	6	19	<5	<1	0.2	<0.01	1.6	<0.005	
Twin Gully (Springvale Site)	27/12/2017	Mod Flow	Clear		11.5	33	5.4											7.3	233									197								4.3		
Twin Gully (Springvale Site)	6/02/2017	Low Flow	Clear		15.6	26	5.2	0.006	0.41	0.14	<0.001	<0.05	<0.0001	<1	4	<0.001	<0.001	8.25	195		<0.001	<1		<0.0001	<0.001	0.02	<1	438	4	<1	68	<5	<1	0.1	<0.01	5	<0.005	
Twin Gully (Springvale Site)	20/02/2017	Low Flow	Clear		13.2	24	5.29											8.96	36									302								4		
Twin Gully (Springvale Site)	8/01/2018	Low Flow	Clear	Too low for flow mon	16	33	5.2	0.009	0.68	0.17	<0.001	<0.05	<0.0001	<1	6	0.003	<0.001	7.8			<0.001	<1		<0.0001	<0.001	0.02	1	143	3	<1	38	12	<1	0.4	<0.01	9.6	<0.005	
Twin Gully (Springvale Site)	22/01/2018	Low Flow	Clear	Too low for flow mon	10.2	27	4.8											8.9										378								2		
Upstream Wolgan River	30/01/2008				16.6	71	7																															
Upstream Wolgan River	4/02/2008				16.5	57	6.6																															
Upstream Wolgan River	15/02/2008				14.4	56	6.4																															
Upstream Wolgan River	19/02/2008				15.5	67	7.1																															

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) mg/L	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
Upstream Wolgan River	26/02/2008				15.7	67	7.2																														
Upstream Wolgan River	3/03/2008				12	69	6.9																														
Upstream Wolgan River	10/03/2008				14.5	65	7																														
Upstream Wolgan River	18/03/2008				16.6	38	6.7																														
Upstream Wolgan River	26/03/2008				14.2	69	6.9																														
Upstream Wolgan River	2/04/2008				10.6	57	6.9	0.006	1.06																												
Upstream Wolgan River	8/04/2008				12.5	56	6.9																														
Upstream Wolgan River	15/04/2008				10.6	55	6.9																														
Upstream Wolgan River	23/04/2008				10.4	64	6.8																														
Upstream Wolgan River	28/04/2008				6.8	59	7																														
Upstream Wolgan River	28/04/2008				6.8	59	7																														
Upstream Wolgan River	6/05/2008				8.1	54	7																									6					
Upstream Wolgan River	13/05/2008																																				
Upstream Wolgan River	20/05/2008				6.7	55	7																														
Upstream Wolgan River	28/05/2008					50	6.8																														
Upstream Wolgan River	5/06/2008				9.9	66	7.6																														
Upstream Wolgan River	11/06/2008				11.2	57	6.9																														
Upstream Wolgan River	17/06/2008				9.2	58	7.4																														
Upstream Wolgan River	24/06/2008				5.1	65	7.4																														
Upstream Wolgan River	5/06/2008				9.9	66	7.6																														
Upstream Wolgan River	11/06/2008				11.2	57	6.9																														
Upstream Wolgan River	17/06/2008				9.2	58	7.4																														
Upstream Wolgan River	24/06/2008				5.1	65	7.4																														
Upstream Wolgan River	3/07/2008				5.3	59	7.5																														
Upstream Wolgan River	8/07/2008				6.3	59	7.4																														
Upstream Wolgan River	16/07/2008				3.6	54	7.2																														
Upstream Wolgan River	22/07/2008				4.7	58	7.3																														
Upstream Wolgan River	29/07/2008				5.4	59	7.5																														
WOLGAN D/S	8/02/2011				16.2	40	7	0.012	0.76	0.14	<0.001	<0.05	0.0002		6		0.001	6.5	1204	0.2	<0.001		<1		0.001	0.03				<1	31		16	0.2	0.09	42	0.024	0.009
WOLGAN D/S	23/02/2011				14.8	41	6.99	0.012	0.86	0.14	<0.001	<0.05	0.0013		5		0.001	6.97	59	<0.1	<0.001		<1		<0.001	0.02				<1	56		16	0.6	0.04	9	0.027	<0.005
WOLGAN D/S	8/03/2011				14.3	39	6.9	0.016	0.58	0.09	<0.001	<0.05	0.0006		5		0.004	8.37	304	<0.1	<0.001		<1		0.001	4.05				<1	37		15	4.4	0.12	14	0.012	0.005
WOLGAN D/S	22/03/2011				17	36	7.08	0.013	0.81	0.19	<0.001	<0.05	0.001		3		0.004	7.09	6189	<0.1	<0.001		<1		<0.001	0.03				<1	89		10	0.4	0.14	17	0.008	<0.005
WOLGAN D/S	8/03/2011				14.3	39	6.9	0.016	0.58	0.09	<0.001	<0.05	0.0006		5		0.004	8.37	304	<0.1	<0.001		<1		0.001	4.05				<1	37		15	4.4	0.12	14	0.012	0.005
WOLGAN D/S	22/03/2011				17	36	7.08	0.013	0.81	0.19	<0.001	<0.05	0.001		3		0.004	7.09	6189	<0.1	<0.001		<1		<0.001	0.03				<1	89		10	0.4	0.14	17	0.008	<0.005
WOLGAN D/S	5/04/2011				13.1	39	7.25	0.01	0.51	0.1	<0.001	<0.05	0.0015		5		0.006	8.44	480	<0.1	<0.001		<1		0.001	0.38				<1	32		14	0.8	0.25	7	0.087	<0.005
WOLGAN D/S	18/04/2011				11.3	32	7.14	0.005	0.33	0.06	<0.001	<0.05	0.0001		5		<0.001	6.48	56	<0.1	<0.001		<1		<0.001	<0.01				<1	44		13	0.2	<0.01	6	0.009	<0.005
WOLGAN D/S	5/04/2011				13.1	39	7.25	0.01	0.51	0.1	<0.001	<0.05	0.0015		5		0.006	8.44	480	<0.1	<0.001		<1		0.001	0.38				<1	32		14	0.8	0.25	7	0.087	<0.005
WOLGAN D/S	18/04/2011				11.3	32	7.14	0.005	0.33	0.06	<0.001	<0.05	0.0001		5		<0.001	6.48	56	<0.1	<0.001		<1		<0.001	<0.01				<1	44		13	0.2	<0.01	6	0.009	<0.005
WOLGAN D/S	4/05/2011				10.3	36	7.06	0.005	0.35	0.06	<0.001	<0.05	0.0003		5		0.006	9.4	883	<0.1	<0.001		<1		<0.001	0.05				<1	33		12	0.2	<0.01	6	0.011	<0.005
WOLGAN D/S	17/05/2011				5.4	30	7.3	0.006	0.36	0.07	<0.001	<0.05	0.0048		4		<0.001	9.36	231	<0.1	<0.001		2		<0.001	0.04				<1	54		17	0.2	0.03	4	0.006	<0.005
WOLGAN D/S	30/05/2011				7.9	29	7.41	0.006	0.48	0.08	<0.001	<0.05	<0.0001		5		<0.001	10.91	135	<0.1	<0.001		<1		<0.001	0.08				<1	44		10	0.4	0.14	3	0.008	<0.005
WOLGAN D/S	4/05/2011				10.3	36	7.06	0.005	0.35	0.06	<0.001	<0.05	0.0003		5		0.006	9.4	883	<0.1	<0.001		<1		<0.001	0.05				<1	33		12	0.2	<0.01	6	0.011	<0.005
WOLGAN D/S	17/05/2011				5.4	30	7.3	0.006	0.36	0.07	<0.001	<0.05	0.0048		4		<0.001	9.36	231	<0.1	<0.001		2		<0.001	0.04				<1	54		17	0.2	0.03	4	0.006	<0.005
WOLGAN D/S	30/05/2011				7.9	29	7.41	0.006	0.48	0.08	<0.001	<0.05	<0.0001		5		<0.001	10.91	135	<0.1	<0.001		<1		<0.001	0.08				<1	44		10	0.4	0.14	3	0.008	<0.005
WOLGAN D/S	14/06/2011				8	31	7.15	0.007	0.65	0.18	<0.001	<0.05	<0.0001		5		0.002	8.96	1939	<0.1	<0.001		<1		0.001	0.02				<1	39		9	0.1	0.06	14	0.023	<0.005
WOLGAN D/S	27/06/2011				6.4	31	7.47	0.006	0.43	0.09	<0.001	<0.05	<0.0001		5		0.0050.0	11.29	831	<0.1	<0.001		<1		0.001	0.31				1	39		10	0.3	0.05	5	0.153	<0.005
WOLGAN D/S	14/06/2011				8	31	7.15	0.007	0.65	0.18	<0.001	<0.05	<0.0001		5		0.002	8.96	1939	<0.1	<0.001		<1		0.001	0.02				<1	39		9	0.1	0.06	14	0.023	<0.005
WOLGAN D/S	27/06/2011				6.4	31	7.47	0.006	0.43	0.09	<0.001	<0.05	<0.0001		5		0.0050.0	11.29	831	<0.1	<0.001		<1		0.001	0.31				1	39		10	0.3	0.05	5	0.153	<0.005
Wolgan River Downstream	25/07/2012					37	7.8	0.005	0.45	<0.001	<0.001	<0.05	<0.0001	<1	5		0.001			<0.1	<0.001	<1			<0.001	<0.01	<1			6		47	3				3	0.006	<0.005
Wolgan River Downstream	6/07/2012					39	6.76	0.005	0.64																												
Wolgan River Downstream	18/07/2012					36	6.61	0.007	0.48																												
Wolgan River Downstream	31/07/2012					38	6.65	0.005	0.48																												
Wolgan River Downstream	8/08/2012					38	7.36	0.004	0.38	0.08	<0.001	<0.05	<0.0001	<1	5		0.008	11.37	3177	<0.1	<0.001		<1		<0.001	0.2	<1			6		3	2				5	0.006	0.014
Wolgan River Downstream	13/08/2012					36	6.86	0.005	0.51																												
Wolgan River Downstream	30/08/2012					34	6.32	0.004	0.31																												
Wolgan River Downstream	11/09/2012				10.1	35	6.57	0.005	0.2	0.1	<0.001	<0.05	<0.0001	<1	4		0.002	9.9		<0.1	<0.001		<1		<0.001	0.01	<1			6			4				8	0.009	0.009
Wolgan River Downstream	10/09/2012				8.8	35	6.34	0.006	0.41																												
Wolgan River Downstream	25/09/2012				7.8	35	6.38	0.007	0.47																												
Wolgan River Downstream	9/10/2012				10.8	37	7.02	0.005	0.39	0.06	<0.001	<0.05	<0.0001	<1	4		<0.001	9.36	3288	<0.1	<0.001	<1			<0.001	0.05	<1			5		3	1				13	0.008	<0.005
Wolgan River Downstream	8/10/2012				11.4	36	6.76	0.006	0.4																												
Wolgan River Downstream	24/10/2012				10.4	36	6.35	0.009	0.37																												
Wolgan River Downstream	15/11/2012				14.1	38	6.83	0.01	0.51	0.09	<0.001	<0.05	<0.0001	<1	6		<0.001	7.72	1871	<0.1	<0.001		<1		<0.001	0.01	<1			5		35	4				7	0.006	<0.005
Wolgan River Downstream	7/11/2012				15.7	38	6.89	0.009	0.44																												
Wolgan River Downstream	22/11/2012				12.6	37	6.1	0.007	0.45																												
Wolgan River Downstream	12/12/2012				16	37	6.7	0.01	0.57	0.08	<0.001	<0.05	<0.0001	<1	5		<0.001	8.08	1441	<0.1	<0.001		<1		<0.001	0.08	<1			6		54	3				14	0.013	<0.005
Wolgan River Downstream	3/12/2012				16.9	39	6.58	0.011	0.59																												
Wolgan River Downstream	17/12/2012				14.6	37	6.94	0.01	0.32																												
Wolgan River Downstream	9/01/2013				19.2	47	7.11	0.013	0.35	0.07	<0.001	<0.05	<0.0001	<1	5		<0.001	7	456	<0.1	<0.001		<1		<0.001	<0.01	<1			6		44	5				9	<0.005	0.006
Wolgan River Downstream	3/01/2013				16.2	42	6.65	0.011	0.66																												
Wolgan River Downstream	16/01/2013				17.6	46	6.72	0.014	0.58																												
Wolgan River Downstream	29/01/2013				17.9	45	6.02	0.025	0.94																												
Wolgan River Downstream	11/02/2013				16.5	36	6.55	0.014	0.58	0.16	<0.001	<0.05	<0.0001	<1	4		0.009	8.09		<0.1	<0.001		<1		0.002	0.02	<1			7		68	4				12	0.014	<0.005
Wolgan River Downstream	11/02/2013				16.5	36	6.55	0.01	0.51																												
Wolgan River Downstream	25/02/2013				16.7	40	6.22	0.013	0.37																												
Wolgan River Downstream	14/03/2013				16.1	61	7.49	0.009	0.59	0.11	<0.001	<0.05	<0.0001	<1	5		0.006	7.76		<0.1	<0.001		<1		<0.001	10	<1			7		35	3				8	0.006	<0.005
Wolgan River Downstream	11/03/2013				12.4	40	6.42	0.011	0.36																												
Wolgan River Downstream	25/03/2013				15.1	46	7.24																														
Wolgan River Downstream	18/04/2013				12.5	35	7	0.009	0.37	0.12	<0.001	<0.05	<0.0001	<1	5		0.016	9.13	3635	<0.1	<0.001		<1		<0.001	<0.01	<1			6		40	4				7	0.017	<0.005
Wolgan River Downstream	9/04/2013				12.6	39	5.72	0.009	0.29																												
Wolgan River Downstream	22/04/2013				10.6	35	6.62	0.01	0.43																												
Wolgan River Downstream	16/05/2013				8.9	35	7.15	0.007	0.24	0.04	<0.001	<0.05	<0.0001	<1	4		0.001	9.6	81	<0.1	<0.001		<1		<0.001	<0.01	<1			5		35	5				7	0.008	<0.005
Wolgan River Downstream	6/05/2013				8.8	40	7.11	0.011	0.36																												
Wolgan River Downstream	20/05/2013				7.6	32	6.65	0.009	0.28																												
Wolgan River Downstream	13/06/2013				8.1	47	8	0.006	0.31	0.09	<0.001	<0.05	<0.0001	<1	5		<0.001	7.61	2380	<0.1	<0.001		<1		<0.001	0.03	<1			5		52	3				6	0.006	<0.005

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) mg/L	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
Wolgan River Downstream	3/06/2013				8.4	36	6.33	0.008	0.41																													
Wolgan River Downstream	18/06/2013				6.5	32	6.08	0.007	0.23																													
Wolgan River Downstream	11/07/2013				7.6	35	6.79	0.008	0.08	0.07	<0.001	<0.05	0.0001	<1	4		0.07	10.8		<0.1	<0.001		<1		<0.001	<0.01	<1		6		7	2				2	0.197	<0.005
Wolgan River Downstream	1/07/2013				8.9	33	6.55	0.006	0.29																												
Wolgan River Downstream	19/07/2013				9.3	35	6.9	0.006	0.16																												
Wolgan River Downstream	30/07/2013				6.9	31	6.06	0.005	0.23																												
Wolgan River Downstream	8/08/2013				7.1	32	7.29	0.005	0.25	0.06	<0.001	<0.05	<0.0001	<1	5		0.002	12.95	1909	<0.1	<0.001		<1		<0.001	<0.01	<1		5		<10	<5				51	0.02	<0.005
Wolgan River Downstream	13/08/2013				6.5	30	6.72	0.007	0.23																												
Wolgan River Downstream	30/08/2013				8.3	30	6.7	0.003	0.05																												
Wolgan River Downstream	13/09/2013				7.9	29	6.33	0.008	0.33																												
Wolgan River Downstream	25/09/2013				10	32	6.23	0.005	0.2																												
Wolgan River Downstream	9/10/2013				9.5	35	6.63	0.004	0.23										965																		
Wolgan River Downstream	24/10/2013																																				
Wolgan River Downstream	4/11/2013				11.2	35	6.17	0.009	0.4										737																		
Wolgan River Downstream	18/11/2013				11.2	35	6.62	0.006	0.34										1626																		
Wolgan River Downstream	3/12/2013				16.8	36	6.58	0.006	0.37										284																		
Wolgan River Downstream	20/12/2013				8	47	6.37	0.009	0.44										822																		
Wolgan River Downstream	31/12/2013				15.1	37	6.5	0.008	0.38										1062																		
Wolgan River Downstream	17/01/2014				16.6	40	6.64	0.021	0.71										229																		
Wolgan River Downstream	30/01/2014				14.9	38	6.54	0.018	0.81	0.1				<1	6	<0.001	<0.001	4.95	219				<1			<0.01	<1		8			<5				0.006	0.018
Wolgan River Downstream	11/02/2014																																				
Wolgan River Downstream	27/02/2014				16.2	32	6.75	0.008	0.46	0.08				<1	4	<0.001	<0.001	7.02	344			<1				<0.01	<1		7			<5	8			0.008	0.07
Wolgan River Downstream	12/03/2014				14.6	31	6.55	0.007	0.39	0.08				<1	5	<0.001	<0.001	8.45	2408				<1			<0.01	<1		8			<5	8			0.016	0.008
Wolgan River Downstream	26/03/2014				13.4	31	6.61	0.005	0.34	0.08				<1	4	<0.001	<0.001		1415				<1			<0.01	<1		6			<5	7			<0.005	0.005
Wolgan River Downstream	8/04/2014				13.8	32	6.62	0.007	0.44	0.14				<1	5	<0.001	<0.001	8.4	7400				<1			<0.01	<1		7			<5	7			<0.005	
Wolgan River Downstream	22/04/2014				10.7	44	6.77	0.006	0.26	0.04				<1	4	<0.001	<0.001	13.8	3180				<1			<0.01		6	<1			<5	6			<0.005	
Wolgan River Downstream	5/05/2014				7.9	28	7.09	0.005	0.29	0.05				<1	4	0.001	<0.001	10.22	1603				<1			<0.01	<1		6			<5	6			0.011	
Wolgan River Downstream	21/05/2014				11.6	29	6.44	0.004	0.22	0.04				<1	4	<0.001	<0.001	9.6	1559				<1			<0.01	<1		6			<5	7			0.006	
Wolgan River Downstream	4/06/2014				7.9	30	6.65	0.005	0.27	0.04				<1	5	<0.001	<0.001	10.17	1384				<1			<0.01	<1		5			<10	6			0.007	
Wolgan River Downstream	16/06/2014				6.6	48	6.81	0.004	0.26	0.05				<1	4	0.001	<0.001	11.51	1244				<1			<0.01	<1		5			<10	4			0.006	
Wolgan River Downstream	1/07/2014				6.2	28	6.47	0.004	0.27	0.08				<1	5	<0.001	<0.001	11.13	1227				<1			<0.01	<1		5			<10	5			<0.005	
Wolgan River Downstream	15/07/2014				4.8	28	6.5	<0.001	0.2	0.04				<1	5	<0.001	<0.001	9.52	1124				<1			0.03	<1		5			<10	7			<0.005	
Wolgan River Downstream	29/07/2014				6.1	30	6.61	0.005	0.28	0.06				<1	5	<0.001	<0.001	10.6	1880				<1			0.01	<1		5			<10	6			<0.005	
Wolgan River Downstream	12/08/2014				4.5	52	7.05	0.004	0.2	0.04				<1	5	<0.001	<0.001	10.6	1405				<1			0.02	<1		6			<10	6			<0.005	
Wolgan River Downstream	28/08/2014				9.72	46	6.28	0.006	0.4	0.15				<1	5	<0.001	0.003	9.21	12983				<1			0.02	<1		6			<10	4			0.01	
Wolgan River Downstream	10/09/2014				10	<100	6.1	0.006	0.31	0.16				<1	5	<0.001	0.004	9.69	10109				<1			<0.01	<1		4			<10	4			0.025	
Wolgan River Downstream	24/09/2014				10.5	<10	6.56	0.01	0.29	0.06				<1	5	<0.001	<0.001	0.04	2140				<1			<0.01	<1		5			<10	6			0.005	
Wolgan River Downstream	4/02/2008				16	46	6.2	0.007	0.69										6434																		
Wolgan River Downstream	19/02/2008				14.8	56	6.8	0.009	0.81										6427																		
Wolgan River Downstream	3/03/2008				12.2	57	6.8	0.008	0.68										6827																		
Wolgan River Downstream	18/03/2008				14.9	409	7.9	0.008	0.9										7640																		
Wolgan River Downstream	2/04/2008				11	63	7	0.005	0.52										2428																		
Wolgan River Downstream	15/04/2008				10.5	55	6.8	0.006	0.58										1760																		
Wolgan River Downstream	29/04/2008				7	50	7	0.006	0.72										3127																		
Wolgan River Downstream	13/05/2008				11.2	465	7.8	0.01	0.81										8395																		
Wolgan River Downstream	28/05/2008				9.8	677	8.3	0.002	0.5										6953																		
Wolgan River Downstream	10/06/2008																																				
Wolgan River Downstream	24/06/2008				6.9	83	7.2	0.005	0.8										3769																		
Wolgan River Downstream	10/06/2008																																				
Wolgan River Downstream	24/06/2008				6.9	83	7.2	0.005	0.8										3769																		
Wolgan River Downstream	8/07/2008				9.2	625	8.2	0.005	0.55										13683																		
Wolgan River Downstream	22/07/2008				7.2	594	7.8	0.005	0.51										No flow rate due to																		
Wolgan River Downstream	6/08/2008				6.3	334	8	0.006	0.92										3394																		
Wolgan River Downstream	20/08/2008				4.9	78	7.1	0.005	0.53										No flow rate measu																		
Wolgan River Downstream	2/09/2008	Mod High flo			7.7	92	7.3	0.006	0.93										5139																		
Wolgan River Downstream	18/09/2008	High flow			10.8	50	7.9	0.005	0.67										10493																		
Wolgan River Downstream	2/10/2008	Mod flow			14	650	8.2	0.008	0.7										7677																		
Wolgan River Downstream	15/10/2008	High flow			12.4	354	7.8	0.009	0.96										11564																		
Wolgan River Downstream	29/10/2008	Mod flow			17.1	570	8.3	0.005	0.49										12410																		
Wolgan River Downstream	11/11/2008	High flow			16.6	683	8.3	0.007	0.44										8673																		
Wolgan River Downstream	26/11/2008	High flow			14.2	525	8	0.007	0.61										12367																		
Wolgan River Downstream	8/12/2008	High flow			17.8	623	8.3	0.008	0.59										12423																		
Wolgan River Downstream	22/12/2008	Mod flow			16.5	462	8.3	0.008	0.72										9416																		
Wolgan River Downstream	8/01/2009	High flow			20.2	656	8.3	0.009	0.51										10993																		
Wolgan River Downstream	21/01/2009	High flow			20.6	673	8.4	0.007	0.48										12919																		
Wolgan River Downstream	3/02/2009	Mod flow			21.5	686	8.4	0.006	0.52										7461																		
Wolgan River Downstream	17/02/2009	High flow			14.7	400	7.9	0.009	0.87										20989																		
Wolgan River Downstream	3/03/2009	Low flow			16.2	106	7.5	0.007	0.88										928																		
Wolgan River Downstream	17/03/2009	Mod flow			12.6	76	6.9	0.007	0.98										1653																		
Wolgan River Downstream	2/04/2009	High flow			14.8	68	7.3												9685																		
Wolgan River Downstream	16/04/2009	Mod flow			12.2	60	7.2	0.008	0.78										2679																		
Wolgan River Downstream	29/04/2009	Low flow			8.7	52	7	0.004	0.8										2175																		
Wolgan River Downstream	12/05/2009	Low flow			7.8	50	7												1749																		
Wolgan River Downstream	27/05/2009	Mod flow			11.2	158	7.5	0.01	1.09										10798																		
Wolgan River Downstream	11/06/2009				5.6	53	7.5	0.005	0.81										5257																		
Wolgan River Downstream	23/06/2009				8.7	70	6.8	0.005	0.82										4300																		
Wolgan River Downstream	7/07/2009				6.2	50	6.8	0.004	0.73										3564																		
Wolgan River Downstream	22/07/2009				11.9	662	8.4	0.004	0.47										8413																		
Wolgan River Downstream	5/08/2009				10.6	606	8.2	0.005	0.36										7323																		
Wolgan River Downstream	19/08/2009				10.3	572	8.1	0.004	0.38										9351																		
Wolgan River Downstream	3/09/2009				10.6	441	7.9	0.005	0.81										9379																		
Wolgan River Downstream	16/09/2009				11.5	108	6.91	0.005	0.72										1120																		
Wolgan River Downstream	29/09/2009				8.8	72	6.83	0.007	0.66										1241																		
Wolgan River Downstream	14/10/2009				10	60	6.84	0.004	0.48										663																		

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) (mg/L)	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
Wolgan River Downstream	27/10/2009				9.8	54	6.83	0.004	0.45										1363																		
Wolgan River Downstream	9/11/2009				14.7	63	6.91	0.006	0.45										271																		
Wolgan River Downstream	24/11/2009				14.3	121	6.87	0.034	1.12										45																		
Wolgan River Downstream	7/12/2009																		0																		
Wolgan River Downstream	23/12/2009																		0																		
Wolgan River Downstream	6/01/2010				17.9	62	7.21	0.005	0.57										624																		
Wolgan River Downstream	18/01/2010				13.8	72	7.13	0.006	0.54										80																		
Wolgan River Downstream	3/02/2010				16.8	62	7.07	0.01	0.7										743																		
Wolgan River Downstream	19/02/2010				15.5	70	6.73	0.009	1.04										2929																		
Wolgan River Downstream	3/03/2010				13.3	58	6.49	0.008	0.6										1030																		
Wolgan River Downstream	20/03/2010				13.1	60	6.14	0.007	0.6										524																		
Wolgan River Downstream	29/03/2010				15.3	62	6.98	0.009	0.63										222																		
Wolgan River Downstream	12/04/2010				11.4	51	6.87	0.006	0.66										761																		
Wolgan River Downstream	27/04/2010					44	7.74	0.006	0.57										433																		
Wolgan River Downstream	12/05/2010				7.2	49	6.89	0.005	0.36										491																		
Wolgan River Downstream	24/05/2010				9	46	6.76	0.004	0.38										339																		
Wolgan River Downstream	10/06/2010				6.8	45	6.44	0.006	0.49										1836																		
Wolgan River Downstream	23/06/2010				8.7	42	6.65	0.006	0.46										1388																		
Wolgan River Downstream	6/07/2010				7	43	6.55	0.005	0.49										132																		
Wolgan River Downstream	20/07/2010				6.2	46	6.55	0.008	0.57										2158																		
Wolgan River Downstream	4/08/2010				7.7	46	6.68	0.006	0.53										4740																		
Wolgan River Downstream	16/08/2010				8.1	43	5.2	0.006	0.48										5090																		
Wolgan River Downstream	3/09/2010				10.1	40	6.63	0.006	0.55										1822																		
Wolgan River Downstream	13/09/2010				9.8	42	6.61	0.007	0.53										4891																		
Wolgan River Downstream	29/09/2010				10.1	25	6.2	0.006	0.52										48																		
Wolgan River Downstream	14/10/2010				13.5	49	6.88	0.007	0.59										2937																		
Wolgan River Downstream	25/10/2010				10.9	40	6.94	0.006	0.67										7550																		
Wolgan River Downstream	9/11/2010				14.2	41	6.96	0.008	0.68										2694																		
Wolgan River Downstream	25/11/2010				14.8	41	6.87	0.008	0.62										3442																		
Wolgan River Downstream	7/12/2010				15.4	37	6.56	0.006	0.41										25762																		
Wolgan River Downstream	21/12/2010				12.4	58	6.98	0.006	0.54										4693																		
Wolgan River Downstream	5/01/2011				15.3	40	6.92	0.009	0.58										707																		
Wolgan River Downstream	18/01/2011				17.2	40	6.88	0.009	1.22										3287																		
Wolgan River Downstream	2/02/2011				19.1	44	6.97	0.014	0.83										1426																		
Wolgan River Downstream	18/02/2011				16.8	34	6.54	0.011	0.67										2205																		
Wolgan River Downstream	2/03/2011				14.8	39	6.56	0.011	0.55										508																		
Wolgan River Downstream	17/03/2011				16.1	37	6.72	0.009	0.7																												
Wolgan River Downstream	29/03/2011				13.7	36	6.89	0.008	0.63										756																		
Wolgan River Downstream	2/03/2011				14.8	39	6.56	0.011	0.55										508																		
Wolgan River Downstream	17/03/2011				16.1	37	6.72	0.009	0.7																												
Wolgan River Downstream	29/03/2011				13.7	36	6.89	0.008	0.63										756																		
Wolgan River Downstream	15/04/2011				9.8	34	6.85	0.007	0.28										70																		
Wolgan River Downstream	27/04/2011				11.3	32	7.21	0.005	0.37										532																		
Wolgan River Downstream	15/04/2011				9.8	34	6.85	0.007	0.28										70																		
Wolgan River Downstream	27/04/2011				11.3	32	7.21	0.005	0.37										532																		
Wolgan River Downstream	9/05/2011				7	29	6.04	0.005	0.4										325																		
Wolgan River Downstream	25/05/2011				7.8	28	6.35	0.008	0.42										668																		
Wolgan River Downstream	9/05/2011				7	29	6.04	0.005	0.4										325																		
Wolgan River Downstream	25/05/2011				7.8	28	6.35	0.008	0.42										668																		
Wolgan River Downstream	10/06/2011				6	29	6.71	0.005	0.49										154																		
Wolgan River Downstream	22/06/2011																																				
Wolgan River Downstream	10/06/2011				6	29	6.71	0.005	0.49										154																		
Wolgan River Downstream	22/06/2011																																				
Wolgan River Downstream	6/07/2011				6.1		6.78	0.006	0.68										2942																		
Wolgan River Downstream	20/07/2011				7.1	37	6.73	0.005	0.57										3170																		
Wolgan River Downstream	6/07/2011				6.1		6.78	0.006	0.68										2942																		
Wolgan River Downstream	20/07/2011				7.1	37	6.73	0.005	0.57										3170																		
Wolgan River Downstream	5/08/2011				6.2	40	6.67	0.004	0.53										0																		
Wolgan River Downstream	17/08/2011				6.7	37	6.72	0.005	0.46										1296																		
Wolgan River Downstream	31/08/2011				7.9	40	6.62	0.007	0.61										2478																		
Wolgan River Downstream	5/08/2011				6.2	40	6.67	0.004	0.53										0																		
Wolgan River Downstream	17/08/2011				6.7	37	6.72	0.005	0.46										1296																		
Wolgan River Downstream	31/08/2011				7.9	40	6.62	0.007	0.61										2478																		
Wolgan River Downstream	14/09/2011				7.9	39	6.78	0.007	0.79										1541																		
Wolgan River Downstream	28/09/2011				9.3	41	6.51	0.007	0.59										1660																		
Wolgan River Downstream	14/09/2011				7.9	39	6.78	0.007	0.79										1541																		
Wolgan River Downstream	28/09/2011				9.3	41	6.51	0.007	0.59										1660																		
Wolgan River Downstream	12/10/2011				8.3	30	6.22	0.005	0.42										2967																		
Wolgan River Downstream	26/10/2011				11.8	29	6.8	0.008	1.24										182																		
Wolgan River Downstream	12/10/2011				8.3	30	6.22	0.005	0.42										2967																		
Wolgan River Downstream	26/10/2011				11.8	29	6.8	0.008	1.24										182																		
Wolgan River Downstream	10/11/2011				16	40	6.37	0.011	0.51										859																		
Wolgan River Downstream	23/11/2011				10.8	28	6.17	0.016	0.41										18524																		
Wolgan River Downstream	10/11/2011				16	40	6.37	0.011	0.51										859																		
Wolgan River Downstream	23/11/2011				10.8	28	6.17	0.016	0.41										18524																		
Wolgan River Downstream	5/12/2011				11.5	44	6.26	0.011	0.52										3135																		
Wolgan River Downstream	28/12/2011				13.5	49	6.12	0.006	0.74										455																		
Wolgan River Downstream	5/12/2011				11.5	44	6.26	0.011	0.52										3135																		
Wolgan River Downstream	28/12/2011				13.5	49	6.12	0.006	0.74										455																		
Wolgan River Downstream	5/01/2012				16.6	43	6.28	0.008	0.68										864																		
Wolgan River Downstream	18/01/2012				16.1	46	6.89	0.006	0.61										504																		
Wolgan River Downstream	31/01/2012				17.2	45	6.73	0.008	0.81										1535																		
Wolgan River Downstream	15/02/2012				14.8	34	5.69	0.009	0.49										8050																		
Wolgan River Downstream	13/03/2012				14.5	29	6.36	0.009	0.72										16042																		

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) mg/L	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
Wolgan River Downstream	28/03/2012				13.5	39	6.23	0.015	0.62										7818																			
Wolgan River Downstream	11/04/2012				10.9	28	5.85	0.007	0.58										3284																			
Wolgan River Downstream	24/04/2012				12.4	36	6.15	0.008	0.59										6174																			
Wolgan River Downstream	9/05/2012				8.8	27	6.68	0.49	0.006										3557																			
Wolgan River Downstream	24/05/2012				6.5	36	5.66	0.009	0.48										4080																			
Wolgan River Downstream	6/06/2012				7.4	32	5.76	0.007	0.5										12267																			
Wolgan River Downstream	20/06/2012				7.3	35	6.75	0.007	0.52										6397																			
Wolgan River Downstream	6/07/2012				6.9	39	6.76	0.005	0.64										3356																			
Wolgan River Downstream	18/07/2012				6.8	36	6.61	0.007	0.48										5343																			
Wolgan River Downstream	31/07/2012				5.5	38	6.65	0.005	0.48										3968																			
Wolgan River Downstream	13/08/2012				6.5	36	6.86	0.005	0.51										3798																			
Wolgan River Downstream	30/08/2012				7.5	34	6.32	0.004	0.31										3847																			
Wolgan River Downstream	10/09/2012				8.8	35	6.34	0.006	0.41										2519																			
Wolgan River Downstream	25/09/2012				7.8	35	6.38	0.007	0.47										1964																			
Wolgan River Downstream	8/10/2012				11.4	36	6.76	0.006	0.4										2804																			
Wolgan River Downstream	24/10/2012				10.4	36	6.35	0.009	0.37										1813																			
Wolgan River Downstream	7/11/2012				15.1	38	6.89	0.009	0.44																													
Wolgan River Downstream	22/11/2012				12.6	37	6.1	0.007	0.45										1441																			
Wolgan River Downstream	3/12/2012				16.9	39	6.58	0.011	0.59										1861																			
Wolgan River Downstream	17/12/2012				14.6	37	6.94	0.01	0.32										875																			
Wolgan River Downstream	3/01/2013				16.2	42	6.65	0.011	0.66										877																			
Wolgan River Downstream	16/01/2013				17.6	46	6.72	0.014	0.58										593																			
Wolgan River Downstream	29/01/2013				17.9	45	6.02	0.025	0.94																													
Wolgan River Downstream																																					
Wolgan River Downstream	11/02/2013				16.5	36	6.55	0.01	0.51										Current to strong to																			
Wolgan River Downstream	25/02/2013				16.7	40	6.22	0.013	0.37										Current to strong to																			
Wolgan River Downstream																																					
Wolgan River Downstream	11/03/2013				12.4	40	6.42	0.011	0.36										12203																			
Wolgan River Downstream	25/03/2013				15.1	46	7.24	0.01	0.65										2131																			
Wolgan River Downstream	9/04/2013				12.6	39	5.72	0.009	0.29										2641																			
Wolgan River Downstream	22/04/2013				10.6	35	6.62	0.01	0.43										2240																			
Wolgan River Downstream	6/05/2013				8.8	40	7.11	0.011	0.36										1616																			
Wolgan River Downstream	20/05/2013				9.7	32	6.65	0.009	0.28										2094																			
Wolgan River Downstream	3/06/2013				8.4	36	6.33	0.008	0.41										5958																			
Wolgan River Downstream	18/06/2013				6.5	32	6.08	0.007	0.23										2467																			
Wolgan River Downstream	1/07/2013				8.9	33	6.55	0.006	0.29										6464																			
Wolgan River Downstream	19/07/2013				9.3	35	6.9	0.006	0.16										4859																			
Wolgan River Downstream	30/07/2013				6.9	31	6.06	0.005	0.23										2585																			
Wolgan River Downstream	13/08/2013				6.5	30	6.72	0.007	0.23										1200																			
Wolgan River Downstream	30/08/2013				8.3	30	6.7	0.003	0.05										417																			
Wolgan River Downstream	13/09/2013				7.9	29	6.33	0.008	0.33										402																			
Wolgan River Downstream	25/09/2013				10	32	6.23	0.005	0.2										1995																			
Wolgan River Downstream	9/10/2013				9.5	35	6.63	0.004	0.23										965																			
Wolgan River Downstream	24/10/2013																																				
Wolgan River Downstream	4/11/2013				11.2	35	6.17	0.009	0.4										737																			
Wolgan River Downstream	18/11/2013				11.2	35	6.62	0.006	0.34										1626																			
Wolgan River Downstream	3/12/2013				16.8	36	6.58	0.006	0.37										284																			
Wolgan River Downstream	20/12/2013				8	47	6.37	0.009	0.44										822																			
Wolgan River Downstream	31/12/2013				15.1	37	6.5	0.008	0.38										1062																			
Wolgan River Downstream	17/01/2014				16.6	40	6.64	0.021	0.71										229																			
Wolgan River Downstream	30/01/2014				14.9	38	6.54	0.018	0.81	0.1					6	<0.001	<0.001	4.95	219				<1			<0.01	<1		8			<5				0.006	0.018
Wolgan River Downstream	11/02/2014																																				
Wolgan River Downstream	27/02/2014				16.2	32	6.75	0.008	0.46	0.08					4	<0.001	<0.001	7.02	344			<1				<0.01	<1		7			<5	8			0.008	0.07
Wolgan River Downstream	12/03/2014				14.6	31	6.55	0.007	0.39	0.08					5	<0.001	<0.001	8.45	2408				<1			<0.01	<1		8			<5	8			0.016	0.008
Wolgan River Downstream	26/03/2014				13.4	31	6.61	0.005	0.34	0.08					4	<0.001	<0.001		1415				<1			<0.01	<1		6			<5	7			<0.005	0.005
Wolgan River Downstream	8/04/2014				13.8	32	6.62	0.007	0.44	0.14					5	<0.001	<0.001	8.4	7400				<1			<0.01	<1		7			<5	7			<0.005	
Wolgan River Downstream	22/04/2014				10.7	44	6.77	0.006	0.26	0.04					4	<0.001	<0.001	13.8	3180				<1			<0.01	6		<1			<5	6			<0.005	
Wolgan River Downstream	5/05/2014				7.9	28	7.09	0.005	0.29	0.05					4	0.001	<0.001	10.22	1603				<1			<0.01	<1		6			<5	6			0.011	
Wolgan River Downstream	21/05/2014				11.6	29	6.44	0.004	0.22	0.04					4	<0.001	<0.001	9.6	1559				<1			<0.01	<1		6			<5	7			0.006	
Wolgan River Downstream	4/06/2014				7.9	3	6.65	0.005	0.27	0.04					5	<0.001	<0.001	10.17	1384				<1			<0.01	<1		5			<10	6			0.007	
Wolgan River Downstream	16/06/2014				6.6	48	6.81	0.004	0.26	0.05					4	0.001	<0.001	11.51	1244				<1			<0.01	<1		5			<10	4			0.006	
Wolgan River Downstream	1/07/2014				6.2	28	6.47	0.004	0.27	0.08					5	<0.001	<0.001	11.13	1227				<1			<0.01	<1		5			<10	5			<0.005	
Wolgan River Downstream	15/07/2014				4.8	28	6.5	<0.001	0.2	0.04					5	<0.001	<0.001	9.52	1124				<1			0.03	<1		5			<10	7			<0.005	
Wolgan River Downstream	29/07/2014				6.1	3	6.61	0.005	0.28	0.06					5	<0.001	<0.001	10.6	1880				<1			0.01	<1		5			<10	6			<0.005	
Wolgan River Downstream	12/08/2014				4.5	52	7.05	0.004	0.2	0.04					5	<0.001	<0.001	10.6	1405				<1			0.02	<1		6			<10	6			<0.005	
Wolgan River Downstream	28/08/2014				9.72	46	6.28	0.006	0.4	0.15					5	<0.001	0.003	9.21	12983				<1			0.02	<1		6			<10	4			0.01	
Wolgan River Downstream	10/09/2014				10		6.1	0.006	0.31	0.16					5	<0.001	0.004	9.69	10109				<1			<0.01	<1		4			<10	4			0.025	
Wolgan River Downstream	24/09/2014				10.5		6.56	0.01	0.29	0.06					5	<0.001	<0.001	0.04	2140				<1			<0.01	<1		5			<10	6			0.005	
Wolgan River Downstream	9/10/2014	Mod flow	Clear		10.7	31	6.53	0.006	0.39	0.09				<1		<0.001	0.001	9.27	979			<1				<0.01	<1		5	5		<10	<1	<0.1		0.025	
Wolgan River Downstream	20/10/2014	Mod flow	Clear		14	45	5.9	0.006	0.3	0.07					5	<0.001	0.003	7.37	2455			<1				0.04	4		<1	<1		<10	7	<0.1		0.018	
Wolgan River Downstream	5/11/2014	Mod Flow	Clear		13.9	44	6.78	0.007	0.34	0.07					5	<0.001	<0.001	6.42	1188			<1				<0.01	7		<1	<1			7	0.1		0.008	
Wolgan River Downstream	19/11/2014	Mod Flow	Clear		15.4		6.25	0.01	0.47	0.1					5	<0.001	<0.001	7.75	447			<1				<0.01	5		<1	<1		<5	8	0.2		0.008	
Wolgan River Downstream	3/12/2014	Low Flow	Clear		18.5	8	6.33	0.012	0.5	0.13					5	<0.001	0.003	6.74	1140			<1				0.03	4		<1	<1		<5	5	0.2		0.008	
Wolgan River Downstream	17/12/2014	Mod Flow	Clear		16.2	35	6.43	0.011	0.43	0.11					4	<0.001	0.002	7.81	113			<1				<0.01	6		<1	1		<5	8	0.3		0.01	
Wolgan River Downstream	31/12/2014	Low Flow	Clear		15.9	32	5.97	0.01	0.49	0.12					5	<0.001	0.002	7.96				<1				<0.01	6		<1	<1		<5	9	0.3		0.01	
Wolgan River Downstream	12/01/2015	Mod Flow	Clear		16.7	4	6.85	0.01	0.54	0.2					4	<0.001	0.002	7.1	9132			<1				0.01	5		<1	2		<5	5	0.2		0.013	
Wolgan River Downstream	28/01/2015	High Flow	Clear		14.2	33	8.83	0.016	0.42	0.26					3	<0.001	0.003	8.7	13231			<1				0.03	5		<1	<1		5	4	0.2		0.017	
Wolgan River Downstream	12/02/2015	Mod Flow	Clear		16.8	43	6.41	0.028	0.44	0.09					5	<0.001	0.001	8.21	1702			<1				<0.01	8		<1	<1		<5	9	0.6		0.047	
Wolgan River Downstream	26/02/2015	Mod Flow	Clear		17.6	45	6.68	0.01	0.42	0.07					5	<0.001	0.048	5.49	2217			<1				<0.01	7		<1	<1		<5	8	0.1		0.131	
Wolgan River Downstream	11/03/2015	Mod Flow	Clear		16.7	42	6.65	0.01	0.51	0.08					5	<0.001	<0.001	4.29	920			<1				<0.01	5		<1	<1		<5	10	0.1		0.009	
Wolgan River Downstream	26/03/2015	Mod Flow	Clear		13.4	39	6.43	0.007	0.51	0.09					5	<0.001	<0.001	7.57	544			<1				<0.01	4		<1	<1		<5	8	0.2		0.007	
Wolgan River Downstream	9/04/2015	Mod Flow	Clear		10.8	35	7	0.003	0.55	0.09					4	<0.001	<0.001	9.53	1769			<1				<0.01	5		<1	<1		<5	6	0.2		<0.005	
Wolgan River Downstream	22/04/2015			Dry																																	
Wolgan River Downstream	6/05/2015	High Flow	Clear		10.6	37	6.39	0.005	0.42	0.13				<1	4	<0.001	<0.001	10.97	3940			<1				<0.01	<1		6	1		<5	6	0.2		0.009	

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) mg/L	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
Wolgan River Downstream	20/05/2015	High Flow	Clear		10.9	36	6.62	0.005	0.36	0.08				<1	4	<0.001	<0.001	11.47	2568			<1				0.01	<1		4	<1		<5	6	0.1			0.009	
Wolgan River Downstream	3/06/2015	High Flow	Clear		6.2	39	7.18	0.004	0.3	0.06				4		<0.001	<0.001	11.04	1069			<1				<0.01	3		<1	<1		<5	7	<0.1			0.007	
Wolgan River Downstream	17/06/2015	High Flow	Clear		9.4	37	6.75	0.006	0.36	0.06				4		<0.001	0.001	8.45	1543			<1				0.03	4		<1	<1		<5	5	0.2			0.01	
Wolgan River Downstream	30/06/2015	Mod Flow	Clear		6	37	6.51	0.006	0.22	0.05				4		<0.001	<0.001	8.82	3109			<1				0.04	5		<1	<1		<5	6	0.1			0.007	
Wolgan River Downstream	15/07/2015	Mod Flow	Clear		5.1	34	6.7	0.004	0.35	0.1				4	4	<0.001	<0.001	11.08	875			<1				0.01	2		<1	1		<5	5	0.1			0.006	
Wolgan River Downstream	29/07/2015	Mod Flow	Clear	Flow too low for flow	4.8	35	6.84	0.006	0.36	0.09				<1	4	<0.001	<0.001	11.33	2021			<1				0.07	<1		4	<1		<5	5	<0.1			0.007	
Wolgan River Downstream	12/08/2015	Mod Flow	Clear		5	36	7.28	0.004	0.24	0.04				<1	3	<0.001	<0.001	11.16	886			<1				<0.01	<1		5	<1		<5	6	<0.1			<0.005	
Wolgan River Downstream	18/08/2015	Mod Flow	Clear		8.8	33	6.85	0.005	0.31	0.1				<1	3	<0.001	<0.001	10.31	4220			<1				0.02	<1		4	1		<5	3	0.2			<0.005	
Wolgan River Downstream	9/09/2015	Mod flow	Clear		9	37	7.18	0.005	0.27	0.04				<1	3	<0.001	<0.001	9.61	630			<1				0.02	<1		5	<1		<5	5	<0.1			<0.005	
Wolgan River Downstream	23/09/2015	Mod flow	Clear		7.8	36	7.01	0.005	0.4	0.07				<1	5	<0.001	<0.001	9.55	228			<1				0.04	<1		5	<1		<5	6	<0.1			<0.005	
Wolgan River Downstream	7/10/2015	Mod Flow	Clear		12.2	27	6.83	0.006	0.28	0.03				<1	4	<0.001	<0.001	9.79	688			<1				0.04	<1		4	<1		<5	6	<0.1			<0.005	
Wolgan River Downstream	21/10/2015	Mod Flow	Clear		14.5	39	6.12	0.008	0.5	0.08				<1	5	<0.001	<0.001	7.23	2872			<1				<0.01	<1		4	<1		<5	4	0.1			0.006	
Wolgan River Downstream	4/11/2015	Mod Flow	Clear		14.6	40	6.6	0.01	0.44	0.18				<1	4	<0.001	<0.001	7.3	141			<1				0.02	<1		5	<1		6	6	0.3			0.012	
Wolgan River Downstream	18/11/2015	Mod Flow	Clear		14	32	7	0.008	0.46	0.1				<1	4	<0.001	<0.001	8.55	1169			<1				<0.01	<1		5	<1		<5	7	0.2			<0.005	
Wolgan River Downstream	30/11/2015	Mod Flow	Clear		15.4	40	7.51	0.009	0.44	0.05				<1	4	<0.001	<0.001	7.28	1397			<1				<0.01	<1		4	<1		<5	8	0.2			<0.005	
Wolgan River Downstream	16/12/2015	Mod Flow	Clear		16.3	41	6.52	0.014	0.63	0.09				<1	5	<0.001	<0.001	6.35	357			<1				0.04	<1		5	<1		<5	10	0.2			<0.005	
Wolgan River Downstream	30/12/2015	Mod flow	Clear		14.2	48	6.95	0.009	0.43	0.06				<1	4	<0.001	<0.001	7.77	1477			<1				<0.01	<1		4	<1		<5	7	0.1			<0.005	
Wolgan River Downstream	13/01/2016	Mod Flow	Clear		18	38	6.67	0.009	0.41	0.06				<1	5	<0.001	<0.001	6.8	194			<1				<0.01	<1		5	<1		12	9	<0.1			<0.005	
Wolgan River Downstream	28/01/2016	High Flow	Clear		16.8	37	6.51	0.008	0.4	0.07				<1	4	<0.001	<0.001	7.06	2217			<1				<0.01	<1		5	<1		<5	6	<0.1			<0.005	
Wolgan River Downstream	10/02/2016	Mod Flow	Clear		16.3	40	7.38	0.008	0.42	0.06				<1	4	<0.001	<0.001	7	379			<1				<0.01	<1		5	<1		<5	7	0.4			<0.005	
Wolgan River Downstream	22/02/2016	Mod Flow	Clear		17.6	41	6.36	0.017	1.37	0.22				<1	5	<0.001	<0.001	5.69	148			<1				0.04	<1		6	<1		<5	9	0.1			<0.005	
Wolgan River Downstream	8/03/2016	Mod Flow	Clear		17.5	46	6.32	0.018	1.33	0.1				<1	5	<0.001	<0.001	5.54	396			<1				<0.01	<1		6	<1		<5	10	0.3			<0.005	
Wolgan River Downstream	21/03/2016	Mod Flow	Clear		14	39	6.37	0.008	0.38	0.06				<1	5	<0.001	<0.001	7.61	259			<1				0.01	<1		4	3		<5	6	0.2			<0.005	
Wolgan River Downstream	6/04/2016	Mod Flow	Clear		15.1	45	6.61	0.01	0.5	0.06				<1	4	<0.001	0.001	6.23	290			<1				<0.01	<1		8	<1		<5	10	<0.1			<0.005	
Wolgan River Downstream	19/04/2016	Mod Flow	Clear		12.6	38	6.52	0.008	0.39	0.04				<1	5	<0.001	<0.001	7.91	174			<1				<0.01	<1		5	<1		<5	13	<0.1			<0.005	
Wolgan River Downstream	2/05/2016	Mod Flow	Clear		11.5	32	6	0.007	0.35	0.05				<1	5	<0.001	<0.001	8.29	263			<1				0.03	<1		4	<1		<5	5	0.3			<0.005	
Wolgan River Downstream	16/05/2016	Mod Flow	Clear		9.3	37	6.58	0.006	0.34	0.05				<1	4	<0.001	<0.001	8.13	638			<1				<0.01	<1		5	<1		<5	7	0.2			<0.005	
Wolgan River Downstream	30/05/2016	Mod Flow	Clear		6.1	39	6.81	0.005	0.28	0.05				<1	4	<0.001	0.002	9.32	133			<1				<0.01	<1		4	<1		<5	7	<0.1			<0.005	
Wolgan River Downstream	15/06/2016	High Flow	Clear		6.5	39	6.48	0.008	0.4	0.11				<1	4	<0.001	<0.001	10.13	1457			<1				0.01	<1		5	1		<5	6	0.2			<0.005	
Wolgan River Downstream	29/06/2016	High Flow	Clear		6.6	39	6.38	0.007	0.34	0.14				<1	3	<0.001	<0.001	8.69	4401			<1				<0.01	<1		4	1		<5	5	3.1			<0.005	
Wolgan River Downstream	11/07/2016	High Flow	Clear		8.2	38	6.46	0.008	0.34	0.11				<1	4	<0.001	<0.001	10.15	3985			<1				<0.01	<1		4	2		<5	6	0.2			<0.005	
Wolgan River Downstream	27/07/2016	Mod Flow	Clear		8.5	37	6.55	0.006	0.29	0.14				<1	3	<0.001	<0.001	9.24	4831			<1				0.02	<1		4	2		<5	6	<0.1			<0.005	
Wolgan River Downstream	10/08/2016	Mod Flow	Clear		8.7	38	6.9	0.006	0.27	0.08				<1	3	<0.001	<0.001	9.29	2647			<1				0.02	<1		5	1		<5	6	0.3			<0.005	
Wolgan River Downstream	24/08/2016	High Flow	Clear		7.8	33	6.26	0.005	0.24	0.05				<1	5	<0.001	<0.001	10.36	2404			<1				<0.01	<1		4	<1		<5	5	<0.1			<0.005	
Wolgan River Downstream	7/09/2016	High flow	Clear		9.4	40	6.62	0.006	0.31	0.12				<1	5	<0.001	<0.001	9.48	8642			<1				<0.01	<1		4	5		<5	4	0.2			<0.005	
Wolgan River Downstream	21/09/2016	High flow	Clear		10	36	6.28	0.008	0.3	0.12				<1	4	<0.001	<0.001	8.16	5202			<1				<0.01	<1		5	2		<5	6	0.1			<0.005	
Wolgan River Downstream	5/10/2016	Mod Flow	Clear		9.9	35.5	6.62	0.007	0.28	0.07				<1	4	<0.001	<0.001	8.66	2281			<1				0.01	<1		5	1		<5	4	<0.1			<0.005	
Wolgan River Downstream	20/10/2016	Mod Flow	Clear		10.8	40	6.78	0.005	0.35	0.04				<1	4	<0.001	<0.001	8.92	1428			<1				<0.01	<1		5	<1		<5	5	0.1			<0.005	
Wolgan River Downstream	2/11/2016	Mod Flow	Clear		10.2	33	6.05	0.008	0.36	0.08				<1	4	<0.001	<0.001	9.48	1026			<1				<0.01	<1		5	<1		<5	6	<0.1			<0.005	
Wolgan River Downstream	17/11/2016	High Flow	Clear		14.3	39	6.56	0.009	0.28	0.06				<1	4	<0.001	<0.001	7.56	624			<1				0.03	<1		6	<1		<5	6	<0.1			0.013	
Wolgan River Downstream	28/11/2016	Low Flow	Clear		16.8	39	6.66	0.009	0.4	0.05				<1	5	<0.001	<0.001	7.39	750			<1				0.03	<1		5	<1		<5	7	0.2			<0.005	
Wolgan River Downstream	12/12/2016	Low Flow	Clear		16.9	35	5.93	0.016	0.46	0.05				<1	5	<0.001	<0.001	7.65	85			<1				0.03	<1		5	<1		<5	7	0.1			<0.005	
Wolgan River Downstream	29/12/2016	Low Flow	Clear		18.1	36	6.96	0.01	0.38	0.05				<1	4	<0.001	0.001	7.01	602			<1				0.02	<1		6	<1			6	0.4			0.006	
Wolgan River Downstream	10/01/2017	Low Flow	Clear		19.6	38	6.41	0.017	0.42	0.05				<1	4	<0.001	<0.001	6.12	31			<1				<0.01	<1		6	<1		<5	8	0.1			<0.005	
Wolgan River Downstream	25/01/2017	Low Flow	Clear		17.3	31	5.95	0.019	0.62	0.06				<1	5	<0.001	<0.001	5.16	181			<1				<0.01	<1		7	<1		<5	9	0.2			<0.005	
Wolgan River Downstream	5/10/2017	Low Flow	Clear		8	35	7.5	0.006	0.24	0.03				<1	5	<0.001	<0.001	8	134			<1				0.02	<1		5	<1		<5	6	0.1			<0.005	
Wolgan River Downstream	19/10/2017		Clear		15.6	28	6.3	0.004	0.23	0.03				<1	5	<0.001	<0.001	5.8	276			<1				0.03	<1		4	<1		<5	2	0.1			<0.005	
Wolgan River Downstream	30/10/2017	Low Flow	Clear		13.7	40	6.6	0.008	0.26	0.04				<1	5	<0.001	<0.001	6.4	140			<1				0.04	<1		4	<1		<5	7	<0.1			<0.005	
Wolgan River Downstream	14/11/2017	Mod Flow	Clear		11.2	40	6	0.008	0.46	0.06				<1	4	<0.001	<0.001	6.1	454			<1				0.02	<1		5	<1		<5	6	<0.1			<0.005	
Wolgan River Downstream	30/11/2017	Mod Flow	Clear		14	34	6.1	0.01	0.29	0.06				<1	5	<0.001	<0.001	6.7	399			<1				<0.01	<1		5	<1		<5	6	0.1			<0.005	
Wolgan River Downstream	14/12/2017	Mod Flow	Clear		14.7	38	6.4	0.012	0.38	0.04				<1	5	<0.001	<0.001		274			<1				0.03	<1		1	<1		<5	7	0.2			<0.005	
Wolgan River Downstream	28/12/2017	Low Flow	Clear		15.5	37	6.8	0.014	0.37	0.04				<1	4	<0.001	<0.001	5.9	799			<1				<0.01	<1		5	<1		8	9	<0.1			<0.005	
Wolgan River Downstream	9/02/2017	Low Flow	Clear		19.1	40	6.36	0.023	0.87	0.07				<1	4	<0.001	<0.001	5.2	369			<1				0.03	<1		7	<1		<5	9	0.9			<0.005	
Wolgan River Downstream	21/02/2017	Low Flow	Clear		13.5	41	6.35	0.015	0.41	0.06				<1	5	<0.001	0.001	5.49	810			<1				<0.01	<1		6	<1		6	7	0.2			0.005	
Wolgan River Downstream	9/03/2017	Mod flow	Clear		13.6	49	6.49	0.007	0.37	0.04				<1	5	<0.001	<0.001	7.4	391			<1				0.01	<1		3	<1		5	6	0.2			<0.005	
Wolgan River Downstream	21/03/2016	Low flow	Clear		16.1	27	6.02	0.017	0.55	0.2				<1	6	<0.001	<0.001	7.61	945			<1				<0.01	<1		6	2		<5	4	0.4			0.006	
Wolgan River Downstream	6/04/2017	Low Flow	Clear		11.9	29	5.72	0.005	0.34	0.06				<1	5	<0.001	<0.001	9.12	412			<1				0.03	<1		5	1		<5	6	<0.1			<0.005	
Wolgan River Downstream	20/04/2017	Mod Flow	Clear		12.2	34	6.9	0.004	0.24	0.03				<1	4	<0.001	<0.001	8.21	726			<1				<0.01	<1		5	<1		<5	4	<0.1			<0.005	
Wolgan River Downstream	11/05/2017	Mod Flow	Clear		11.2	35	7.16	0.003	0.14	0.02				<1	4	<0.001	<0.001	7.97	1594			<1				0.01	<1		5	<1		<5	4	<0.1			<0.005	
Wolgan River Downstream	25/05/2017	Low Flow	Clear		9.4	29	7.89	0.003	0.38	0.04				<1	5	<0.001	<0.001	10.08	461			<1				<0.01	<1		4	<1		14	3	0.2			<0.005	
Wolgan River Downstream	15/06/2017	Mod Flow	Clear		10.4	36	6.87	0.01	0.07	0.04				<1	4	<0.001	<0.001	9.01	2780			<1				<0.01	<1		3	4		<5	<1	<0.1			<0.005	
Wolgan River Downstream	27/06/2017	Low Flow	Clear		6.4	32	8.6	0.004	0.34	0.03				<1	5	<0.001	<0.001	9.47	974			<1				0.04	<1		5	2			1	0.1			<0.005	
Wolgan River Downstream	13/07/2017	Mod Flow	Clear		4.1	27	7.4	0.005	0.22	0.02				<1	2	<0.001	<0.001	10.1	555			<1				<0.01	<1		4	<1		<5	4	0.1			<0.005	
Wolgan River Downstream	25/07/2017	Mod Flow	Clear		5.4	39	7	0.002	0.3	0.03				<1	5	<0.001	<0.001	9.1	564			<1				0.05	<1		4	<1		<5	1	<0.1			<0.005	
Wolgan River Downstream	10/08/2017	Mod Flow	Clear		4.8	25	6.2	0.004	0.26	0.03				<1	6	<0.001	<0.001	10	310			<1				<0.01	<1		4	<1		<5	4	<0.1			<0.005	
Wolgan River Downstream	25/08/2017	Mod Flow	Clear		5.8	32	7.89	0.004	0.18	0.03				<1	5	<0.001	0.011	8.7	389			<1				<0.01	<1		4	<1		<5	4	0.2			0.006	
Wolgan River Downstream	7/09/2017	Mod Flow	Clear		8.9	30	6.9	0.004	0.16	0.02				<1	5	<0.001	<0.001	9.2	337			<1				<0.01	<1		7	<1		<5	5	0.5			<0.005	
Wolgan River Downstream	18/09/2017	Low Flow	Clear	Flow too low for flow	5	37	7.4	0.007	0.22	0.04				<1	4	<0.001	<0.001	8.4				<1				<0.01	<1		5	<1		<5	4	<0.1			<0.005	
Wolgan River Downstream	10/01/2018	mod Flow	Clear		13.9	19	6.9	0.013	0.3	0.11				<1	3	<0.001	<0.001					<1				<0.01	<1		2	4		18	<1	0.3			<0.005	
Wolgan River Downstream	23/01/2018		Slightly Cloudy		14.5	92	5.9	0.094	3.59	0.1				<1	2	<0.001	0.002	4.8				<1				<0.01	2		10	<1		32	21	0.4			0.007	
Wolgan River downstream	7/02/2018		Clear	Too Low For Flow Mo	13.8	31	6.3	0.018	0.64	0.06				<1	4	<0.001	<0.001	4				<1				<0.01	<1		6	<1		6	8	0.3			<0.005	
Wolgan River downstream	19/02/2018		Clear	Too Low For Flow Mo	14.1	44	6.2	0.072	1.06	0.08				<1	5	0.003	<0.001	4.1				<1				0.02	1		8	<1		24	16	0.4			<0.005	
Wolgan River downstream	7/03/2018	Mod Flow	Clear		12.9	43	6	0.011	0.42	0.1				<1	5	<0.001	<0.001	6.7	428			<1				<0.01	<1		4	<1		<5	4	<0.1			<0.005	
Wolgan River downstream	21/03/2018				14	16	4.4	0.006	0.28	0.1				<1	6	<0.001	<0.001	7.3				<1				<0.01	<1		2	<1		16	<1	0.4			<0.005	
Wolgan River downstream	4/04/2018	Mod Flow	Clear		12.8	39	6.4	0.009	0.37	0.04				<1	5	<0.001	<0.001	5.9	450			<1				<0.01	<1		4	1		<5	9	0.2			<0.005	
Wolgan River downstream	17/04/2018	Low Flow	Clear		10.7	66	6.9	0.013	0.46	0.04				<1	5	<0.001	<0.001	3.7	201			<1				<0.01	1		6	<1		<5	10	0.2			<0.005	
Wolgan River Downstream	30/04/2018	Mod Flow	Clear		13	49	6.1											9.4	7876																		
Wolgan River Downstream	30/04/2018	Mod Flow	Clear		8.6	41	5.5	0.009	0.38	0.04				<1	5	<0.001	<0.001	6.7	578			<1				0.02	<1		8	<1		<5	7	0.2			<0.005	
Wolgan River Downstream	15/05/2018	Low Flow	Clear		5.2	43	4.6	0.007	0.31	0.03				<1	5	<0.001	<0.001	7.4	291			<1				<0.01	<1		4	<1		6	6	0.2			<0.005	
Wolgan River Downstream	31/05/2018	Low Flow	Clear		4.7	43	5.5	0.007	0.22	0.03				<1	6	<0.001	<0.001	11	137			<1				0.03	2		5	1		<5	6	<0.1			<0.005	
Wolgan River Downstream	13/06/2018	Low Flow	Clear		5.4	38	5.6	0.005	0.25	0.04				<1	5	<0.001	<0.001	8	29			<1				<0.01	<1		4	<1		<5	5	<0.1			<0.005	
Wolgan River Downstream	27/06/2018	Mod Flow	Clear		4.6	61	6.1	0.004	0.24	0.02				1	5	<0.001	<0.001	9.7	1702.08			<1				0.02	<1		7	2		<5	14	<0.1			<0.005	
Wolgan River Downstream	11/07/2018	Mod Flow	Clear		2	36	5.6	0.004	0.2	0.03				<1	5	<0.001	<0.001	9.7	7171.2			<1				<0.01	<1		4	<1		29	5	<0.1			<0.005	
Wolgan River Downstream	25/07/2018	Mod flow	Clear	Technical issues anab	2.2	44	6	0.005	0.19	0.04				<1	4	<0.001	<0.001	7.7				<1				0.02	<1		5	<1		<5	4	0.2			<0.005	

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) mg/L	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L	
Wolgan River Downstream	8/08/2018	Mod flow	Clear		5.8	47	5.6	0.004	0.18	0.03				<1	5	<0.001	<0.001	7.7	532			<1				0.01	<1		4	<1		<5	<1	<0.1			<0.005		
Wolgan River Downstream	22/08/2018	Mod flow	Clear		3	37	5.1	0.004	0.13	0.02				<1	6	<0.001	<0.001	8.1	527			<1				<0.01	<1		4	<1		<5	6	<0.1			<0.005		
Wolgan River Downstream	5/09/2018	Mod Flow	Clear		9.3	54	6.9		0.11	0.03				4	10	<0.001	<0.001	9.1	1226.88	<0.1		4				0.09	<1		11	26		<5	10	0.4	0.01		<0.005		
Wolgan River Downstream	18/09/2018	Low Flow	Clear		4.2	36	6.5		0.28	0.05				<1	5	<0.001	<0.001	8.6	319	<0.1		<1				0.01	<1	203	5	<1	16	<5	6	<0.1	<0.01	3.1	<0.005		
Wolgan River Downstream	3/10/2018	Mod Flow	Clear		8.6	38	7.3		0.27	0.05				<1	5	<0.001	<0.001	7	13686	<0.1		<1				0.01	<1	357	5	<1		8		0.1	<0.01	2.5	<0.005		
Wolgan River Downstream	16/10/2018	Mod Flow	Clear		12	50	7		0.22	0.07				<1	5	<0.001	<0.001	9.9	629			<1				0.04	<1	302	5	2	<5	9		0.2		3.4	<0.005		
Wolgan River Downstream	31/10/2018	Mod flow	Clear		15	41	7.7		0.27	0.07				<1	4	<0.001	0.002	7.6	734			<1				<0.01	1	200	6	1	40	14		0.1		5.4	0.026		
Wolgan River Downstream	12/11/2018	Low flow	Clear		19	74	7		0.36	0.11				2	9	<0.001	<0.001	6.9	2782	<0.1		2				<0.01	<1	395	9	10		<5		0.1	<0.01	1.8	0.006		
Wolgan River Downstream	27/11/2018	Low Flow	Clear		15.1	53	7		0.15	0.02				<1	9	<0.001	<0.001	8	449			<1				<0.01	<1	261	8	3	47	<5		0.2		3	<0.005		
Wolgan River Downstream	10/12/2018	Mod flow	Clear		17.5	77	6.1		0.63	0.16				<1	6	<0.001	<0.001	6.7		<0.1		<1				0.02	1		6	2	60	10		0.1	<0.01	5.4	<0.005		
Wolgan River Downstream	28/12/2018	Mod flow	Clear		14.2	40	6.8		0.42	0.08				<1	6	<0.001	<0.001	5.5	1296			<1				<0.01	<1	295	5	1	63	8		0.2		3.7	0.005		
Wolgan River Downstream	7/01/2019	Low flow	Clear		18	80	6		0.55	0.06				2	7	<0.001	<0.001	7	207	<0.1		2				<0.01	1	197	9	9	63	<5		0.2	<0.01	2.9	<0.005		
Wolgan River Downstream	21/01/2019	High flow	Clear		19	96	6.5		0.97	0.29				2	2	<0.001	0.002	7	90547			<1				<0.01	<1	251	8	1		<5		0.2		4.9	0.03		
Wolgan River Downstream	6/02/2019	Mod flow	Clear		14.7	38	6.1		0.63	0.08				<1	4	<0.001	<0.001	6.3	3463	<0.1		<1				0.02	<1	260	5	<1	32	<5		0.1	0.06	3	<0.005		
Wolgan River Downstream	18/02/2019	Mod flow	Clear		22.5	5890	6.5		0.3	0.05				1	9	<0.001	0.002	6.7				1				0.03	2	311	7	2		8		1.4		3.9	0.021		
Wolgan River Downstream	6/03/2019	Low flow	Clear	Depth too low to reco	18.1	73	6.2		0.51	0.05				1	6	<0.001	0.001	6.8		<0.1		<1				0.01	2	204	8	3	78	12		0.3	<0.01	3.7	0.028		
Wolgan River Downstream	20/03/2019	Mod flow	Clear		15.5	38	7.3		0.59	0.06				<1	5	<0.001	<0.001	7.7	501			<1				<0.01	<1	158	4	<1		<5		0.1		4.3	<0.005		
Wolgan River Downstream	3/04/2019	Low flow	Clear	Depth too low for flow	11.8	41	7.2		0.42	0.08				1	6	<0.001	<0.001	5.4		<0.1		<1				<0.01	1	180	6	<1	31	<5		0.1	<0.01	4.7	<0.005		
Wolgan River Downstream	15/04/2019	Low flow	Clear		11.2	37	6.6		0.38	0.04				2	7	<0.001	<0.001	6.6	328			1				0.04	<1	259	9	<1		6		0.1		5	<0.005		
Wolgan River Downstream	2/05/2019	Low flow	Clear		11.7	34	6.3		0.27	0.03				<1	6	<0.001	<0.001	16.3	85	<0.1		<1				<0.01	<1	389	5	2	29	<5		<0.1	0.02	2.7	<0.005		
Wolgan River Downstream	13/05/2019	Low level	Clear	Depth too low for flow	7.3	36	5.6		0.46	0.93				<1	5	0.005	0.003	7.7				<1				0.02	2	167	5	<1		<5		0.1		2.6	0.088		
Wolgan River Downstream	28/05/2019	Low flow	Clear	Depth too low for flow	5.3	43	6.3		0.31	0.03				<1	5	<0.001	0.008	7.3				<1				0.01	<1	242	5	<1		<5		<0.1		1.8	0.006		
Wolgan River Downstream	29/07/2008				7.3	678	8.4																															
Wolgan River Downstream	6/08/2008				6.3	334	8																															
Wolgan River Downstream	12/08/2008				5.6	98	7.6																															
Wolgan River Downstream	20/08/2008				4.9	78	7.1																															
Wolgan River Downstream	26/08/2008				4.6	71	6.6																															
Wolgan River Downstream	2/09/2008				7.7	92	7.3																													10		
Wolgan River Downstream	9/09/2008				9.1	498	8.1																													10		
Wolgan River Downstream	18/09/2008				10.8	50	7.9																													6		
Wolgan River Downstream	22/09/2008				12	577	8.1																													23		
Wolgan River Downstream	2/10/2008				14	650	8.2																													14		
Wolgan River Downstream	8/10/2008				10.7	558	8.2																													7		
Wolgan River Downstream	15/10/2008				12.4	354	7.8																													11		
Wolgan River Downstream	23/10/2008				10.8	609	8																													126		
Wolgan River Downstream	28/10/2008				17.1	570	8.3																													12		
Wolgan River Downstream	4/11/2008				13.9	620	8.3																													9		
Wolgan River Downstream	11/11/2008				16.6	683	8.3																													17		
Wolgan River Downstream	19/11/2008				16	643	8.5																													185		
Wolgan River Downstream	26/11/2008				14.2	525	8																													13		
Wolgan River Downstream	3/12/2008				16.6	530	8																													30		
Wolgan River Downstream	9/12/2008				17.8	623	8.3																													15		
Wolgan River Downstream	17/12/2008				15	482	8																													8		
Wolgan River Downstream	22/12/2008				16.5	462	8.3																													9		
Wolgan River Downstream	30/12/2008				18.4	529	7.9																													6		
Wolgan River Downstream	8/01/2009				20.2	656	8.3																													22		
Wolgan River Downstream	15/01/2009				19.2	644	7.9																													18		
Wolgan River Downstream	21/01/2009				20.6	673	8.4																													25		
Wolgan River Downstream	30/01/2009				17.6	684	8.4																													26		
Wolgan River Downstream	3/02/2009				21.5	686	8.4																													22		
Wolgan River Downstream	10/02/2009				19.6	714	8.5																													29		
Wolgan River Downstream	17/02/2009				14.7	400	7.9																													43		
Wolgan River Downstream	26/02/2009				16.2	117	7.4																															
Wolgan River Downstream	3/03/2009				16.2	106	7.5																															
Wolgan River Downstream	12/03/2009				15	90	7.6																															
Wolgan River Downstream	17/03/2009				12.6	76	6.9																															
Wolgan River Downstream	25/03/2009				13.8	79	6.9																															
Wolgan River Downstream	2/04/2009				14.8	68	7.3																															
Wolgan River Downstream	6/04/2009				12.3	73	7.2																															
Wolgan River Downstream	16/04/2009				12.2	60	7.2																													8		
Wolgan River Downstream	21/04/2009				11.1	58	7.5																													120		
Wolgan River Downstream	29/04/2008				8.7	52	7																													2		
Wolgan River Downstream	5/05/2009				10.5	55	7.6																															
Wolgan River Downstream	12/05/2009				7.8	50	7																															
Wolgan River Downstream	18/05/2009				8.6	50	6.9																													18		
Wolgan River Downstream	27/05/2009				11.2	158	7.5																															
Wolgan River Downstream	3/06/2009				11	66	8.2																															
Wolgan River Downstream	11/06/2009				5.6	53	7.5																															
Wolgan River Downstream	16/06/2009				6	50	7.1																															
Wolgan River Downstream	23/06/2009				8.7	70	6.8																															
Wolgan River Downstream	2/07/2009				8.1	63	7.6																															
Wolgan River Downstream	7/07/2009				6.2	50	6.8																															
Wolgan River Downstream	15/07/2009				9.9	674	8																													<1		
Wolgan River Downstream	22/07/2009				11.9	662	8.4																															
Wolgan River Downstream	29/07/2009				10.9	587	8.1																															
Wolgan River Downstream	5/08/2009				10.6	606	8.2																															
Wolgan River Downstream	12/08/2009				10.6	574	8.2																															
Wolgan River Downstream	19/08/2009				10.3	572	8.1																															
Wolgan River Downstream	26/08/2009				11.2	531	6.7																															
Wolgan River Downstream	2/09/2009				10.6	531	8.26																															
Wolgan River Downstream	9/09/2009				11.4	536	8.24																															
Wolgan River Downstream	16/09/2009				11.5	108	6.91																															
Wolgan River Downstream	24/09/2009				14.3	75	7.57																															
Wolgan River Downstream	29/09/2009				8.8	72	6.83																															

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) (mg/L)	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
Wolgan River Downstream	7/10/2009				7.8	61	7.34																												5		
Wolgan River Downstream	14/10/2009				10	60	6.85																														
Wolgan River Downstream	19/10/2009				9.3	66	7.54																														
Wolgan River Downstream	27/10/2009				9.8	54	6.83																														
Wolgan River Downstream	4/11/2009				16.4	68	6.69																														
Wolgan River Downstream	9/11/2009				14.8	63	6.91																														
Wolgan River Downstream	16/11/2009				15.6	103	7.2																														
Wolgan River Downstream	24/11/2009				14.3	121	6.87																														
Wolgan River Downstream	2/12/2009				11.7	61	6.96																														
Wolgan River Downstream	7/12/2009																																				
Wolgan River Downstream	18/12/2009																																				
Wolgan River Downstream	23/12/2009																																				
Wolgan River Downstream	30/12/2009				16.1	82	7.34																														
Wolgan River Downstream	6/01/2010				17.9	62	7.21																														
Wolgan River Downstream	14/01/2010				17.9	88	7.13																														
Wolgan River Downstream	18/01/2010				13.8	72	7.13																														
Wolgan River Downstream	27/01/2010																																				
Wolgan River Downstream	3/02/2010				16.8	62	7.07																														
Wolgan River Downstream	9/02/2010				16.3	78	7.31																														
Wolgan River Downstream	19/02/2010				15.5	70	6.73																														
Wolgan River Downstream	26/02/2010				15	64	7.21																														
Wolgan River Downstream	3/03/2010				13.3	58	6.49																														
Wolgan River Downstream	8/03/2010				16.3	54	6.68																														
Wolgan River Downstream	20/03/2010				13.1	30	6.14																														
Wolgan River Downstream	26/03/2010				13.8	61	7.29																														
Wolgan River Downstream	29/03/2010				15.3	62	6.97																														
Wolgan River Downstream	6/04/2010				13.6	54	6.99																														
Wolgan River Downstream	12/04/2010				11.4	51	6.87																														
Wolgan River Downstream	23/04/2010				11.3	55	7.5																														
Wolgan River Downstream	27/04/2010				9.5	44	7.74																														
Wolgan River Downstream	5/05/2010				10.3	50	7.76																														
Wolgan River Downstream	12/05/2010				7.2	49	6.89																														
Wolgan River Downstream	17/05/2010				7.5	50	7.47																														
Wolgan River Downstream	24/05/2010				9	46	6.76																														
Wolgan River Downstream	1/06/2010				9.8	46	7.11																														
Wolgan River Downstream	10/06/2010					45	6.44																														
Wolgan River Downstream	16/06/2010				6	44	6.84																														
Wolgan River Downstream	23/06/2010				8.7	42	6.65																														
Wolgan River Downstream	2/07/2010				4.8	44	7.29																														
Wolgan River Downstream	6/07/2010				7	43	6.55																														
Wolgan River Downstream	13/07/2010				8.3	39	6.51																														
Wolgan River Downstream	20/07/2010				6.2	46	6.55																														
Wolgan River Downstream	27/07/2010				8.1	43	7.62																														
Wolgan River Downstream	4/08/2010				7.7	46	6.68																														
Wolgan River Downstream	10/08/2010				7.2	38	6.8																														
Wolgan River Downstream	16/08/2010				8.1	43	5.2																														
Wolgan River Downstream	23/08/2010				7.7	43	7.33																														
Wolgan River Downstream	3/09/2010				10.1	40	6.63																														
Wolgan River Downstream	10/09/2010				10.1	36	7.84																														
Wolgan River Downstream	13/09/2010				9.8	42	6.61																														
Wolgan River Downstream	24/09/2010				11.4	50	7.03																														
Wolgan River Downstream	29/09/2010				10.1	25	6.2																														
Wolgan River Downstream	5/10/2010				11.8	34	7.32																														
Wolgan River Downstream	14/10/2010				13.5	49	6.88																														
Wolgan River Downstream	18/10/2010																																				
Wolgan River Downstream	25/10/2010				10.9	40	6.94																														
Wolgan River Downstream	5/11/2010				10.2	41	6.76																														
Wolgan River Downstream	9/11/2010				14.2	41	6.96																														
Wolgan River Downstream	19/11/2010				13	40	6.84																														
Wolgan River Downstream	25/11/2010				14.8	41	6.87																														
Wolgan River Downstream	29/11/2010				14	36	7.05																														
Wolgan River Downstream	7/12/2010				15.4	35	6.56																														
Wolgan River Downstream	14/12/2010				15.3	38	6.84																														
Wolgan River Downstream	14/12/2010				15.3	38	6.84																														
Wolgan River Downstream	21/12/2010				12.4	58	6.98																														
Wolgan River Downstream	31/12/2010				15.7	38	6.77																														
Wolgan River Downstream	5/01/2011				15.3	40	6.92																														
Wolgan River Downstream	13/01/2011				16.7	36	6.68																														
Wolgan River Downstream	18/01/2011				17.2	40	6.88																														
Wolgan River Downstream	25/01/2011				16.7	40	6.95																														
Wolgan River Downstream	2/02/2011				19.1	44	6.97	0.014	0.83																							4						<0.005
Wolgan River Downstream	9/02/2011				15.6	40	6.76																														
Wolgan River Downstream	16/02/2011				15.6	38	6.95																														
Wolgan River Downstream	25/02/2011				14.9	40	7																														
Wolgan River Downstream	2/03/2011				14.8	39	6.56	0.011	0.56																							3						<0.005
Wolgan River Downstream	9/03/2011				14.7	38	6.84																														
Wolgan River Downstream	17/03/2011				16.1	37	6.72																														
Wolgan River Downstream	25/03/2011				13.2	37	5.56																														
Wolgan River Downstream	29/03/2011				13.7	36	6.89																														
Wolgan River Downstream	2/03/2011				14.8	39	6.56	0.011	0.56																							3						<0.005
Wolgan River Downstream	9/03/2011				14.7	38	6.84																														
Wolgan River Downstream	17/03/2011				16.1	37	6.72																														
Wolgan River Downstream	25/03/2011				13.2	37	5.56																														
Wolgan River Downstream	29/03/2011				13.7	36	6.89																														

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) (mg/L)	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
Wolgan River Downstream	4/04/2011				13	36	6.69	0.01	0.41																						2							<0.005
Wolgan River Downstream	15/04/2011					34	6.85																															
Wolgan River Downstream	18/04/2011				11.3	32	7.14																															
Wolgan River Downstream	27/04/2011				11.3	32	7.21																															
Wolgan River Downstream	4/04/2011				13	36	6.69	0.01	0.41																						2							<0.005
Wolgan River Downstream	15/04/2011					34	6.85																															
Wolgan River Downstream	18/04/2011				11.3	32	7.14																															
Wolgan River Downstream	27/04/2011				11.3	32	7.21																															
Wolgan River Downstream	3/05/2011				11.4	35	6.63	0.007	0.43																						2							0.076
Wolgan River Downstream	9/05/2011				7	29	6.04																															
Wolgan River Downstream	17/05/2011				5.4	30	7.3																															
Wolgan River Downstream	25/05/2011				7.8	28	6.35																															
Wolgan River Downstream	3/05/2011				11.4	35	6.63	0.007	0.43																						2							0.076
Wolgan River Downstream	9/05/2011				7	29	6.04																															
Wolgan River Downstream	17/05/2011				5.4	30	7.3																															
Wolgan River Downstream	25/05/2011				7.8	28	6.35																															
Wolgan River Downstream	3/06/2011				8.1	31	6.63	0.009	0.69																						3							<0.005
Wolgan River Downstream	10/06/2011				6	29	6.71																															
Wolgan River Downstream	14/06/2011				8	31	7.15																															
Wolgan River Downstream	23/06/2011				6.3	29	5.71																															
Wolgan River Downstream	3/06/2011				8.1	31	6.63	0.009	0.69																						3							<0.005
Wolgan River Downstream	10/06/2011				6	29	6.71																															
Wolgan River Downstream	14/06/2011				8	31	7.15																															
Wolgan River Downstream	23/06/2011				6.3	29	5.71																															
Wolgan River Downstream	1/07/2011				7.2	40	6.74	0.006	0.56																						3.2							<0.005
Wolgan River Downstream	6/07/2011				6.1	29	6.78																															
Wolgan River Downstream	11/07/2011					52	7.45																															
Wolgan River Downstream	20/07/2011				7.1	37	6.73																															
Wolgan River Downstream	25/07/2011				5.9	41	7.05																															
Wolgan River Downstream	11/07/2011				5.2	52	7.45	0.004	0.52	0.11	<0.001	<0.05	<0.0001		5		<0.001<0	8.74	1374	<0.1	<0.001		<1		<0.001	<0.01				1	5		10	0.2	<0.01	2	<0.005	<0.005
Wolgan River Downstream	25/07/2011				5.9	41	7.05	0.004	0.67	0.1	<0.001	<0.05	<0.0001		5		0.0020.0	7.88	1537	<0.1	<0.001		<1		<0.001	<0.01				<1	28		10	<0.1	<0.01	4	0.006	<0.005
Wolgan River Downstream	1/07/2011				7.2	40	6.74	0.006	0.56																						3.2							<0.005
Wolgan River Downstream	6/07/2011				6.1	29	6.78																															
Wolgan River Downstream	11/07/2011					52	7.45																															
Wolgan River Downstream	20/07/2011				7.1	37	6.73																															
Wolgan River Downstream	25/07/2011				5.9	41	7.05																															
Wolgan River Downstream	11/07/2011				5.2	52	7.45	0.004	0.52	0.11	<0.001	<0.05	<0.0001		5		<0.001<0	8.74	1374	<0.1	<0.001		<1		<0.001	<0.01				1	5		10	0.2	<0.01	2	<0.005	<0.005
Wolgan River Downstream	25/07/2011				5.9	41	7.05	0.004	0.67	0.1	<0.001	<0.05	<0.0001		5		0.0020.0	7.88	1537	<0.1	<0.001		<1		<0.001	<0.01				<1	28		10	<0.1	<0.01	4	0.006	<0.005
Wolgan River Downstream	3/08/2011				5.6	39	6.71	0.012	0.5																						1.2							<0.005
Wolgan River Downstream	9/08/2011					40	7.14																															
Wolgan River Downstream	17/08/2011				6.7	37	6.72																															
Wolgan River Downstream	25/08/2011				6.9	43	6.65																															
Wolgan River Downstream	31/08/2011				7.9	440	6.62																															
Wolgan River Downstream	9/08/2011				5	40	7.14	0.005	0.64	0.16	<0.001	<0.05	<0.0001		5		0.0020.0	10.4	264	<0.1	<0.001		<1		<0.001	<0.01				1	45		8	0.2	0.02	9	0.007	<0.005
Wolgan River Downstream	25/08/2011				6.9	43	6.65	0.005	0.49	0.12	<0.001	<0.05	<0.0001		5		0.0070.0	8.78	2963	<0.1	<0.001		<1		<0.001	0.13				2	56		10	0.3	<0.01	21	0.006	<0.005
Wolgan River Downstream	3/08/2011				5.6	39	6.71	0.012	0.5																						1.2							<0.005
Wolgan River Downstream	9/08/2011					40	7.14																															
Wolgan River Downstream	17/08/2011				6.7	37	6.72																															
Wolgan River Downstream	25/08/2011				6.9	43	6.65																															
Wolgan River Downstream	31/08/2011				7.9	440	6.62																															
Wolgan River Downstream	9/08/2011				5	40	7.14	0.005	0.64	0.16	<0.001	<0.05	<0.0001		5		0.0020.0	10.4	264	<0.1	<0.001		<1		<0.001	<0.01				1	45		8	0.2	0.02	9	0.007	<0.005
Wolgan River Downstream	25/08/2011				6.9	43	6.65	0.005	0.49	0.12	<0.001	<0.05	<0.0001		5		0.0070.0	8.78	2963	<0.1	<0.001		<1		<0.001	0.13				2	56		10	0.3	<0.01	21	0.006	<0.005
Wolgan River Downstream	6/09/2011					41	6.67	0.005	0.54																						2							<0.005
Wolgan River Downstream	6/09/2011					41	6.67																															
Wolgan River Downstream	14/09/2011				7.9	39	6.78																															
Wolgan River Downstream	22/09/2011					42	6.65																															
Wolgan River Downstream	28/09/2011				9.3	41	6.51																															
Wolgan River Downstream	6/09/2011				10.3	41	6.67	0.005	0.52	0.13	<0.001	<0.05	<0.0001		5		0.008	10.5	2194	<0.1	<0.001		<1		0.002	<0.01				1	52		9	<0.1	<0.01	5	0.015	<0.005
Wolgan River Downstream	22/09/2011				10	42	6.65	0.011	0.58	0.11	<0.001	<0.05	0.0001		5		0.015	9.67	1374	<0.1	<0.001		<1		0.001	0.03				<1	8		11	<0.1	<0.01	5	0.039	<0.005
Wolgan River Downstream	6/09/2011					41	6.67	0.005	0.54																						2							<0.005
Wolgan River Downstream	6/09/2011					41	6.67																															
Wolgan River Downstream	14/09/2011				7.9	39	6.78																															
Wolgan River Downstream	22/09/2011					42	6.65																															
Wolgan River Downstream	28/09/2011				9.3	41	6.51																															
Wolgan River Downstream	6/09/2011				10.3	41	6.67	0.005	0.52	0.13	<0.001	<0.05	<0.0001		5		0.008	10.5	2194	<0.1	<0.001		<1		0.002	<0.01				1	52		9	<0.1	<0.01	5	0.015	<0.005
Wolgan River Downstream	22/09/2011				10	42	6.65	0.011	0.58	0.11	<0.001	<0.05	0.0001		5		0.015	9.67	1374	<0.1	<0.001		<1		0.001	0.03				<1	8		11	<0.1	<0.01	5	0.039	<0.005
Wolgan River Downstream	5/10/2011				9.6	42	6.67	0.007	0.6																						0.6							<0.005
Wolgan River Downstream	12/10/2011				8.3	30	6.22																															
Wolgan River Downstream	19/10/2011				10.5	42	6.51																															
Wolgan River Downstream	26/10/2011				11.8	29	6.8																															
Wolgan River Downstream	11/10/2011				8.6	31	6.68	0.007	0.55	0.14	<0.001	<0.05	<0.0001		5		0.001	9.57		<0.1	<0.001		<1		<0.001	0.02				2	48		8	0.4	0.1	20	<0.005	<0.005
Wolgan River Downstream	27/10/2011				11.2	29	7.08	0.006	0.55	0.09	<0.001	<0.05	<0.0001		5		0.002	9.55	683	<0.1	<0.001		<1		<0.001	<0.01				<1	42		16	0.2	<0.01	10	0.009	<0.005
Wolgan River Downstream	5/10/2011				9.6	42	6.67	0.007	0.6																						0.6							<0.005
Wolgan River Downstream	12/10/2011				8.3	30	6.22																															
Wolgan River Downstream	19/10/2011				10.5	42	6.51																															
Wolgan River Downstream	26/10/2011				11.8	29	6.8																															
Wolgan River Downstream	11/10/2011				8.6	31	6.68	0.007	0.55	0.14	<0.001	<0.05	<0.0001		5		0.001	9.57		<0.1	<0.001		<1		<0.001	0.02				2	48		8	0.4	0.1	20	<0.005	<0.005
Wolgan River Downstream	27/10/2011				11.2	29	7.08	0.006	0.55	0.09	<0.001	<0.05	<0.0001		5		0.002	9.55	683	<0.1	<0.001		<1		<0.001	<0.01				<1	42		16	0.2	<0.01	10	0.009	<0.005
Wolgan River Downstream	1/11/2011					42	6.59	0.011	0.64																						2.4							<0.005
Wolgan River Downstream	10/11/2011				16	40	5.47																															
Wolgan River Downstream	14/11/2011				15.8	16	6.53																															
Wolgan River Downstream	23/11/2011				12.3	28	6.17																															
Wolgan River Downstream	14/11/2011				15.8	46	6.53	0.012	0.62	0.17	<0.001	<0.05	0.0001		5		0.06	8.25	1056	<0.1	<0.001		<1		<0.001	0.11				2	64		11	0.5	<0.01	9	0.066	<0.005
Wolgan River Downstream	29/11/2011				17.4	6.45	6.66	0.009	0.57	0.35	<0.001	<0.05	<0.0001		6		0.002	6.78	8955	<0.1	0.002		<1		0.001	<0.01				3	58		9	0.1	0.02	9	<0.005	<0.005

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) mg/L	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
Wolgan River Downstream	1/11/2011					42	6.59	0.011	0.64																						2.4							<0.005
Wolgan River Downstream	10/11/2011				16	40	5.47																															
Wolgan River Downstream	14/11/2011				15.8	16	6.53																															
Wolgan River Downstream	23/11/2011				12.3	28	6.17																															
Wolgan River Downstream	14/11/2011				15.8	46	6.53	0.012	0.62	0.17	<0.001	<0.05	0.0001		5		0.06	8.25	1056	<0.1	<0.001		<1		<0.001	0.11				2	64		11	0.5	<0.01	9	0.066	<0.005
Wolgan River Downstream	29/11/2011				17.4	6.45	6.66	0.009	0.57	0.35	<0.001	<0.05	<0.0001		6		0.002	6.78	8955	<0.1	0.002		<1		0.001	<0.01				3	58		9	0.1	0.02	9	<0.005	<0.005
Wolgan River Downstream	5/12/2011				11.7	46	7.2	0.01	0.51																												<0.005
Wolgan River Downstream	5/12/2011				11.5	46	7.2																														
Wolgan River Downstream	14/12/2011				13.2	41	6.18																														
Wolgan River Downstream	19/12/2011				14.3	43	6.35																														
Wolgan River Downstream	28/12/2012				13.5	49	6.12																														
Wolgan River Downstream	14/12/2011				13.2	41	6.18	0.009	0.48	0.14	<0.001	<0.05	0.0001		5		0.011	5.45	6316	<0.1	<0.001		<1		<0.001	0.02				2	35		9	0.1	0.03	4	0.017	0.01
Wolgan River Downstream	19/12/2011				14.3	43	6.93	0.009	0.62	0.18	<0.001	<0.05	0.0001		5		0.004	8.44	2974	<0.1	<0.001		<1		<0.001	0.02				<1	18		13	0.2	0.02	7	0.016	<0.005
Wolgan River Downstream	5/12/2011				11.7	46	7.2	0.01	0.51																												<0.005
Wolgan River Downstream	5/12/2011				11.5	46	7.2																														
Wolgan River Downstream	14/12/2011				13.2	41	6.18																														
Wolgan River Downstream	19/12/2011				14.3	43	6.35																														
Wolgan River Downstream	28/12/2012				13.5	49	6.12																														
Wolgan River Downstream	14/12/2011				13.2	41	6.18	0.009	0.48	0.14	<0.001	<0.05	0.0001		5		0.011	5.45	6316	<0.1	<0.001		<1		<0.001	0.02				2	35		9	0.1	0.03	4	0.017	0.01
Wolgan River Downstream	19/12/2011				14.3	43	6.93	0.009	0.62	0.18	<0.001	<0.05	0.0001		5		0.004	8.44	2974	<0.1	<0.001		<1		<0.001	0.02				<1	18		13	0.2	0.02	7	0.016	<0.005
Wolgan River Downstream	3/01/2012				15.3	44	6.04	0.006	0.55																							<1						<0.005
Wolgan River Downstream	5/01/2012				16.6	43	6.28																														
Wolgan River Downstream	9/01/2012				16.5	44	6.38																														
Wolgan River Downstream	18/01/2012				16.1	46	6.89																														
Wolgan River Downstream	25/01/2012				16	42	7.04																														
Wolgan River Downstream	31/01/2012				17.2	45	6.73																														
Wolgan River Downstream	9/01/2012				16.5	44	6.38	0.009	0.97	0.11	<0.001	<0.05	<0.0001		5		<0.001	7.7	1740	<0.1	0.005		<1		<0.001	<0.01				<1	40		13	<0.1	<0.01	10	<0.005	0.006
Wolgan River Downstream	25/01/2012				16	42	7.04	0.008	0.65	0.11	<0.001	<0.05	<0.0001		5		<0.001	4.36	457	<0.1	<0.001		<1		<0.001	<0.01				<1	50		11	0.2	0.02	6	<0.005	0.01
Wolgan River Downstream	1/02/2012				15.3	43	7.09	0.031	0.86																							<1						<0.005
Wolgan River Downstream	8/02/2012				14.6	45	7.05																														
Wolgan River Downstream	15/02/2012				14.8	34	5.69																														
Wolgan River Downstream	23/02/2012				14.2	39	6.63																														
Wolgan River Downstream	8/02/2012				15	45	7.05	0.009	0.74	0.16	<0.001	<0.05	<0.0001		5		0.006	8.64	6987	<0.1	<0.001		<1		0.004	<0.01				<1			15	0.2	0.02	8	<0.005	<0.005
Wolgan River Downstream	22/02/2012				14.2	39	6.63	0.011	0.49	0.2	<0.001	<0.05	<0.0001		5		0.004	6.69	18329	<0.1	<0.001		<1		<0.001	<0.01				4	17		4	0.4	0.03	11	0.032	<0.005
Wolgan River Downstream	1/03/2012					32	5.85	0.013	0.68																							8.4						0.01
Wolgan River Downstream	6/03/2012				15.4	35	6.6																														
Wolgan River Downstream	13/03/2012				14.5	29	6.36																														
Wolgan River Downstream	20/03/2012				14.5	30	7.43																														
Wolgan River Downstream	28/03/2012				13.5	39	6.25																														
Wolgan River Downstream	6/03/2012				15.9	35	6.6	0.006	0.33	0.2	<0.001	<0.05	<0.0001		4		0.003	8.12	35047	<0.1	<0.001		<1		0.001	<0.01				11	24	1.11111	6	0.2	0.04	10	0.01	<0.005
Wolgan River Downstream	20/03/2012				14.6	29	6.57	0.004	0.58	0.1	<0.001	<0.05	<0.0001		6		0.002	7.55	14203	<0.1	<0.001		<1		<0.001	<0.01				<1	42	1.11111	11	0.3	<0.01	7	0.011	0.006
Wolgan River Downstream	18/04/2012				12.8	29	7.6	0.008	1.21	0.11	<0.001	<0.05	<0.0001		6		0.001	8.84	5866	<0.1	<0.001		<1		<0.001	0.04				<1	26	2.4	10	0.1	<0.01	4	<0.005	<0.005
Wolgan River Downstream	16/05/2012				7.4	28	7.22	0.007	0.46	0.09	<0.001	<0.05	0.0002		5		0.003	11.02	3226	<0.1	<0.001		<1		<0.001	<0.01				<1	65	1.9	8	0.1	0.03	4	0.006	<0.005
Wolgan River Downstream	14/06/2012					38	6.42	0.004	0.44	0.11	<0.001	<0.05	<0.0001		4		<0.001		7931	<0.1	<0.001		<1		<0.001	<0.01				1	35	1.6	8	<0.1	0.01	5	<0.005	0.021
Wolgan River Upstream	25/07/2012					42	7.4	0.003	0.6	<0.001	<0.001	<0.05	<0.0001	<1	6		0.003			<0.1	<0.001	<1			<0.001	<0.01	<1		8		52	6				6	0.012	<0.005
Wolgan River Upstream	8/08/2012					43	7.28	0.003	0.51	0.4	<0.001	<0.05	<0.0001	<1	6		0.004	11.44	566	<0.1	<0.001		<1		<0.001	4.32	<1		9		40	<1				4	0.006	0.007
Wolgan River Upstream	11/09/2012				9.2	45	7.51	0.004	0.66	0.12	<0.001	<0.05	<0.0001	<1	6		<0.001	10.1		<0.1	<0.001		<1		<0.001	0.01	<1		7			2				5	<0.005	<0.005
Wolgan River Upstream	9/10/2012				11.4	43	6.43	0.004	0.57	0.1	<0.001	<0.05	<0.0001	<1	6		0.002	9.4	500	<0.1	<0.001	<1			<0.001	0.07	<1		8		38	3				8	0.01	0.02
Wolgan River Upstream	15/11/2012				16.7	48	6.86	0.006	0.72	0.11	<0.001	<0.05	<0.0001	<1	6		<0.001	7.57	305	<0.1	<0.001		<1		<0.001	0.02	<1		7		36	3				7	<0.005	<0.005
Wolgan River Upstream	12/12/2012				14.8	39	7.06	0.006	0.49	0.11	<0.001	<0.05	<0.0001	<1	5		<0.001	8.33	149	<0.1	<0.001		<1		<0.001	0.06	<1		8		9	5				7	0.008	<0.005
Wolgan River Upstream	9/01/2013				18.2	36	7.19	0.006	0.32	0.06	<0.001	<0.05	<0.0001	<1	5		<0.001	8.15	94	<0.1	<0.001		<1		0.001	<0.01	<1		6		32	3				7	0.007	<0.005
Wolgan River Upstream	11/02/2013				15.7	39	6.86	0.01	0.87	0.26	<0.001	<0.05	0.0001	<1	4		0.006	8.5		<0.1	<0.001		<1		<0.001	<0.01	<1		10		49	2				8	0.01	<0.005
Wolgan River Upstream	14/03/2013				14.9	42	7.37	0.008	0.87	0.14	<0.001	<0.05	<0.0001	<1	6		0.003	8.18		<0.1	<0.001		<1		<0.001	<0.01	<1		7		23	2				7	0.012	<0.005
Wolgan River Upstream	18/04/2013				13.3	37	7.44	0.006	0.62	0.12	<0.001	<0.05	<0.0001	<1	5		0.012	9.78	175	<0.1	<0.001		<1		<0.001	<0.01	<1		7		82	2				7	0.012	<0.005
Wolgan River Upstream	16/05/2013				8.9	33	7.39	0.006	0.43	0.08	<0.001	<0.05	<0.0001	<1	6		0.001	9.86	118	<0.1	<0.001		<1		<0.001	<0.01	<1		6		37	9				8	0.01	<0.005
Wolgan River Upstream	13/06/2013				7.8	35	7.14	0.005	0.58	0.16	<0.001	<0.05	<0.0001	<1	6		0.003	7.43	390	<0.1	<0.001		<1		0.001	<0.01	<1		7		87	3				6	0.025	0.006
Wolgan River Upstream	11/07/2013				6.1	35	7.1	0.008	0.31	0.12	<0.001	<0.05	0.0002	<1	5		0.108	10.95		<0.1	<0.001		<1		0.001	0.01	<1		9		23	1				3	0.244	0.005
Wolgan River Upstream	8/08/2013				8	35	7.26	0.007	0.41	0.12	<0.001	<0.05	0.0001	<1	6		0.003	11.18	740	<0.1	<0.001		<1		<0.001	0.02	<1		6		23	<5				53	0.026	0.013
Wolgan River Upstream	29/07/2008				5.4	59	7.5																														
Wolgan River Upstream	6/08/2008				4.3	52	5.6																														
Wolgan River Upstream	12/08/2008				4.6	53	7.1																														
Wolgan River Upstream	20/08/2008				4.8	51	6.9																														
Wolgan River Upstream	26/08/2008				6.2	50	6.9																														
Wolgan River Upstream	2/09/2008				8.8	56	7																												9		
Wolgan River Upstream	9/09/2008				8.6	63	7.6																												12		
Wolgan River Upstream	18/09/2008				12	60	7.4																												7		
Wolgan River Upstream	22/09/2008				13.2	71	7.3																												7		
Wolgan River Upstream	2/10/2008				14.1	63	7.2																												6		
Wolgan River Upstream	8/10/2008				8.3	59	7.4																												56		
Wolgan River Upstream	15/10/2008				12.6	66	7.3																												6		
Wolgan River Upstream	23/10/2008				12.3	59	7.3																												28		
Wolgan River Upstream	28/10/2008				14.7	42	7.1																												7		
Wolgan River Upstream	4/11/2008				11.9	44	7.6																												17		
Wolgan River Upstream	11/11/2008				15.3	46	7.2																												3		
Wolgan River Upstream	19/11/2008				15.3	44	7.7																												45		
Wolgan River Upstream	26/11/2008				12.7	45	7																												3		
Wolgan River Upstream	3/12/2008				16.2	46	7.3																												39		
Wolgan River Upstream	9/12/2008				16.4	51	7.4																												1		
Wolgan River Upstream	17/12/2008				14	51	7.3																												32		
Wolgan River Upstream	22/12/2008				16.4	510	7.5																												2		
Wolgan River Upstream	30/12/2008				19.8	51	7																												5		
Wolgan River Upstream	8/01/2009				18.1	50	7.1																												4		
Wolgan River Upstream	15/01/2009				16.7	50	7.3																												5		
Wolgan River Upstream	21/01/2009				17.9	40	7.1																												4		

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) mg/L	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
Wolgan River Upstream	30/01/2009				15	46	7.1																												16		
Wolgan River Upstream	3/02/2009				19.7	42	7.3																												5		
Wolgan River Upstream	10/02/2009				16.5	39	7.7																												4		
Wolgan River Upstream	17/02/2009				13.4	54	7.8																												40		
Wolgan River Upstream	26/02/2009				16.1	48	7.4																														
Wolgan River Upstream	3/03/2009				16.1	45	7.1																														
Wolgan River Upstream	12/03/2009				14.9	44	7.3																														
Wolgan River Upstream	17/03/2009				11.1	40	6.9																														
Wolgan River Upstream	25/03/2009				14.6	40	7.4																														
Wolgan River Upstream	2/04/2009				15.3	56	7.6																														
Wolgan River Upstream	6/04/2009				11.9	47	7.7																														
Wolgan River Upstream	16/04/2009				11.5	45	7.2																												10		
Wolgan River Upstream	21/04/2009				11.2	43	7.3																												8		
Wolgan River Upstream	29/04/2008				8.1	40	6.9																												6		
Wolgan River Upstream	5/05/2009				10.2	41	7.3																														
Wolgan River Upstream	12/05/2009				6.7	37	6.7																														
Wolgan River Upstream	18/05/2009				9	39	7.2																												9		
Wolgan River Upstream	27/05/2009				10.8	53	7.4																														
Wolgan River Upstream	3/06/2009				9.8	53	7.4																														
Wolgan River Upstream	11/06/2009				4.4	47	7.4																														
Wolgan River Upstream	16/06/2009				5.2	48	7																														
Wolgan River Upstream	23/06/2009				6.2	49	6.9																														
Wolgan River Upstream	2/07/2009				7.9	47	7.6																														
Wolgan River Upstream	7/07/2009				5.1	44	7																														
Wolgan River Upstream	15/07/2009				6.1	47	7.2																												38		
Wolgan River Upstream	22/07/2009				8.6	41	7.4																														
Wolgan River Upstream	29/07/2009				5.9	47	7.7																														
Wolgan River Upstream	5/08/2009				4.6	49	7.6																														
Wolgan River Upstream	12/08/2009				5.3	46	6.8																														
Wolgan River Upstream	19/08/2009				4.5	41	7.2																														
Wolgan River Upstream	26/08/2009				6.5	55	8.1																														
Wolgan River Upstream	2/09/2009				6.6	45	7.11																														
Wolgan River Upstream	9/09/2009				7.5	46	7.72																														
Wolgan River Upstream	16/09/2009				12.9	42	6.94																														
Wolgan River Upstream	24/09/2009				15.2	50	7.87																														
Wolgan River Upstream	29/09/2009				9.9	42	6.87																														
Wolgan River Upstream	7/10/2009				7.5	45	7.33																												8		
Wolgan River Upstream	14/10/2009				10	45	7.73																														
Wolgan River Upstream	19/10/2009				8.6	44	7.81																														
Wolgan River Upstream	27/10/2009				10	42	6.89																														
Wolgan River Upstream	4/11/2009				15.3	43	6.95																														
Wolgan River Upstream	9/11/2009				24.6	44	7.05																														
Wolgan River Upstream	16/11/2009				18.6	46	7.64																														
Wolgan River Upstream	24/11/2009				14.2	39	7.03																														
Wolgan River Upstream	2/12/2009				12.8	46	7.41																														
Wolgan River Upstream	7/12/2009				15.1	44	7.01																														
Wolgan River Upstream	18/12/2009																																				
Wolgan River Upstream	23/12/2009																																				
Wolgan River Upstream	30/12/2009				15.5	43	7.08																														
Wolgan River Upstream	6/01/2010				16.9	43	7.12																														
Wolgan River Upstream	14/01/2010																																				
Wolgan River Upstream	18/01/2010																																				
Wolgan River Upstream	27/01/2010																																				
Wolgan River Upstream	3/02/2010				16.4	43	6.72																														
Wolgan River Upstream	9/02/2010				17.2	43	6.84																														
Wolgan River Upstream	19/02/2010				15.6	46	6.72																														
Wolgan River Upstream	26/02/2010				15.2	46	6.95																														
Wolgan River Upstream	3/03/2010				13.4	45	6.76																														
Wolgan River Upstream	8/03/2010				16.5	45	6.85																														
Wolgan River Upstream	20/03/2010																																				
Wolgan River Upstream	26/03/2010																																				
Wolgan River Upstream	29/03/2010																																				
Wolgan River Upstream	6/04/2010				15.1	46	6.96																														
Wolgan River Upstream	12/04/2010				11.9	41	6.84																														
Wolgan River Upstream	23/04/2010																																				
Wolgan River Upstream	27/04/2010				10.1	41	6.93																														
Wolgan River Upstream	5/05/2010																																				
Wolgan River Upstream	12/05/2010																																				
Wolgan River Upstream	17/05/2010																																				
Wolgan River Upstream	24/05/2010																																				
Wolgan River Upstream	1/06/2010				9.8	34	7.42																														
Wolgan River Upstream	10/06/2010					34	6.86																														
Wolgan River Upstream	16/06/2010				6.9	34	7.33																														
Wolgan River Upstream	23/06/2010				7.8	34	6.81																														
Wolgan River Upstream	2/07/2010				4.4	34	7.81																														
Wolgan River Upstream	6/07/2010				5.2	34	6.97																														
Wolgan River Upstream	13/07/2010				7.9	35	6.69																														
Wolgan River Upstream	20/07/2010				4.2	37	6.85																														
Wolgan River Upstream	27/07/2010				6.9	38	7.77																														
Wolgan River Upstream	4/08/2010				5.2	42	6.83																														
Wolgan River Upstream	10/08/2010				7.2	36	6.82																														
Wolgan River Upstream	16/08/2010				6.9	42	5.55																														
Wolgan River Upstream	23/08/2010				7.5	41	7.64																														
Wolgan River Upstream	3/09/2010				10.7	32	7.66																														

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) mg/L	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
Wolgan River Upstream	10/09/2010				11.2	40	7.73																															
Wolgan River Upstream	13/09/2010				10.9	42	6.99																															
Wolgan River Upstream	24/09/2010				11.2	52	7.12																															
Wolgan River Upstream	29/09/2010				10.3	52	6.83																															
Wolgan River Upstream	5/10/2010				13.3	38	7.7																															
Wolgan River Upstream	14/10/2010				13.4	62	7.11																															
Wolgan River Upstream	18/10/2010				10.8	38	6.76																															
Wolgan River Upstream	25/10/2010				11.7	47	6.85																															
Wolgan River Upstream	5/11/2010				10.6	44	7.03																															
Wolgan River Upstream	9/11/2010				14.8	46	6.9																															
Wolgan River Upstream	19/11/2010				12.9	43	6.9																															
Wolgan River Upstream	25/11/2010				15.2	44	6.91																															
Wolgan River Upstream	29/11/2010				14.3	43	6.95																															
Wolgan River Upstream	7/12/2010				15.7	35	6.7																															
Wolgan River Upstream	14/12/2010				16.6	43	6.85																															
Wolgan River Upstream	14/12/2010				16.6	43	6.85																															
Wolgan River Upstream	21/12/2010				12.1	62	7.15																															
Wolgan River Upstream	31/12/2010				15.1	41	6.81																															
Wolgan River Upstream	5/01/2011				16.5	40	6.92																															
Wolgan River Upstream	13/01/2011				17.1	43	6.81																															
Wolgan River Upstream	18/01/2011				18.3	45	6.99																															
Wolgan River Upstream	25/01/2011				16.6	43	6.7																															
Wolgan River Upstream	2/02/2011				18.5	47	6.91	0.009	1.46																								5						0.006
Wolgan River Upstream	9/02/2011				16.1	47	6.94																															
Wolgan River Upstream	16/02/2011				15.6	46	7.12																															
Wolgan River Upstream	25/02/2011				13.5	49	6.59																															
Wolgan River Upstream	2/03/2011				15.1	47	6.89	0.008	1.25																								9						0.006
Wolgan River Upstream	9/03/2011				15	45	6.74																															
Wolgan River Upstream	17/03/2011				16.2	50	6.84																															
Wolgan River Upstream	25/03/2011				13.4	49	6.81																															
Wolgan River Upstream	29/03/2011				13.7	47	6.93																															
Wolgan River Upstream	2/03/2011				15.1	47	6.89	0.008	1.25																								9						0.006
Wolgan River Upstream	9/03/2011				15	45	6.74																															
Wolgan River Upstream	17/03/2011				16.2	50	6.84																															
Wolgan River Upstream	25/03/2011				13.4	49	6.81																															
Wolgan River Upstream	29/03/2011				13.7	47	6.93																															
Wolgan River Upstream	4/04/2011				12.8	47	7.03	0.012	1.04																								3						<0.005
Wolgan River Upstream	15/04/2011				9.8	44	6.97																															
Wolgan River Upstream	18/04/2011				12	43	7.32																															
Wolgan River Upstream	27/04/2011				11.3	44	7.47																															
Wolgan River Upstream	4/04/2011				12.8	47	7.03	0.012	1.04																								3						<0.005
Wolgan River Upstream	15/04/2011				9.8	44	6.97																															
Wolgan River Upstream	18/04/2011				12	43	7.32																															
Wolgan River Upstream	27/04/2011				11.3	44	7.47																															
Wolgan River Upstream	3/05/2011				11.6	45	6.98	0.011	0.93																								10						0.009
Wolgan River Upstream	9/05/2011				5.9	37	6.27																															
Wolgan River Upstream	17/05/2011				5.2	40	7.54																															
Wolgan River Upstream	25/05/2011				7.4	35	6.98																															
Wolgan River Upstream	3/05/2011				11.6	45	6.98	0.011	0.93																								10						0.009
Wolgan River Upstream	9/05/2011				5.9	37	6.27																															
Wolgan River Upstream	17/05/2011				5.2	40	7.54																															
Wolgan River Upstream	25/05/2011				7.4	35	6.98																															
Wolgan River Upstream	3/06/2011				6.6	39	7.02	0.008	0.82																								4						<0.005
Wolgan River Upstream	10/06/2011				5.7	35	6.64																															
Wolgan River Upstream	14/06/2011				7.6	39	7.14																															
Wolgan River Upstream	23/06/2011				7.1	35	6.96																															
Wolgan River Upstream	3/06/2011				6.6	39	7.02	0.008	0.82																								4						<0.005
Wolgan River Upstream	10/06/2011				5.7	35	6.64																															
Wolgan River Upstream	14/06/2011				7.6	39	7.14																															
Wolgan River Upstream	23/06/2011				7.1	35	6.96																															
Wolgan River Upstream	1/07/2011				8.4	52	7.5	0.006	1.05																								1.4						<0.005
Wolgan River Upstream	6/07/2011				6.5	35	6.46																															
Wolgan River Upstream	11/07/2011					50	7.21																															
Wolgan River Upstream	20/07/2011				7.1	55	6.86																															
Wolgan River Upstream	25/07/2011				4.8	55	6.95																															
Wolgan River Upstream	11/07/2011				4.9	50	7.21	0.004	0.85	0.17	<0.001	<0.05	<0.0001		6		<0.001<0	9.57	334	<0.1	<0.001		<1		<0.001	<0.01				2	48		14	0.2	<0.01	4	<0.005	<0.005
Wolgan River Upstream	25/07/2011				4.8	55	6.95	0.003	0.9	0.18	<0.001	<0.05	<0.0001		6		0.0020.0	8.07	265	<0.1	<0.001		<1		<0.001	<0.01				1	54		16	0.3	0.01	5	0.007	<0.005
Wolgan River Upstream	1/07/2011				8.4	52	7.5	0.006	1.05																							1.4						<0.005
Wolgan River Upstream	6/07/2011				6.5	35	6.46																															
Wolgan River Upstream	11/07/2011					50	7.21																															
Wolgan River Upstream	20/07/2011				7.1	55	6.86																															
Wolgan River Upstream	25/07/2011				4.8	55	6.95																															
Wolgan River Upstream	11/07/2011				4.9	50	7.21	0.004	0.85	0.17	<0.001	<0.05	<0.0001		6		<0.001<0	9.57	334	<0.1	<0.001		<1		<0.001	<0.01				2	48		14	0.2	<0.01	4	<0.005	<0.005
Wolgan River Upstream	25/07/2011				4.8	55	6.95	0.003	0.9	0.18	<0.001	<0.05	<0.0001		6		0.0020.0	8.07	265	<0.1	<0.001		<1		<0.001	<0.01				1	54		16	0.3	0.01	5	0.007	<0.005
Wolgan River Upstream	3/08/2011				5.9	53	6.91	0.006	1.09																							2						<0.005
Wolgan River Upstream	9/08/2011					55	7.17																															
Wolgan River Upstream	17/08/2011				6.5	48	6.84																															
Wolgan River Upstream	25/08/2011				5	55	7.14																															
Wolgan River Upstream	31/08/2011				8.4	50	6.52																															
Wolgan River Upstream	9/08/2011				5.1	55	7.17	0.006	1.43	0.39	<0.001	<0.05	<0.0001		6		0.0020.0	9.6	126	<0.1	<0.001		<1		<0.001	<0.01				2	57		12	0.4	0.02	6	0.007	<0.005
Wolgan River Upstream	25/08/2011				5	55	7.14	0.003	0.71	0.16	<0.001	<0.05	<0.0001		6		0.0110.0	9.02	469	<0.1	<0.001		<1		<0.001	0.05				2	62		13	0.2	0.02	9	0.007	<0.005
Wolgan River Upstream	3/08/2011				5.9	53	6.91	0.006	1.09																							2						<0.005
Wolgan River Upstream	9/08/2011					55	7.17																															
Wolgan River Upstream	17/08/2011				6.5	48	6.84																															

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) mg/L	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
Wolgan River Upstream	25/08/2011				5	55	7.14																														
Wolgan River Upstream	31/08/2011				8.4	50	6.52																														
Wolgan River Upstream	9/08/2011				5.1	55	7.17	0.006	1.43	0.39	<0.001	<0.05	<0.0001		6		0.0020.0	9.6	126	<0.1	<0.001		<1		<0.001	<0.01				2	57		12	0.4	0.02	6	0.007	<0.005
Wolgan River Upstream	25/08/2011				5	55	7.14	0.003	0.71	0.16	<0.001	<0.05	<0.0001		6		0.0110.0	9.02	469	<0.1	<0.001		<1		<0.001	0.05				2	62		13	0.2	0.02	9	0.007	<0.005
Wolgan River Upstream	6/09/2011					51	6.74	0.006	1.12																						2.4						<0.005
Wolgan River Upstream	6/09/2011					51	6.74																														
Wolgan River Upstream	14/09/2011				8.1	57	6.68																								2						
Wolgan River Upstream	22/09/2011					54	7.07																														
Wolgan River Upstream	28/09/2011				9.2	55	6.58																														
Wolgan River Upstream	6/09/2011				9.8	51	6.74	0.004	1	0.22	<0.001	<0.05	<0.0001		6		0.001	9.71	255	<0.1	<0.001		<1		<0.001	<0.01				1	59		14	0.3	<0.01	6	<0.005	<0.005
Wolgan River Upstream	22/09/2011				9.8	54	7.07	0.011	1.37	0.2	<0.001	<0.05	0.0001		6		0.012	10.79	146	<0.1	0.002		<1		0.002	0.04				1	38		17	<0.1	<0.01	15	0.056	<0.005
Wolgan River Upstream	6/09/2011					51	6.74	0.006	1.12																						2.4						<0.005
Wolgan River Upstream	6/09/2011					51	6.74																														
Wolgan River Upstream	14/09/2011				8.1	57	6.68																								2						
Wolgan River Upstream	22/09/2011					54	7.07																														
Wolgan River Upstream	28/09/2011				9.2	55	6.58																														
Wolgan River Upstream	6/09/2011				9.8	51	6.74	0.004	1	0.22	<0.001	<0.05	<0.0001		6		0.001	9.71	255	<0.1	<0.001		<1		<0.001	<0.01				1	59		14	0.3	<0.01	6	<0.005	<0.005
Wolgan River Upstream	22/09/2011				9.8	54	7.07	0.011	1.37	0.2	<0.001	<0.05	0.0001		6		0.012	10.79	146	<0.1	0.002		<1		0.002	0.04				1	38		17	<0.1	<0.01	15	0.056	<0.005
Wolgan River Upstream	5/10/2011				9.4	52	6.86	0.005	0.94																						1						0.007
Wolgan River Upstream	12/10/2011				6.2	37	6.66																														
Wolgan River Upstream	19/10/2011				10.5	52	6.64																														
Wolgan River Upstream	26/10/2011				11.1	41	6.62																														
Wolgan River Upstream	11/10/2011				8.2	40	7.64	0.004	0.79	0.15	<0.001	<0.05	<0.0001		6		0.002	9.97		<0.1	<0.001		<1		<0.001	0.02				1	74		23	0.5	0.04	18	<0.005	<0.005
Wolgan River Upstream	27/10/2011				10.8	41	7.54	0.004	1.06	0.18	<0.001	<0.05	<0.0001		6		0.002	9.47	106	<0.1	<0.001		<1		<0.001	<0.01				<1	60		33	0.3	<0.01	9	0.006	0.008
Wolgan River Upstream	5/10/2011				9.4	52	6.86	0.005	0.94																						1						0.007
Wolgan River Upstream	12/10/2011				6.2	37	6.66																														
Wolgan River Upstream	19/10/2011				10.5	52	6.64																														
Wolgan River Upstream	26/10/2011				11.1	41	6.62																														
Wolgan River Upstream	11/10/2011				8.2	40	7.64	0.004	0.79	0.15	<0.001	<0.05	<0.0001		6		0.002	9.97		<0.1	<0.001		<1		<0.001	0.02				1	74		23	0.5	0.04	18	<0.005	<0.005
Wolgan River Upstream	27/10/2011				10.8	41	7.54	0.004	1.06	0.18	<0.001	<0.05	<0.0001		6		0.002	9.47	106	<0.1	<0.001		<1		<0.001	<0.01				<1	60		33	0.3	<0.01	9	0.006	0.008
Wolgan River Upstream	1/11/2011					54	6.86	0.006	1.07																						2.4						<0.005
Wolgan River Upstream	10/11/2011				15.8	55	6.64																														
Wolgan River Upstream	14/11/2011				16.5	59	6.81																														
Wolgan River Upstream	23/11/2011				13.7	31	6.65																														
Wolgan River Upstream	14/11/2011				16.5	59	6.81	0.006	1.05	0.18	<0.001	<0.05	<0.0001		6		0.022	8.36	216	<0.1	<0.001		<1		<0.001	0.02				<1	80		18	0.2	0.02	8	0.022	<0.005
Wolgan River Upstream	29/11/2011				15.3	51	7.38	0.006	0.77	0.38	<0.001	<0.05	<0.0001		6		0.003	7.42	1282	<0.1	0.002		<1		0.002	0.01				<1	55.5		12	0.1	0.03	8	<0.005	<0.005
Wolgan River Upstream	1/11/2011					54	6.86	0.006	1.07																						2.4						<0.005
Wolgan River Upstream	10/11/2011				15.8	55	6.64																														
Wolgan River Upstream	14/11/2011				16.5	59	6.81																														
Wolgan River Upstream	23/11/2011				13.7	31	6.65																														
Wolgan River Upstream	14/11/2011				16.5	59	6.81	0.006	1.05	0.18	<0.001	<0.05	<0.0001		6		0.022	8.36	216	<0.1	<0.001		<1		<0.001	0.02				<1	80		18	0.2	0.02	8	0.022	<0.005
Wolgan River Upstream	29/11/2011				15.3	51	7.38	0.006	0.77	0.38	<0.001	<0.05	<0.0001		6		0.003	7.42	1282	<0.1	0.002		<1		0.002	0.01				<1	55.5		12	0.1	0.03	8	<0.005	<0.005
Wolgan River Upstream	5/12/2011				11.2	48	7.14	0.036	0.78																													<0.005
Wolgan River Upstream	5/12/2011				11.1	48	7.14																														
Wolgan River Upstream	14/12/2011				12.8	50	7.19																														
Wolgan River Upstream	19/12/2011				15.1	50	6.93																														
Wolgan River Upstream	28/12/2012				14.2	43	6.27																														
Wolgan River Upstream	14/12/2011				12.8	50	7.19	0.008	0.62	0.15	<0.001	<0.05	0.0001		6		0.005	7.52	1585	<0.1	<0.001		<1		<0.001	0.02				<1	37		13	<0.1	0.01	5	0.012	<0.005
Wolgan River Upstream	19/12/2011				15.1	50	8.18	0.007	1.08	0.26	<0.001	<0.05	0.0002		6		0.006	9.03	126	<0.1	<0.001		<1		<0.001	0.02				<1	53		16	1.2	<0.01	9	0.015	<0.005
Wolgan River Upstream	5/12/2011				11.2	48	7.14	0.036	0.78																													<0.005
Wolgan River Upstream	5/12/2011				11.1	48	7.14																														
Wolgan River Upstream	14/12/2011				12.8	50	7.19																														
Wolgan River Upstream	19/12/2011				15.1	50	6.93																														
Wolgan River Upstream	28/12/2012				14.2	43	6.27																														
Wolgan River Upstream	14/12/2011				12.8	50	7.19	0.008	0.62	0.15	<0.001	<0.05	0.0001		6		0.005	7.52	1585	<0.1	<0.001		<1		<0.001	0.02				<1	37		13	<0.1	0.01	5	0.012	<0.005
Wolgan River Upstream	19/12/2011				15.1	50	8.18	0.007	1.08	0.26	<0.001	<0.05	0.0002		6		0.006	9.03	126	<0.1	<0.001		<1		<0.001	0.02				<1	53		16	1.2	<0.01	9	0.015	<0.005
Wolgan River Upstream	3/01/2012				14	50	6.28	0.006	0.99																						3						<0.005
Wolgan River Upstream	5/01/2012				15.8	49	6.32																														
Wolgan River Upstream	9/01/2012				16.3	50	6.75																														
Wolgan River Upstream	18/01/2012				16.3	51	7.06																														
Wolgan River Upstream	25/01/2012				15.2	54	7.1																														
Wolgan River Upstream	31/01/2012				16.5	52	6.83																														
Wolgan River Upstream	9/01/2012				16.3	50	6.75	0.008	1.03	0.18	<0.001	<0.05	<0.0001		6		0.006	7.43	1504	<0.1	<0.001		<1		<0.001	<0.01				<1	53		17	0.2	0.01	5	0.013	<0.005
Wolgan River Upstream	25/01/2012				15.2	54	7.1	0.006	1.19	0.19	<0.001	<0.05	<0.0001		6		<0.001	4.06	659	<0.1	<0.001		<1		<0.001	<0.01				<1	61		18	0.4	0.03	9	<0.005	<0.005
Wolgan River Upstream	1/02/2012				14.9	60	7.23	0.008	1.29																						1						<0.005
Wolgan River Upstream	8/02/2012				14.5	49	7.3																														
Wolgan River Upstream	15/02/2012				14.8	34	6.86																														
Wolgan River Upstream	23/02/2012				14.3	43	7.28																														
Wolgan River Upstream	8/02/2012				14.5	49	7.3	0.005	1.05	0.17	<0.001	<0.05	<0.0001		6		0.01	8.11	741	<0.1	<0.001		<1		0.001	<0.01				<1			22	0.3	<0.01	6	0.006	<0.005
Wolgan River Upstream	22/02/2012				14.3	43	7.28	0.006	0.74	0.18	<0.001	<0.05	<0.0001		5		0.006	7.81	2196	<0.1	<0.001		<1		<0.001	<0.01				2	38		11	0.9	0.47	14	0.006	<0.005
Wolgan River Upstream	1/03/2012					33	6.6	0.01	0.59																						2.2						<0.005
Wolgan River Upstream	6/03/2012				15.3	34	6.91																														
Wolgan River Upstream	13/03/2012				14.9	29	6.23																														
Wolgan River Upstream	20/03/2012				14.6	29	6.57																														
Wolgan River Upstream	28/03/2012				13.1	41	6.57																														
Wolgan River Upstream	6/03/2012				15.3	34	6.91	0.005	0.53	0.17	<0.001	<0.05	<0.0001		5		0.002	8.17	1990	<0.1	<0.001		<1		<0.001	0.02				<1	42	1.42857	10	0.2	0.04	9	0.009	<0.005
Wolgan River Upstream	20/03/2012				14.5	30	7.43	0.006	0.44	0.12	<0.001	<0.05	0.0001		5		0.002	7.79	3342	0.4	0.002		<1		<0.001	<0.01				1	39	1.42857	15	0.1	<0.01	5	0.018	<0.005
Wolgan River Upstream	18/04/2012				12.9	31	7.41	0.012	3.44	0.13	<0.001	<0.05	<0.0001		6		0.001	9.03	1896	<0.1	<0.001		<1		<0.001	0.03				<1	32	12.6	11	0.3	<0.01	15	0.009	<0.005
Wolgan River Upstream	16/05/2012				6.9	31	7.31	0.013	0.68	0.08	<0.001	<0.05	<0.0001		6		0.002	10.86	506	<0.1	<0.001		<1		<0.001	<0.01				<1	86	5.1	10	0.2	0.04	6	0.007	0.008
Wolgan River Upstream	14/06/2012					56	6.59	0.003	0.58	0.11	<0.001	<0.05	<0.0001		5		<0.001		1247	<0.1	<0.001		<1		<0.001	0.04				1	37	1.2	29	<0.1	<0.01	6	0.011	<0.005
WOLGAN U/S	8/02/2011				16.4	47	7.04	0.008	1.72	0.21	<0.001	<0.05	0.0005		6		0.001	6.75	78	0.5	<0.001		<1		<0.001	0.02				<1	32		28	0.2	<0.01	16	0.028	<0.005
WOLGAN U/S	23/02/2011				15	49	7.03	0.009	1.68	0.18	<0.001	<0.05	0.0006		5		0.003	7.93	0	<0.1	<0.001		<1		<0.001	0.17				<1	39		23	0.7	0.1	9	0.032	<0.005
WOLGAN U/S	8/03/2011				14.4	49	6.79	0.009	1.07	0.11	<0.001	<0.05	0.0004		5		0.002	8.12	0	<0.1	<0.001		<1		<0.001	0.08				<1	34		23	0.4	0.02	7	0.005	0.007
WOLGAN U/S	22/03/2011				16.8	50	7.12	0.012	1.29	0.21	<0.001	<0.05	0.0003		7		0.002	7.28	218	<0.1	<0.001		<1		<0.001	<0.01				<10	92		23	0.6	0.12	8	0.005	<0.005

Location ID	Date of Sample	Flow Observations	Appearance	Comments	Temp C	EC (us/cm)	pH	Manganese (filt) mg/L	Iron (filt) mg/L	Aluminium (filt) mg/L	Arsenic (filt) (mg/L)	Boron (filt) (mg/L)	Cadmium (filt) (mg/L)	Calcium mg/L	Chloride (mg/L)	Chromium (Dissolved) mg/L	Copper (filt) (mg/L)	DO (mg/L)	Flow rate (KL/day)	Fluoride (mg/L)	Lead (filt) (mg/L)	Magnesium (tot) mg/L	Magnesium (Filt) (mg/L)	Mercury (Dissolved) mg/L	Nickel (filt) (mg/L)	Nitrate as N (mg/L)	Potassium mg/L	Redox Potential	Sodium mg/L	Sulfate as SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	Total Alkalinity as CaCO3 mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Turbidity (NTU)	Zinc (filt) mg/L	Zinc (tot) mg/L
WOLGAN U/S	8/03/2011				14.4	49	6.79	0.009	1.07	0.11	<0.001	<0.05	0.0004		5		0.002	8.12	0	<0.1	<0.001		<1		<0.001	0.08				<1	34		23	0.4	0.02	7	0.005	0.007
WOLGAN U/S	22/03/2011				16.8	50	7.12	0.012	1.29	0.21	<0.001	<0.05	0.0003		7		0.002	7.28	218	<0.1	<0.001		<1		<0.001	<0.01				<10	92		23	0.6	0.12	8	0.005	<0.005
WOLGAN U/S	5/04/2011				13.6	54	7.16	0.011	1.04	0.13	<0.001	<0.05	0.0017		5		0.008	8.64	0	<0.1	<0.001		<1		<0.001	0.02				<1	50		23	0.2	0.13	8	0.227	<0.005
WOLGAN U/S	18/04/2011				12	43	7.32	0.008	0.94	0.14	<0.001	<0.05	0.0001		6		<0.001	6.41	0	<0.1	<0.001		<1		<0.001	<0.01				<1	55		17	0.2	<0.01	7	0.009	<0.005
WOLGAN U/S	5/04/2011				13.6	54	7.16	0.011	1.04	0.13	<0.001	<0.05	0.0017		5		0.008	8.64	0	<0.1	<0.001		<1		<0.001	0.02				<1	50		23	0.2	0.13	8	0.227	<0.005
WOLGAN U/S	18/04/2011				12	43	7.32	0.008	0.94	0.14	<0.001	<0.05	0.0001		6		<0.001	6.41	0	<0.1	<0.001		<1		<0.001	<0.01				<1	55		17	0.2	<0.01	7	0.009	<0.005
WOLGAN U/S	4/05/2011				9.3	48	7.56	0.01	0.67	0.1	<0.001	<0.05	0.0003		7		0.011	9.49	40	<0.1	<0.001		<1		<0.001	0.07				<1	64		22	0.5	<0.01	8	0.014	<0.005
WOLGAN U/S	17/05/2011				5.2	40	7.54	0.008	0.76	0.12	<0.001	<0.05	<0.0001		6		<0.001	9.3	0	<0.1	<0.001		<1		<0.001	0.04				<1	49		10	0.3	<0.01	4	<0.005	<0.005
WOLGAN U/S	30/05/2011				8	36	7.34	0.01	1.34	0.26	<0.001	<0.05	0.0002		6		0.001	10.94	62	<0.1	<0.001		<1		<0.001	<0.01				<1	12		14	0.6	0.13	11	0.016	<0.005
WOLGAN U/S	4/05/2011				9.3	48	7.56	0.01	0.67	0.1	<0.001	<0.05	0.0003		7		0.011	9.49	40	<0.1	<0.001		<1		<0.001	0.07				<1	64		22	0.5	<0.01	8	0.014	<0.005
WOLGAN U/S	17/05/2011				5.2	40	7.54	0.008	0.76	0.12	<0.001	<0.05	<0.0001		6		<0.001	9.3	0	<0.1	<0.001		<1		<0.001	0.04				<1	49		10	0.3	<0.01	4	<0.005	<0.005
WOLGAN U/S	30/05/2011				8	36	7.34	0.01	1.34	0.26	<0.001	<0.05	0.0002		6		0.001	10.94	62	<0.1	<0.001		<1		<0.001	<0.01				<1	12		14	0.6	0.13	11	0.016	<0.005
WOLGAN U/S	14/06/2011				7.6	39	7.14	0.01	0.91	0.2	0.002	<0.05	<0.0001		6		0.006	8.2	223	<0.1	<0.001		<1		0.004	0.02				<1	60		13	0.2	0.13	8	0.073	<0.005
WOLGAN U/S	27/06/2011				4.9	40	7.17	0.003	0.73	0.15	<0.001	<0.05	<0.0001		6		0.0030.0	12.98	427	<0.1	<0.001		<1		<0.001	0.05				1	44		14	<0.1	0.06	5	0.017	<0.005
WOLGAN U/S	14/06/2011				7.6	39	7.14	0.01	0.91	0.2	0.002	<0.05	<0.0001		6		0.006	8.2	223	<0.1	<0.001		<1		0.004	0.02				<1	60		13	0.2	0.13	8	0.073	<0.005
WOLGAN U/S	27/06/2011				4.9	40	7.17	0.003	0.73	0.15	<0.001	<0.05	<0.0001		6		0.0030.0	12.98	427	<0.1	<0.001		<1		<0.001	0.05				1	44		14	<0.1	0.06	5	0.017	<0.005

Appendix D. Site Water and Salt Balance Report



Centennial Angus Place Pty Ltd

Angus Place Mine Extension Project

Site water and salt balance assessment

August 2019

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Glossary

Australian Height Datum	A common national surface level datum approximately corresponding to mean sea level.
Baseflow	The component of streamflow that originates from groundwater.
Bord and pillar	Method of underground coal mining where the coal seam is divided into a regular block array (pillars) by driving roadways. In some cases, the pillars are partly or completely removed in a concurrent or later operation.
Bore	Constructed connection between the surface and a groundwater source that enables groundwater to be transferred to the surface either naturally or through artificial means.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site.
Clean water	Waters within a site that have not come into physical contact with coal or mined carbonaceous material.
Coal handling plant	A facility where coal is crushed and screened.
Cut through	A tunnel driven in a coal seam to connect adjacent headings.
Datum	A level surface used as a reference in measuring elevations.
Dirty water	Waters within a site that have come into contact with coal or mined carbonaceous material or otherwise contain an elevated sediment load.
Discharge	Quantity of water per unit of time flowing in a stream, for example cubic metres per second or megalitres per day.
Electrical conductivity	A measure of the concentration of dissolved salts in water.
Groundwater	Subsurface water that occurs in soils and geological formations.
Hydrogeology	The area of geology that deals with the distribution and movement of groundwater in soils and rocks.
Hydrology	The study of rainfall and surface water runoff processes.
Licensed discharge point	A location where a licensed operation discharges water to the environment in accordance with conditions stipulated within the site environment protection licence.
Median	The middle value, such that there is an equal number of higher and lower values. Also referred to as the 50th percentile.
Percentile	The value of a variable below which a certain per cent of observations fall. For example, the 80th percentile is the value below which 80 percent of values are found.
Rainfall excess	Amount of rainfall that ends up as streamflow, also termed runoff.
Runoff	The amount of rainfall which actually ends up as streamflow.
Surface water	Water that is derived from precipitation or pumped from underground and may be stored in dams, rivers, creeks and drainage lines.
Underground water	Water stored in underground aquifers. During the mining process a proportion of this water is released and managed by the underground settling and pumping system.

Abbreviations

AHD	Australian height datum
BOM	Bureau of Meteorology
Centennial Angus Place	Centennial Angus Place Pty Limited
CHP	Coal handling plant
CT	Cut through
EC	Electrical conductivity
ha	Hectare
kL/day	Kilolitre per day
km	Kilometre
LDP	Licensed discharge point
m	Metre
mg/L	Milligram per litre
ML	Megalitre
ML/day	Megalitre per day
ML/year	Megalitre per year
mm	Millimetre
SWTP	Springvale Water Treatment Project
SILO	Scientific Information for Land Owners
SSD	State significant development
SWTP	Springvale Water Treatment Project
WMP	Water management plan
µS/cm	Microsiemens per centimetre

1. Introduction

1.1 Background

Angus Place Colliery is an existing underground coal mine producing thermal coal for domestic markets, predominantly the Mount Piper Power Station. It is located 15 km to the northwest of the regional city of Lithgow and 120 km west northwest of Sydney in New South Wales, as shown in Figure 1-1.

The Angus Place Colliery project approval (Project Application 06_0021) was granted in September 2006 and authorises the extraction of up to 4 million tonnes per annum (Mtpa) of run of mine (ROM) coal. The current project approval will expire in August 2024 and a new development consent is required to ensure Angus Place Colliery is operational beyond this date.

Angus Place Colliery is owned by Centennial Coal Company Ltd as a joint venture with SK Kores Australia Pty Ltd (50-50% joint venture). The Angus Place Colliery has been operated by Centennial Angus Place Pty Ltd (Centennial Angus Place), on behalf of the joint venture participants since 2002. Centennial Angus Place is the proponent for the Project.

A new state significant development (SSD) application (SSD 5602) and supporting Environmental Impact Statement (EIS) was submitted to the then NSW Department of Planning and Infrastructure in April 2014 (2014 EIS) for the Angus Place Mine Extension Project (the Project). The assessment of the Angus Place Mine Extension Project was placed on hold when the mine was placed in care and maintenance in March 2015.

Since the submission of the Angus Place Mine Extension Project EIS, and subsequent Response to Submission documents, a review has resulted in proposed changes to the Angus Place Mine Extension Project to that presented in the original EIS.

Centennial Angus Place engaged GHD Pty Ltd (GHD) to assess the potential impact of the amended Project (the Project) on the site water and salt balance of Angus Place Colliery. This assessment will be appended to the Surface Water Impact Assessment.

1.2 Project description

The amended Project now proposes to undertake mining operations up to 31 December 2053, with rehabilitation activities to continue beyond this date.

The amended project will seek an increase in the current and previously proposed annual extraction limit from 4 Mtpa of ROM coal to 4.5 Mtpa of ROM coal. Mining will continue to be carried out using a combination of continuous miners and longwall mining equipment. The amended project is now proposing up to 450 full time equivalent personnel. These personnel will include staff, underground mining operators, coal handling operators, contractors and apprentices.

The 2014 EIS proposed that up to 4 Mtpa of ROM coal be transported to the Angus Place Colliery pit top for handling and processing. The amended project proposes to continue to transport coal to the Angus Place Colliery pit top at a rate of up to 4 Mtpa with an alternative option to transfer up to 4.5 Mtpa of ROM coal to the Springvale Mine pit top via a series of underground roadway connections. Once the underground roadway connections between the Angus Place Colliery and the Springvale Mine are completed, the transfer of coal to the Springvale Mine pit top would take precedence over coal being transferred to the Angus Place Colliery pit top with coal transfers to the Angus Place pit top only occurring during emergency situations. For coal transferred to the Springvale Mine pit top, the coal would be handled and processed in accordance with the already approved Springvale Mine Extension Project development consent (SSD 5594). Coal transferred to the Angus Place Colliery pit top will continue to be transported offsite by truck in accordance with the Western Coal Services Project (SSD 5579).

Mine inflows, encountered during mining operations, will be transferred to the Springvale Water Treatment Project (SWTP) (SSD 7592) by either:

- Transferring to the Fire Tanks at the Angus Place Colliery pit top for reuse or transfer via the Angus Place Haul Road Pipeline; or
- Transferring to the SWTP Water Transfer Pipeline via existing and proposed additional dewatering bore facilities and associated infrastructure.

The Project will continue to seek approval to construct and operate additional dewatering bore facilities, including associated electrical easements, booster stations and pipeline connections, on the Newnes Plateau to enable the transfer of water from the 1000 panel longwall mining area to the SWTP.

Bore 930 will continue to be used as a reinjection borehole for raw water from the SWTP Water Transfer Pipeline in the event that the Springvale Water Treatment Project is unable to operate.

The overall configuration of water management at the Angus Place Colliery pit top will not be modified by the Project. Licenced Discharge Point LDP001 will be decommissioned following cessation of discharges in December 2019 and LDP002 will continue to operate as a rainfall based discharge point. Water discharged off site will continue to be done so in accordance with the Angus Place Colliery Environmental Protection Licence (EPL 467).

Should the Project be approved, a pipeline will be constructed to transfer wastewater to the Lithgow City Council main sewerage line. Once the transfer of wastewater from the Angus Place Colliery pit top to the Lithgow City Council main sewerage line is completed, LDP005 will no longer operate. The construction of the wastewater transfer line will be the subject of a separate development application through Lithgow City Council. The sewerage treatment line will be constructed and operational prior to the commencement of longwall extraction at the Angus Place Colliery.

1.3 Overview of site operations

Angus Place Colliery has been in care and maintenance phase operations since March 2015, during which mining operations have ceased but environmental management of the site, including dewatering of the underground workings, is ongoing.

In 2018, the Angus Place Colliery project approval (PA 06_0021) was modified to allow the discharge of up 10 ML/day of treated water via LDP001 until 31 December 2019. The water is treated in a water treatment plant using reverse osmosis to achieve an electrical conductivity (EC) below 350 µS/cm. The residuals from the water treatment plant are temporarily stored within the underground workings within Angus Place Colliery.

1.4 Purpose of this report

The purpose of this report is to describe the site water and salt balance of Angus Place Colliery under existing, baseline and proposed conditions and to assess the impact of the Project on the site water and salt balance. The site water and salt balance has been analysed using a site water and salt balance model. This report describes the input data, the model methodology and presents and interprets the results of the model.

Information prepared as part of this report has been considered for further assessment within the Surface Water Impact Assessment.

1.5 Scope and limitations

The scope of the site water and salt balance includes the rainfall, runoff and evaporation of surface storages on site, gravity and pumped flows of water and water usage for operational processes.

The scope of site water and salt balance is limited to the operational parts of Angus Place Colliery. Clean water catchments diverted around the pit top are not considered. The surface water catchment of the Angus Place ventilation facility (APC-VS2) and proposed additional downcast ventilation shaft within the 1000 panel area (APC-VS3) are not considered.

This report has been prepared by GHD for Centennial Angus Place and may only be used and relied on by Centennial Angus Place for the purpose agreed between GHD and the Centennial Angus Place as set out in Section 1 of this report.

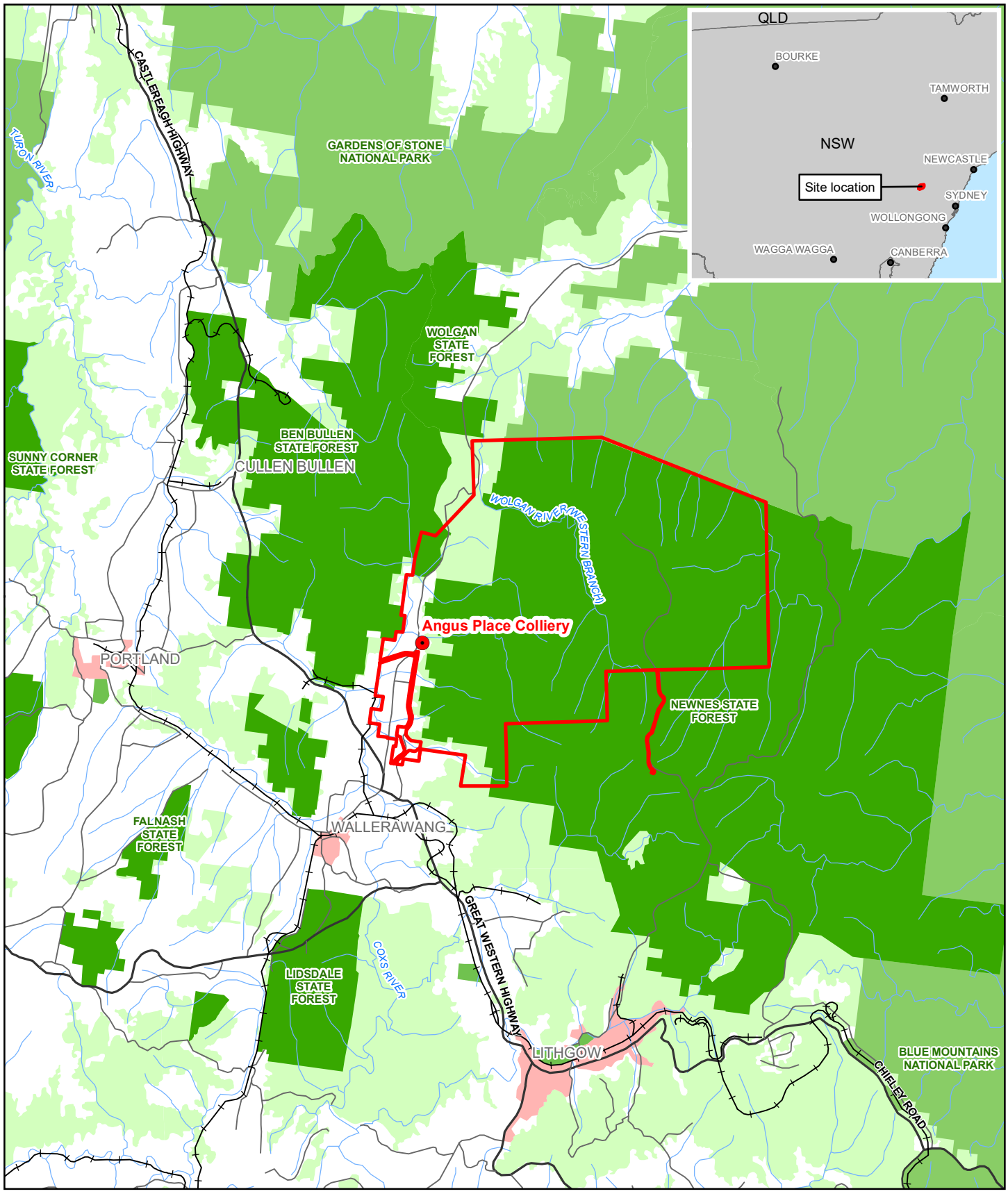
GHD otherwise disclaims responsibility to any person other than Centennial Angus Place arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Centennial Angus Place and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.



LEGEND

- Project Application Area
- Existing rail
- Principal road
- Secondary road
- Minor road
- Waterway
- Built up area
- Recreation area
- Forest or shrub
- Nature conservation
- State forest

Paper Size A4

0 1 2 3 4

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD Centennial Coal

Centennial Angus Place Pty Ltd
Angus Place Mine Extension Project
Site water and salt balance assessment

Job Number 22-20268
Revision 0
Date 14 Aug 2019

Locality plan

Figure 1-1

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\\ghdnet\ghd\AU\Newcastle\Projects\22\0105001\GIS\Maps\Deliverables\Western\AngusPlace\2220268\SWSBA\2220268_SWSBA001_Locality_0.mxd

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Data source: Commonwealth of Australia (Geoscience Australia): 250K Topographic Data Series 3 2006; Centennial: Boundaries, 2018. Created by: fmackay, TMorton

2. Water management

Angus Place Colliery lies within the greater Hawkesbury-Nepean catchment and covers two adjacent catchments of the upper Coxs River and Wolgan River. Underground mining operations traverse the surface catchment divide of the two rivers, while the pit top is located entirely within the upper Coxs River catchment, near its confluence with Kangaroo Creek. Mining at Angus Place Colliery intersects the Lithgow Seam from which groundwater inflows report to the underground workings. Lithgow City Council supplies potable water for amenities, with ablutions treated on site.

The inflows of water to the surface and underground components of the Angus Place Colliery include:

- Direct rainfall onto surface water storages
- Catchment runoff at the pit top
- Groundwater inflows
- Potable water supplied by Lithgow City Council

The outflows of water from Angus Place Colliery include:

- Evaporation from surface water storages
- Discharge from LDP001 to Kangaroo Creek
- Discharge from LDP002 to Coxs River
- Discharge from LDP005 to the irrigation area
- Transfers to SWTP
- Losses from operations

2.1 Clean water management

The clean water management system at Angus Place Colliery consists of a series of diversion bunds and drains around the pit top that intercept clean runoff prior to it entering disturbed areas. This water is directed off-site into Kangaroo Creek or to the Coxs River.

2.2 Dirty water management

The dirty water management system at Angus Place receives catchment runoff from the pit top. Dirty water runoff reports to the 302 Portal, Filter Pond, Oil Water Separator, Primary Ponds and Secondary Pond. Water cascades through the dirty water ponds and ultimately report to the Settling Ponds. Water from the Settling Ponds is discharged via LDP002 into the Coxs River.

2.3 Underground water management

Mining at Angus Place Colliery intersects the Lithgow Seam from which moderate groundwater inflows report to the underground workings, including the extracted longwalls of the 800 Panel area and the 900 Panel area.

Under existing conditions, groundwater inflows into the 800 Panel area and 900 Panel area are extracted to the pit top from various locations underground. At the pit top, water is transferred to the Fire Fighting Tanks where it is available for use in fire-fighting and as process water in the Coal Handling Plant (when the mine is in operation). Excess water that is not used is treated using reverse osmosis in the temporary water treatment plant and discharged via LDP001.

The residuals from the water treatment plant are temporarily stored within the underground workings within the Angus Place Colliery. This will not occur when the temporary water treatment plant is decommissioned and all mine inflows are transferred to the Springvale Water Treatment Project for treatment and beneficial reuse at the Mount Piper Power Station.

Water from the 900 Panel area may also be extracted by the 940 Bore and transferred to the SWTP Water Transfer Pipeline. Water from the SWTP Water Transfer Pipeline may be transferred to the 900 Panel area via the 930 Bore.

2.4 Potable and wastewater management

Potable water is provided to the administration and bathhouse buildings at the Angus Place Colliery pit top by the municipal water supply from Lithgow City Council. Grey water and sewage from the administration and bathhouse buildings is treated on-site in a sewage treatment plant before being directed to Maturation Ponds and disposed via spray irrigation through LDP005.

2.5 Proposed water management

The Project requires changes to the management of underground water at Angus Place Colliery. The Project includes the development and extraction from the 1000 Panel area, which is expected to intercept groundwater. This water is generally expected to be managed by transferring to the SWTP via dewatering bores and the Angus Place East APC-VS2 vent facility to the SWTP Water Transfer Pipeline.

In the event of infrastructure outages, the existing and proposed water management system includes various contingency options to provide operational redundancy. Upgrades to the existing in seam pumping system will allow for potential contingency options, including those summarised in Table 2-1.

Table 2-1 Contingency options

Contingency options	Redundancy provided
Bidirectional movement of water between 900 and 1000 Panel areas – 900 Area to 1000 Panel	Dewatering activities can occur alternatively via proposed dewatering boreholes or APC-VS2 Vent Facility
Bidirectional movement of water between 900 and 1000 Panel areas – 1000 Panel to 900 Area	Dewatering activities can occur alternatively via 940 bore
900 Panel areas to Underground Clean Water Pumping System	Process water demands can be supplemented from 900 Panel area
SWTP Water Transfer Pipeline to 900 Panel area to temporarily store water	In the event that SWTP has an outage or the transfer scheme has a failure, water can be temporarily stored in 800 or 900 Panel area

The contingency options were not modelled as part of the water and salt balance, as the frequency and magnitude of their use as a result of unexpected outages or failures cannot be predicted with any certainty. However, the overall outcomes of this site water and salt balance assessment are not expected to be sensitive to the contingency options, as they do not allow for any change to the inflows or outflows of water from Project as a whole. The operation of contingency options will be undertaken within the constraints of relevant water licences and approvals at the time.

The overall configuration of water management at the Angus Place Colliery pit top will not be modified by the Project. Licensed Discharge Point LDP001 will be decommissioned following cessation of discharges in December 2019 and LDP002 will continue to operate as a rainfall based discharge point. Water discharged off site will continue to be done so in accordance with the Angus Place Colliery Environmental Protection Licence (EPL 467). The Angus Place Haul Road Pipeline is approved as part of the SWTP and is expected to be constructed and operational prior to the commencement of longwall extraction at the Angus Place Colliery.

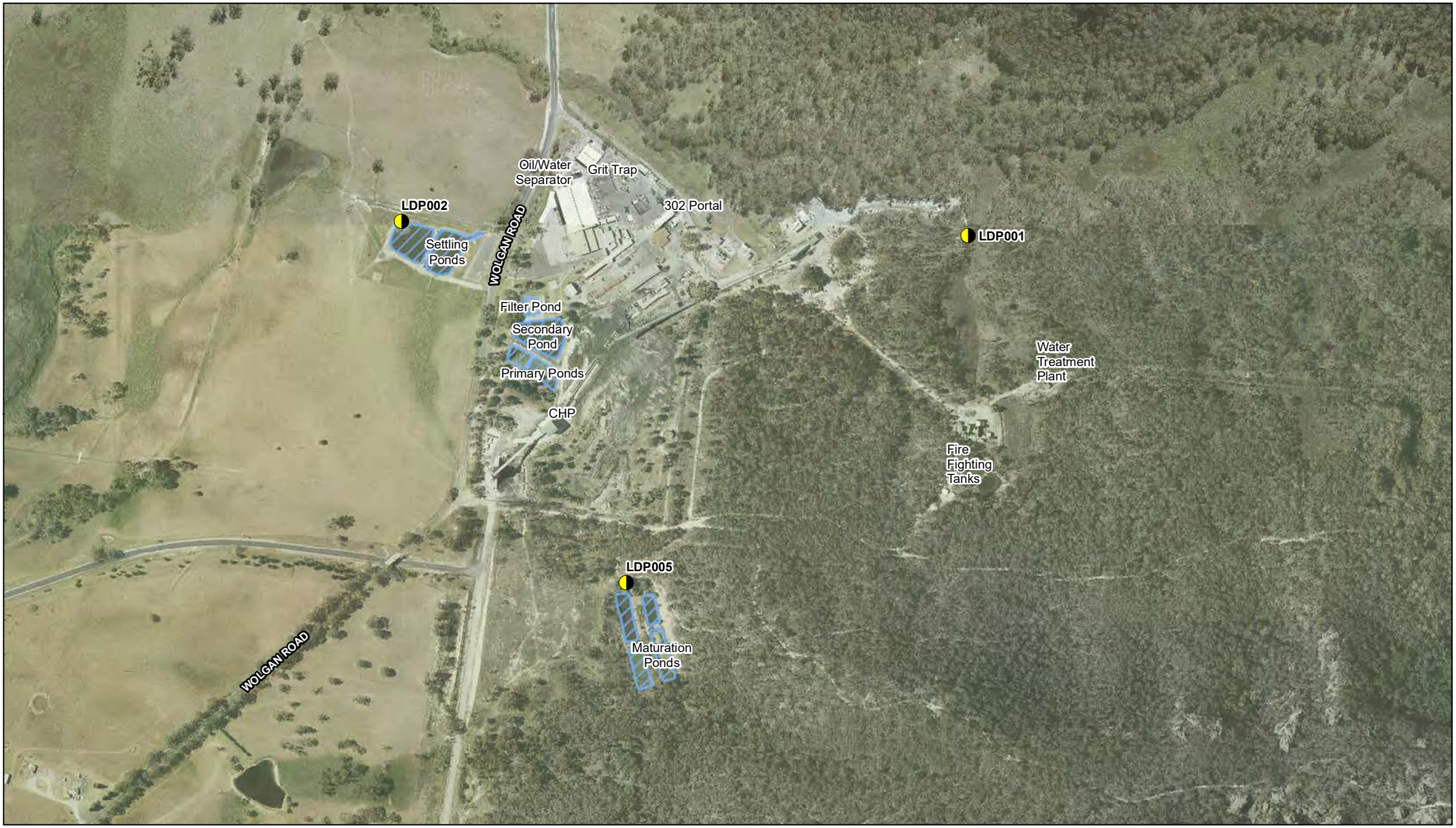
Should the Project be approved, a pipeline will be constructed to transfer wastewater to the Lithgow City Council main sewerage line at the Duncan Street pump station. Once the transfer of wastewater from the Angus Place Colliery pit top to the Lithgow City Council main sewerage line is completed, LDP005 and the associated irrigation area will no longer operate. The construction of the wastewater transfer line will be the subject of a separate development application through Lithgow City Council. The sewerage treatment line will be constructed and operational prior to the commencement of longwall extraction at the Angus Place Colliery.

2.6 Water management features

The existing and proposed water management system at Angus Place Colliery was conceptualised as a network of water management features representing surface water storages, operational processes, discharge points and receiving waters. Each water management feature was defined by its connection to other water management features by inflows and outflows of water. The water management features considered are summarised in Table 2-2. All surface water storages receive direct rainfall and catchment runoff and lose water by evaporation, which, for brevity, is not included in Table 2-2. A plan of water management features are shown spatially in Figure 2-1. The site water cycle is summarised conceptually in Figure 2-2.

Table 2-2 Water management features

Feature	Water storage	Surface water catchment	Inflows	Outflows
Coal handling plant	No	No	Pump from Fire Fighting Tanks	Losses to coal moisture Recycle to Primary Ponds
Filter Pond	Yes	Yes	Overflow from Secondary Pond	Overflow to Settling Ponds
Fire Fighting Tanks	Yes	No	Pump from 800 Panel area Pump from 900 Panel area	Pump to Coal Handling Plant (no demand during care and maintenance) Pump to underground operations (no demand during care and maintenance) Existing conditions: Feed to water treatment plant Proposed conditions: Transfer to the SWTP via the Angus Place Haul Road Pipeline
Grit Trap	No	No	Overflows from wash down	Removal of grit by contractor Overflow to Oil Water Separator
Maturation Ponds	Yes	No	Existing conditions: Wastewater from potable water use	Existing conditions: Irrigation via LDP005
800 Panel area	No	Yes (302 Portal)	Underground operations (no demand during care and maintenance) Groundwater inflows	Pump to Fire Fighting Tanks
900 Panel area	No	No	Groundwater inflows	Pump to Fire Fighting Tanks Pump to SWTP Water Transfer Pipeline via 940 Bore
1000 Panel area	No	No	Groundwater inflows Underground operations	Pump to underground dirty water pumping system Pump to SWTP Water Transfer Pipeline via dewatering boreholes and pump system to APC-VS2 vent facility
Oil Water Separator	No	Yes	Overflows from Grit Trap Overflow from Rainwater Tanks	Overflows to Settling Ponds
Primary Ponds	Yes	Yes	Overflow from Coal Handling Plant	Overflow to Secondary Pond
Secondary Pond	Yes	Yes	Overflow from Primary Ponds	Overflow to Filter Pond
Settling Ponds	Yes	Yes	Overflow from Filter Pond Overflow from Oil Water Separator	Discharge to Coxs River via LDP002
Water Treatment Plant	No	No	Feed from Fire Fighting Tanks	Discharge to Kangaroo Creek via LDP001



Paper Size A4

0 20 40 80 120 160 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Licenced Discharge Point
- Surface water storage

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Angus Place Mine Extension Project
Site water and salt balance assessment

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Revision	0
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Water management features plan

Figure 2-1

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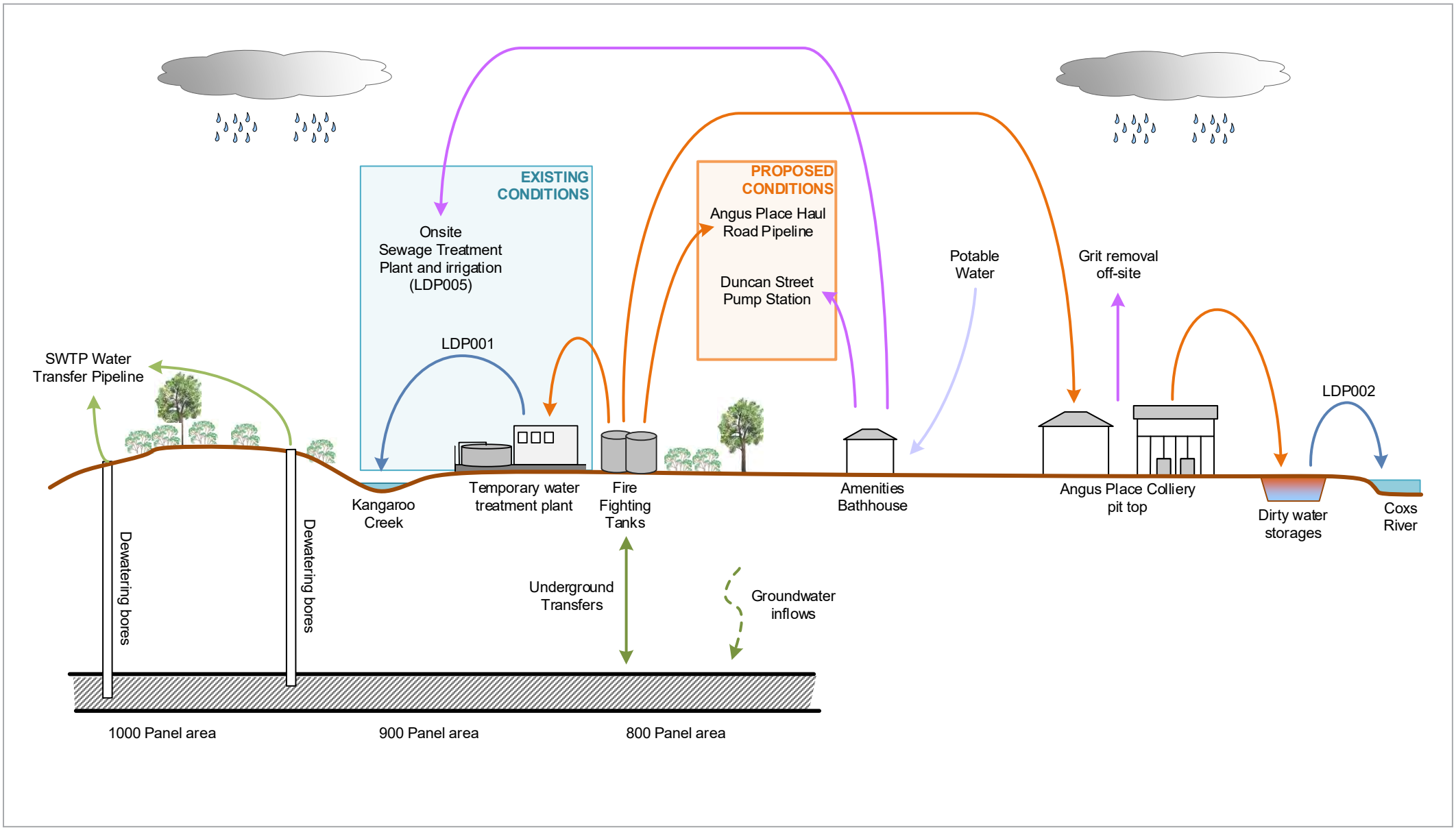
Data source: LPI:DTDB, 2012. Centennial: Imagery, LDP's, Site features, 2017. Created by: smacdonald, TMorton



Legend

- Dirty Water
- Clean Water
- Underground Water
- Potable Water
- Waste Water

GHD

Centennial Angus Place Pty Ltd
Angus Place Mine Extension Project
Site water and salt balance assessment

Water cycle

Project No. 2220268
Revision No. 0
Date 29/08/2019

FIGURE 2-2

Created by: Tyler Tinkler

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3. Data

The site water and salt balance for Angus Place Colliery involved the collation and interpretation of data from various sources. The purpose of this section is to summarise the data used. The sources of data used are shown in Table 3-1.

Table 3-1 Summary of data sources

Data	Source
Historical rainfall record	SILO (DSITI 2019)
Site rainfall record	Provided by ALS and Centennial Angus Place
Average monthly evaporation	BOM (2019)
Catchment areas and landuse	Interpreted from contours and aerial imagery provided by Centennial Angus Place
Storage geometry	Storage capacities provided by Centennial Angus Place Maximum surface area interpreted from site contours and aerial imagery
Operational processes	Provided by Centennial Angus Place
Operational pumping	Provided by Centennial Angus Place
Groundwater inflows	JBS&G (2019)
Monitoring data	Provided by ALS

3.1 Climate

A historical record of daily rainfall depths was obtained in the form of a patched point data set from the Scientific Information for Land Owners (SILO) database operated by the Queensland Department of Environment and Science (DES). SILO patched point data is based on observed historical data from a particular Bureau of Meteorology (BOM) station with missing data 'patched in' by interpolating with data from nearby stations (DSITI, 2017).

For this assessment, SILO data was obtained for the Lidsdale (Maddox Lane) station (station number 63132), which is located approximately 3.5 km south-east of the site at an elevation of 890 m AHD. This station was chosen based on proximity to the site and similarity of elevation. The period of rainfall data used for this assessment extended from 1 January 1889 to 1 January 2019 (a total of 130 years).

Site rainfall data was obtained from ALS for the gauge APLDP003 on 13 June 2019, for the period from 16 April 2009 to 13 June 2019. This gauge is located approximately 3 km south of the pit top, however is considered to have adequate proximity to be representative of rainfall at the pit top.

The cumulative frequency of annual total rainfall and evaporation from the SILO dataset between January 1889 and January 2019 are compared in Figure 3-1. In addition, the figure also presents the comparison between SILO rainfall to site-based rainfall recorded between 2009 to 2019.

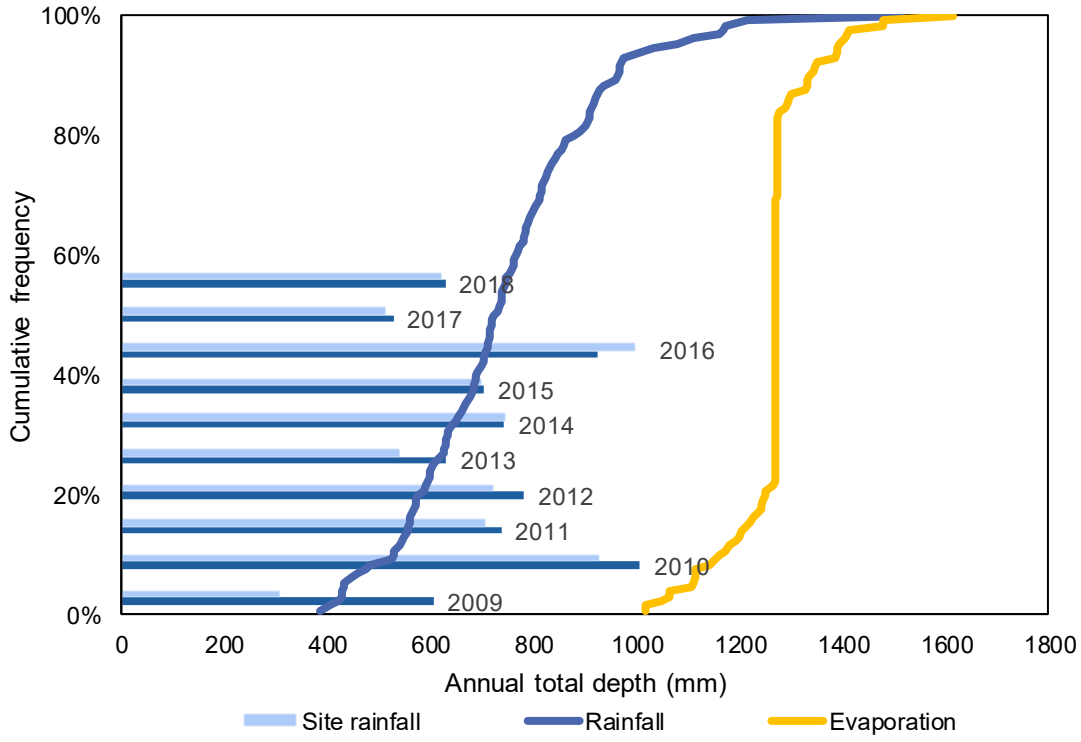

Figure 3-1 Annual rainfall and evaporation

Figure 3-1 shows that the annual totals of the historical rainfall record varied from a minimum of 330 mm (2006), to a maximum of 1515 mm (1950), with a median of 720 mm. Annual evaporation totals have an average of 1261 mm, corresponding to an average annual moisture deficit (the difference between rainfall and evaporation) of 525 mm. The comparison of annual rainfall totals observed at the site weather station against the SILO dataset is presented in the left hand side of Figure 3-1. There is an adequate match between the site and SILO data (normalised root mean square error of 15%) indicating that SILO dataset can provide adequate representation of the potential rainfall variability at the site.

A plot of average monthly pan evaporation is compared to average monthly rainfall from the historical record in Figure 3-2.

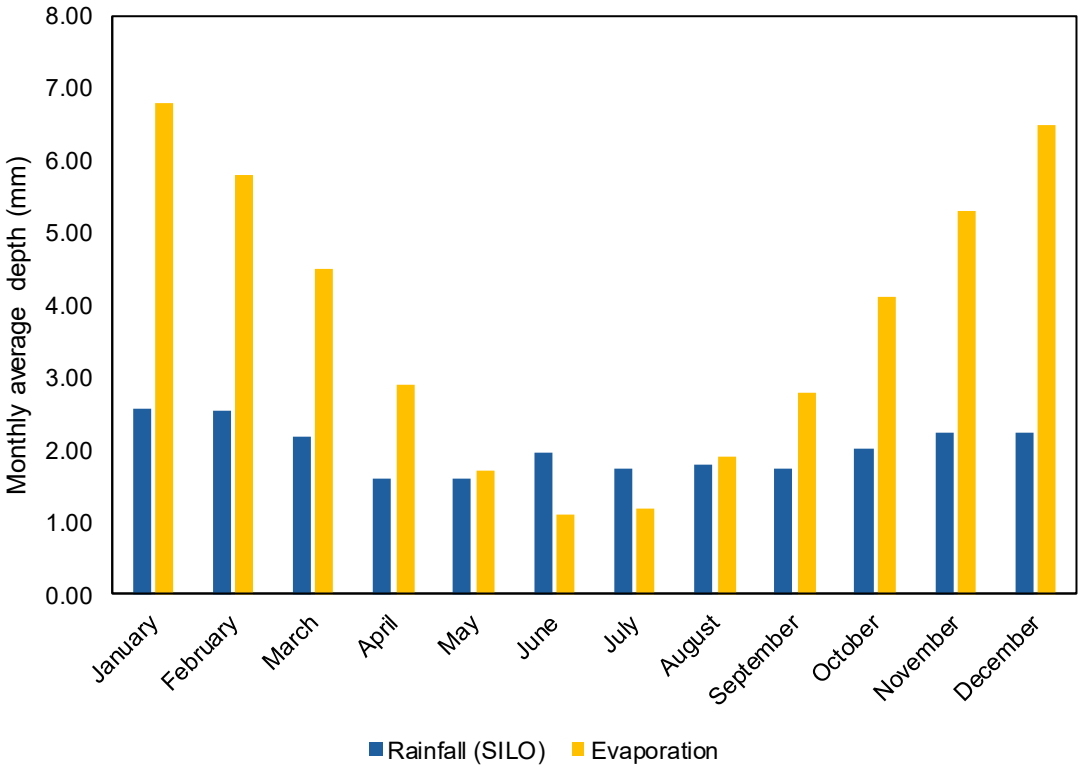

Figure 3-2 Monthly average evaporation and rainfall

Figure 3-2 show that evaporation varies seasonally, having higher records in summer compared in winter. The site has an average monthly net rainfall deficit in all parts of the year except during the winter months.

3.2 Catchments

The catchment areas and land uses for each water management feature were estimated from aerial imagery and contours. The land use of the site was characterised into two different classes:

- Vegetated: all undisturbed bush land and grassed areas
- Hardstand: roads and working pad areas

The catchments and land uses are shown spatially in Figure 3-3 and the areas are summarised in Table 3-2.

No change to surface water catchments are proposed.



Paper Size A4

0 15 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Hardstand catchment
- Vegetated catchment
- Licenced Discharge Point

GHD Centennial Coal

Centennial Angus Place Pty Ltd
Angus Place Mine Extension Project
Site water and salt balance assessment

Job Number	22-20268
Revision	0
Date	14 Aug 2019

Catchment and landuse

Figure 3-3

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Data source: LPI:DTDB, 2012. Centennial: Imagery, LDP's, Site features, 2017. Created by: smacdonald, TMorton

Table 3-2 Catchment areas

Water management feature	Vegetated portion	Hardstand portion	Total catchment area (ha)
Filter Pond	0%	100%	0.3
302 Portal	0%	100%	0.6
Oil Water Separator	0%	100%	2.4
Maturation Ponds	100%	0%	0.4
Primary Ponds	0%	100%	1.8
Secondary Pond	0%	100%	2.1
Settling Ponds	90%	10%	2.6

3.3 Storages

The capacity of surface water storages was provided by Centennial Angus Place and the maximum surface areas were estimated from aerial imagery and contours. The geometric properties of the surface water storages are summarised in Table 3-3.

Table 3-3 Storage geometry

Water management feature	Capacity (ML)	Maximum surface area (m^2)
Filter Pond	1.2	440
Fire Fighting Tanks	1.0	0
Maturation Ponds (existing conditions only)	7.0	3884
800 Panel area	2000 (approximate)	0 (underground)
900 Panel area	1925 (approximate)	0 (underground)
Primary Ponds	1.9	1583
Secondary Pond	2.6	2549
Settling Ponds	7.5	4529

3.4 Operations

Operational rules and parameters were developed in consultation with Centennial Angus Place. The operational processes and pumping rules for the purpose of the site water and salt balance are summarised in Table 3-4 and Table 3-5 respectively.

Table 3-4 Operational processes

Water management feature	Demand
Potable water use	6.75 kL/day for administration 77.6 kL/day for bathhouse during operations
Process water	7.5 L/s during operations
Vehicle wash down	6500 L/day with 50% losses
Grit Trap removal	8000 L/week
Coal Handling Plant (CHP)	During operations: All ROM coal from secondary extraction will be handled at Springvale Mine. Some relatively minor volumes of ROM coal from development will be handled at the Angus Place Colliery CHP.

Table 3-5 Operational pumping

Pumped transfer	Trigger
800 Panel area to Fire Fighting Tanks	Existing: Constant pumping to maintain water levels in the 800 Panel area
	Future: Constant pumping to dewater the stored volume and groundwater inflows.
900 Panel area to Fire Fighting Tanks	Existing: Constant pumping to make up mine water supply to the water treatment plant, as a second priority to maintaining water levels in the 800 Panel area
	Future: Constant pumping to dewater the stored volume and groundwater inflows.
900 Panel area to SWTP Water Transfer Pipeline via the 940 Bore	Existing: Not operational (0 ML/day)
	Future: Constant pumping to dewater the stored volume and groundwater inflows.
1000 Panel area to SWTP Water Transfer Pipeline	Future: Constant pumping to dewater the stored volume and groundwater inflows.

3.5 Water treatment plant

The water treatment plant uses reverse osmosis technology that separates the incoming feed stream into a bypass stream, a relatively fresh permeate stream and a relatively saline residual stream. The bypass and permeate stream are blended to form the discharge stream. The plant is designed to achieve a discharge stream of 10 ML/day with an EC of 350 µS/cm, as measured at the point of discharge. The residuals stream is transferred to the underground workings for temporary storage. The plant was assumed to be sufficiently efficient to discharge 10 ML/day of treated water whilst extracting less than 13.4 ML/day of mine water from the underground workings.

The temporary water treatment plant was commissioned in late 2018. Following cessation of LDP001 discharges at the end of 2019, the temporary water treatment plant is no longer expected to be required.

3.6 Groundwater

Groundwater inflows to the underground workings used for this assessment were based on the Hydrogelogical Model Report (JBS&G 2019). Groundwater inflows for the 800 and 900 Panel areas were presented for two conditions:

- Null case: Dewatering at Angus Place Colliery will continue for five years after the expiry of the current Angus Place Colliery consent, until 2030.
- Proposed conditions: Dewatering of the 1000 Panel area will commence on 1 July 2025 and dewatering of the existing and proposed workings at Angus Place Colliery will continue until 2054.

Figure 3-4 shows the predicted groundwater inflows used for 800, 900 and 1000 Panel Areas for the null case and proposed conditions. The existing groundwater inflows were based on site observations.

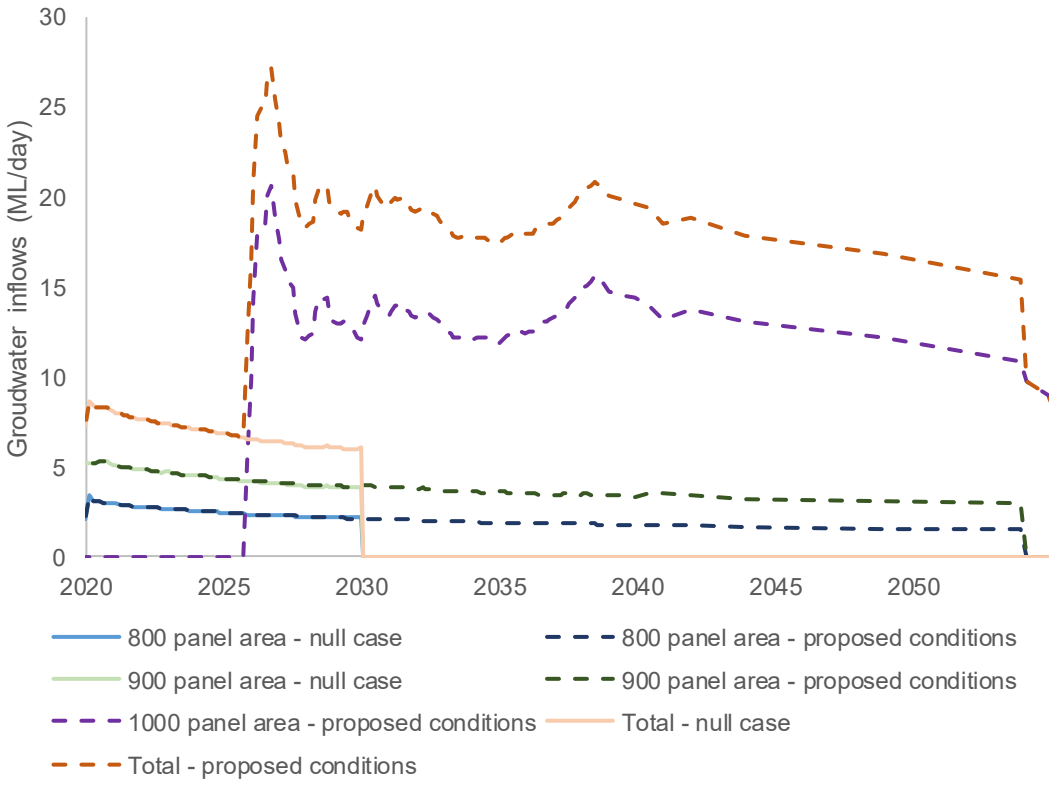


Figure 3-4 Predicted groundwater inflows

3.7 Monitoring data

Water monitoring data were obtained from the onsite monitoring equipment. Observations considered for the site water and salt balance include:

- Daily time series of LDP001 discharge volume and EC
- Daily time series of LDP002 discharge volume and EC
- Daily time series of site rainfall

4. Model methodology

4.1 Water and salt balance

The site water and salt balance for Angus Place Colliery was modelled as a semi-distributed mass balance, considering the existing and proposed water management features, as described in Section 2. A site-specific water balance equation was derived from the catchment scale water balance equation described by Ladson (2008). The water balance equation applies conservation of mass to derive an ordinary differential equation that describes how the volume of water V changes over time t:

$$\frac{dV}{dt} = R + C + G_{in} + P_{in} + Q_{in} - E - P_{out} - Q_{out}$$

The water balance considered the inflows into each storage:

- Direct rainfall R, estimated from the simulated water surface area of the storage and the simulated rainfall intensity.
- Catchment runoff C, using the Australian Water Balance model (AWBM) (Boughton & Chiew, 2003) and accounting for the change in simulated water surface area.
- Groundwater inflows G_{in}, as described in on Section 3.6.

The water balance considered the outflows from each storage:

- Evaporation E, estimated from the simulated water surface area of the storage. A pan factor of 0.9 was adopted to the pan evaporation to estimate both potential evaporation and potential evapotranspiration from simulated pan evaporation.

The water balance considered transfers between storages:

- Pumped transfers P_{in} and P_{out}, according to site-specific operating rules and pump rates.
- Overland channel and gravity pipe flow Q_{in} and Q_{out}, according to site-specific operating rules and flow rates and due to overflows from one storage to another.

A salt mass balance was coupled to the water balance. The salt transfer corresponding to each water transfer was calculated based on the simulated salinity of the respective water storage, assuming instantaneous and complete mixing.

4.2 Rainfall variability

Rainfall variability was considered in the site water and salt balance by sampling simulated rainfall from the historical rainfall record (refer to Section 3.1). A series of simulations were performed, each beginning in a different year of the historical rainfall record and proceeding consecutively through the record (and looped where required).

4.3 Hydrologic model

The Australian Water Balance Model (AWBM) (Boughton & Chiew, 2003) was used to estimate the runoff contributing to the surface water storages. The AWBM was adopted as it:

- Is widely used throughout Australia, especially for mining applications
- Has been verified through comparison with large amounts of recorded streamflow data
- Has literature available to assist in estimating input parameters
- Considers soil moisture retention state when determining runoff

The AWBM is a soil moisture water balance model that calculates runoff from rainfall after allowing for losses and storage. Figure 4-1 is a schematic of the model, which shows that the model consists of three storage elements (with surface areas A_1, A_2 and A_3) representing soil moisture.

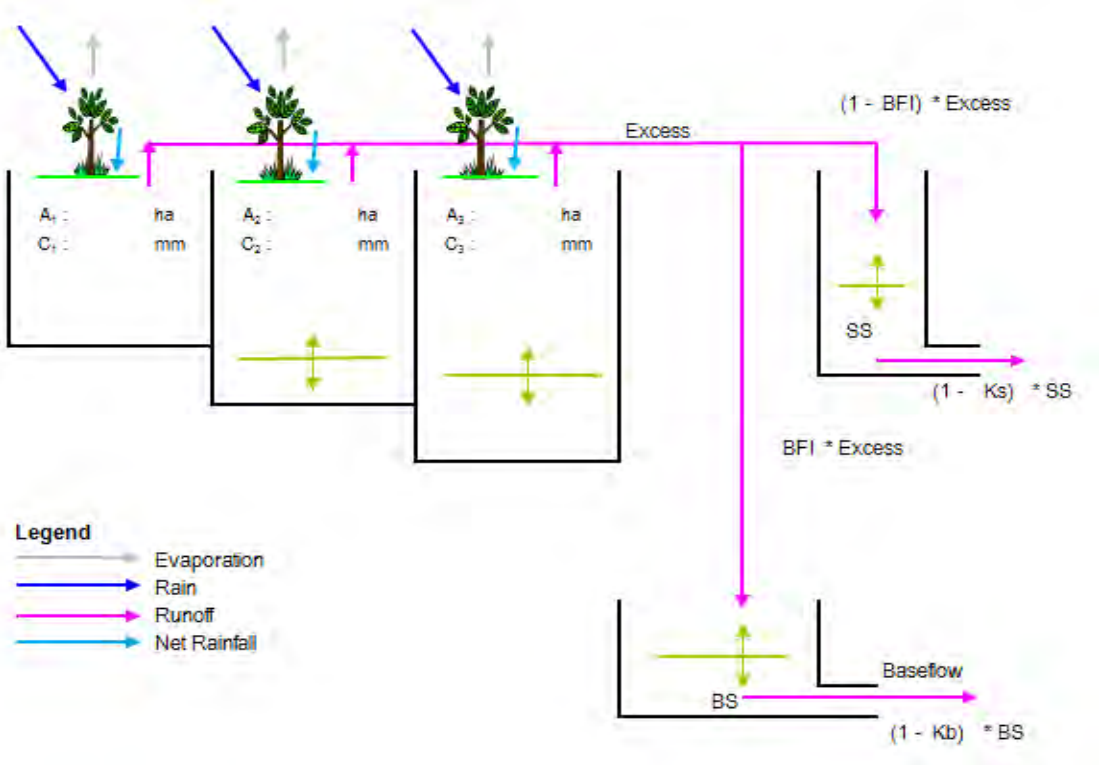


Figure 4-1 AWBM model schematic

Rainfall enters these storages and when a storage element is full, any additional rainfall is considered to be excess rainfall. Of this excess rainfall, a proportion is routed to the baseflow storage (BS) while the remainder is routed to the surface storage (SS). The discharge from the baseflow storage and surface storage is estimated as a proportion of the volume of the storages at the end of each day. The total runoff is the combined volume of water discharged from these two storages. The parameters of the AWBM are summarised in Table 4-1.

Table 4-1 Summary of Australian Water Balance model parameters

Parameter	Description
A_1, A_2, A_3	The partial areas of the overall catchment contributing to each storage.
C_1, C_2, C_3	The capacity of storages 1, 2 and 3 respectively.
BFI	The proportion of excess rainfall flowing to the baseflow.
K_b	The proportion of the volume of the baseflow storage remaining in the storage.
K_s	The proportion of the surface storage remaining in the storage.

The site-specific land uses (refer to Section 3.2) were characterised with different sets of AWBM parameters.

The AWBM parameters adopted for the water balance model are summarised in Table 4-2.

Table 4-2 Parameter values for Australian Water Balance Model

Parameter	Vegetated	Hardstand
A_1, A_2, A_3	0.134, 0.433, 0.433	1.0, 0.0, 0.0
C_1, C_2, C_3 (mm)	8.134, 83.07, 166.1 (C_{ave} = 109 mm)	5.0, 0.0, 0.0
BFI	0.0	0.0
K_s	0.5	0.5
K_b	NA	NA

The parameters used to characterise the land uses are typical hydrologic parameters for such areas. The parameters were validated as part of a validation of the entire model against site observations, as described in Section 4.

4.4 Salinity model

The salinity of the inputs of salt to the site salt balance were estimated based on site observations and validated as part of the model validation described in Section 5. The salinity of rainfall was adopted after DRNW (2007). EC was assumed equivalent to salinity with a factor of 0.67 (mg/L)/(µS/cm) (DNRW, 2007).

The salinity parameters adopted are summarised in Table 4-3.

Table 4-3 Salinity parameters

Parameter	Electrical conductivity (µS/cm)
Rainfall	30
Vegetated runoff	50
Hardstand runoff	250
Groundwater inflows	1050
Potable supply	50
Target EC of temporary water treatment plant	350

4.5 Numerical implementation

The water and salt balance model was implemented in GoldSim (version 12.0). A basic timestep of 1 day was used, with timesteps dynamically inserted were required. GoldSim uses the forward Euler method to solve the mass conservation equations described in Section 4.1.

4.6 Simplifications and assumptions

In additional to specific conceptualisations and assumptions described in this section, the simulated surface area of surface water storages was assumed directly proportional to the simulated storage volume, up to the maximum surface area and total storage capacity of the storage.

This water and salt balance considers the effect of rainfall variation on the results of the model, based on a historical rainfall record. This approach assumes that the historical rainfall record is characteristic of future rainfall variability and does not consider inter-annual climate patterns such as the El Niño Southern Oscillation or long term trends such as climate change.

5. Model validation

The site water and salt balance model for Angus Place Colliery was simulated from 1 July 2017 to 1 January 2019 (the validation period). The simulation used observed site rainfall and operated under the existing conditions. The purpose of validation is to test whether the model is of adequate accuracy for the purpose of making predictions (refer to Section 6). This section compares the observed and model daily average flow and EC at LDP001 and LDP002.

The model was initialised with all storage volumes at their normal operational volumes and all soil moisture storages in the hydrologic model empty. The initial EC was used to estimate the initial salt storage mass, based on the initial water storage volume and the conversion factor described in Section 4.4. The initial levels, estimated initial volumes and initial conductivities for each storage are summarised in Table 5-1.

Table 5-1 Initial conditions

Water management feature	Initial volume (ML)	Initial EC (µS/cm)
Filter Pond	1.2	250
Fire Fighting Tanks	0.2	1050
Maturation Ponds	7.0	250
800 Panel area	2000	1050
900 Panel area	1600	1050
Primary Ponds	1.9	250
Rainwater Tanks	0.3	250
Secondary Pollution Pond	2.6	250
Settling Ponds	7.5	250

The cumulative discharge volume and average monthly EC of LDP001 are shown in Figure 5-1 and Figure 5-2 respectively.

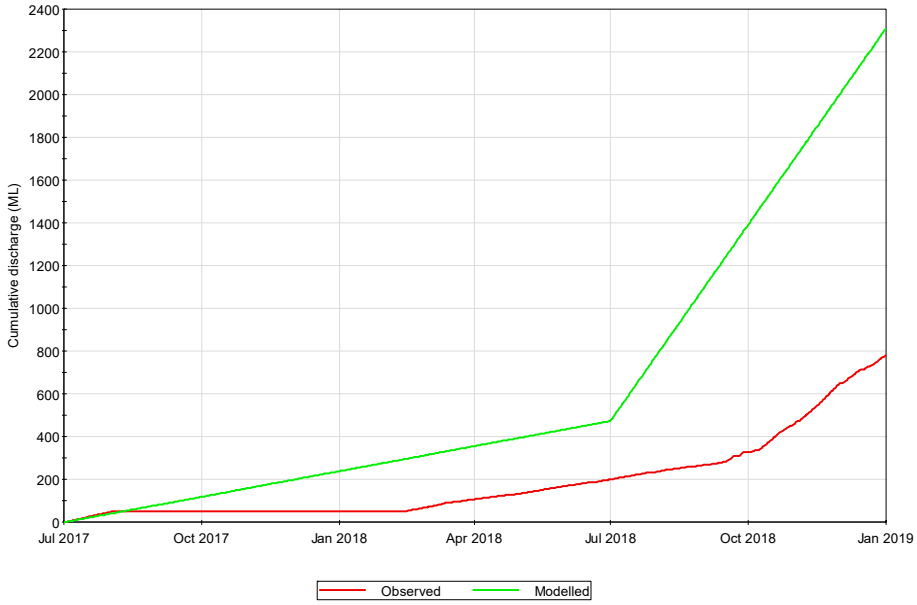


Figure 5-1 Observed and modelled cumulative LDP001 discharge volume

Figure 5-1 shows that the model simulated higher cumulative discharge volume compared to the observed data for LDP001. Centennial Angus Place reported that operational constraints on the treatment process limited the volumetric output of the temporary water treatment plant and therefore LDP001 discharges were less than expected.

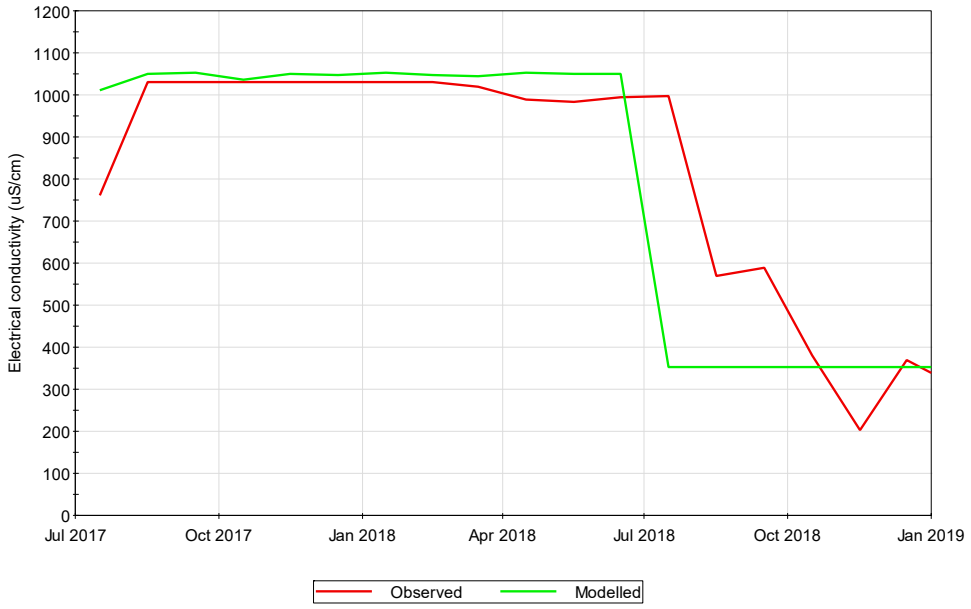


Figure 5-2 Observed and modelled average monthly LDP001 EC

Figure 5-2 shows that the model satisfactorily replicates the general pattern of the average observed EC over the validation period, with a decrease in EC from untreated mine water (about 1000 µS/cm) to treated water (about 350 µS/cm) during 2018, associated with the commissioning of the water treatment plant.

The cumulative discharge volume and average monthly EC of LDP002 are shown in Figure 5-3 and Figure 5-4 respectively.

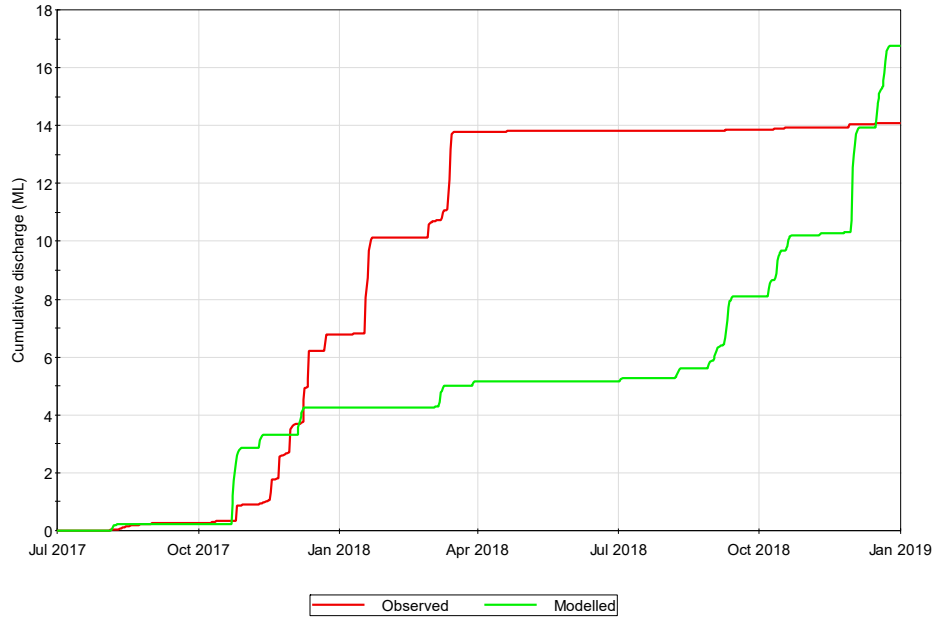


Figure 5-3 Observed and modelled cumulative LDP002 discharge volume

Figure 5-3 shows that the model approximately matches the total discharge volume over the validation period.

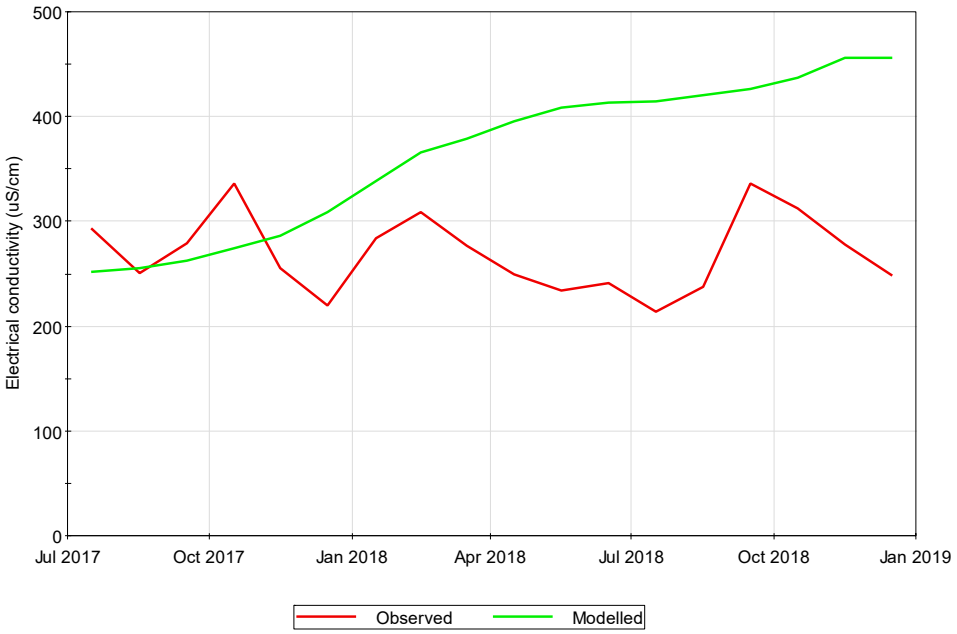


Figure 5-4 Observed and modelled average monthly LDP002 EC

Figure 5-4 shows that the model simulated higher EC compared to the observed EC for LDP002 over the validation period.

Overall, the validation demonstrates that the model is able to satisfactorily replicate the cumulative annual discharge volume and the average monthly EC at LDP001. As the temporary water treatment and LDP001 will not be operated as part of the Project, the model predictions are not sensitive to this part of the model. The model overestimates the cumulative discharge and monthly average EC of LDP002, which indicates that the model prediction in Section 6 are likely to be a reasonable yet conservative estimate of discharges via LDP002.

6. Model results

The validated site water and salt balance model for Angus Place Colliery was used to simulate the following scenarios:

- Existing conditions. This scenario considered the existing care and maintenance phase of Angus Place Colliery, including the water treatment plant and the discharge of treated water via LDP001.
- Baseline conditions. This scenario considered continuation the existing of care and maintenance phase of Angus Place Colliery, following the cessation of discharges via LDP001 and the construction and operation of the Angus Place Haul Road Pipeline. This scenario adopted the null case from the groundwater modelling predictions (refer to Section 3.6).
- Proposed conditions. The scenario was similar to baseline conditions, but considered the Project, with resumption of operations from 2025, transfer of wastewater at the Duncan Street pump station and adopted the proposed case from the groundwater modelling predictions (refer to Section 3.6).

The existing conditions were simulated from 1 January 2019 to 1 January 2020. Although part of this period had elapsed at the time of this assessment, the model was simulated over the entire year, in order to be comparable to the baseline and proposed conditions. The baseline and proposed conditions were simulated from 1 January 2020 to 1 January 2055. The year 2027 was selected for the purpose of comparison between baseline and proposed conditions, as this corresponded to peak in groundwater inflows under the proposed conditions and greatest increase in groundwater inflows for the proposed conditions relative to baseline conditions.

6.1 Interpretation of results

To consider potential climate variability, a total of 130 different rainfall patterns were simulated (as described Section 4.2). The results presented show the average, 10th percentile and 90th percentile values. The purpose of displaying the three results is to indicate both the average value and the likely possible range. The 10th percentile represents the value at which 10% of the modelled outputs were less than this value. Similarly, the 90th percentile represents the value at which 90% of the modelled outputs were less than this value.

The 10th and 90th percentile values have been used rather than minimum and maximum values to exclude infrequent extreme wet and dry conditions. The set of 10th or 90th percentile values do not necessarily all correspond to the same rainfall series, that is, they do not correspond to a 10th percentile “dry” or 90th percentile “wet” year.

6.2 Qualification of predictions

GHD has developed the water and salt balance model for Angus Place Colliery based on information supplied by Centennial Angus Place and external data sources. Where data was not available, GHD has made assumptions as appropriate.

Data used to develop the model are categorised as follows:

- Relatively reliable data: SILO rainfall data, BOM evaporation data, surface catchment areas based on topographic maps.
- Less reliable data: catchment runoff volumes, operational precedence for transfers between storages, storage geometry, salinity parameters.

The items identified as 'less reliable data' present a risk that the model predictions are inaccurate. The accuracy may be improved as additional site data is gathered. This additional data will allow refinement of the model inputs and hence increase the reliability of the model predictions. The adoption of historical rainfall and evaporation data within the detailed water balance model does not take into account the potential impacts of climate change.

6.3 Water balance

The forecast annual water transfers for Angus Place Colliery under existing, baseline and proposed conditions are summarised in Figure 6-2, Figure 6-3 and Figure 6-4 respectively. The average annual water balance is summarised in Table 6-1.

Table 6-1 Average annual site water balance

Water management element	Existing conditions (2019) (ML/year)	Baseline conditions (2027) (ML/year)	Proposed conditions (2027) (ML/year)
INPUTS			
Direct rainfall onto storages	9	9	7
Catchment runoff	24	24	24
Groundwater inflows	3176	2300	7471
External potable water supply	2	2	29
TOTAL INPUTS	**3211**	**2335**	**7531**
OUTPUTS			
Evaporation	15	15	11
Discharge through LDP001	3647	0	0
Discharge through LDP002	19	19	19
Discharge through LDP005	1	1	0
Transfer to Duncan Street Pump Station	0	0	29
Transfer to SWTP	0	2298	7771
Losses from operations	2	2	2
TOTAL OUTPUTS	**3684**	**2335**	**7831**
CHANGE IN STORAGE			
Surface water storages	0	0	0
Underground water storages	-473	0	0
TOTAL CHANGE IN STORAGE	**-473**	**0**	**0**
BALANCE			
Inputs – outputs – change in storage	0	0	0

Rainfall, runoff and evaporation

Direct rainfall, catchment runoff and evaporation of the Angus Place Colliery pit top are expected to remain unchanged from existing conditions. The difference between the proposed conditions and baseline conditions corresponds to the decommissioning of the Maturation Ponds following the connection of wastewater from Angus Place Colliery to the Duncan Street pump station.

Groundwater inflows and transfer to SWTP

Groundwater inflows are expected to gradually decrease during care and maintenance, corresponding in the decrease between existing and baseline conditions. The Project is expected to result in an increase in groundwater inflows, corresponding to the difference between proposed and baseline conditions.

Under both baseline and proposed conditions, the existing and proposed underground workings are expected to be dewatered and transferred to the SWTP via the SWTP Water Transfer Pipeline and the Angus Place Haul Road Pipeline.

Potable water

Potable water use is expected to remain unchanged during care and maintenance, but increase during operations as a result of the Project. Should the Project be approved, a pipeline will be constructed to transfer wastewater to the Lithgow City Council main sewerage line at the Duncan Street pump station. Once the transfer of wastewater from the Angus Place Colliery pit top to the Lithgow City Council main sewerage line is completed, LDP005 and the associated irrigation area will no longer operate.

Discharge via LDP001

Discharges via LDP001 are expected to cease by 2020.

Discharge via LDP002

No change to discharges via LDP002 is expected as a result of the Project.

Losses from operations

No change to losses from operations is expected as a result of the Project.

Change in storage

The underground water storage capacity in the 800 and 900 Panel area provides operational flexibility as part of the transfer of water from the Project to the SWTP. This storage capacity can be expressed in terms of the time that the predicted groundwater make could potentially be temporarily stored in these underground water storages. The forecast available water storage, under baseline (approved) and proposed conditions, is shown in Figure 6-1.

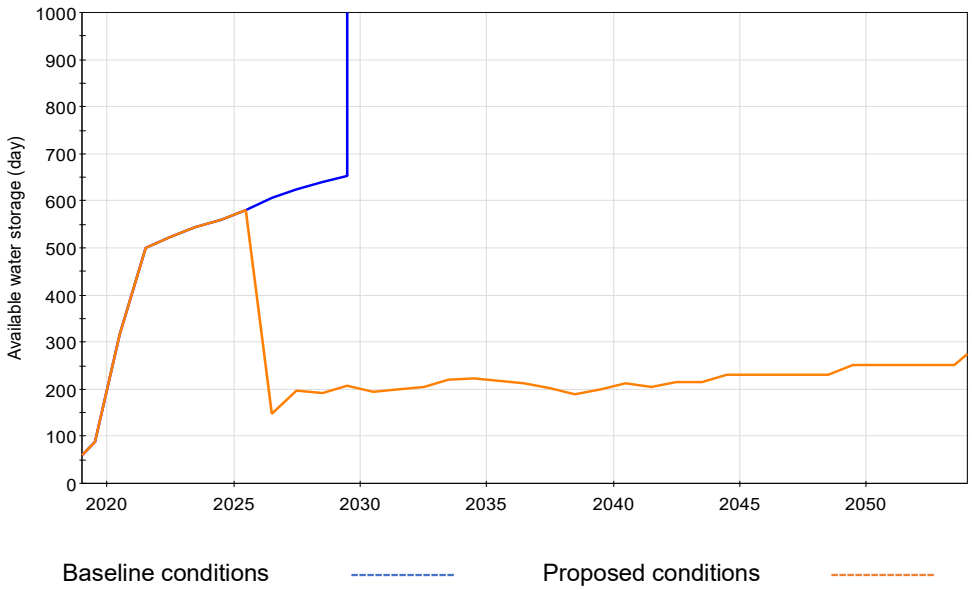
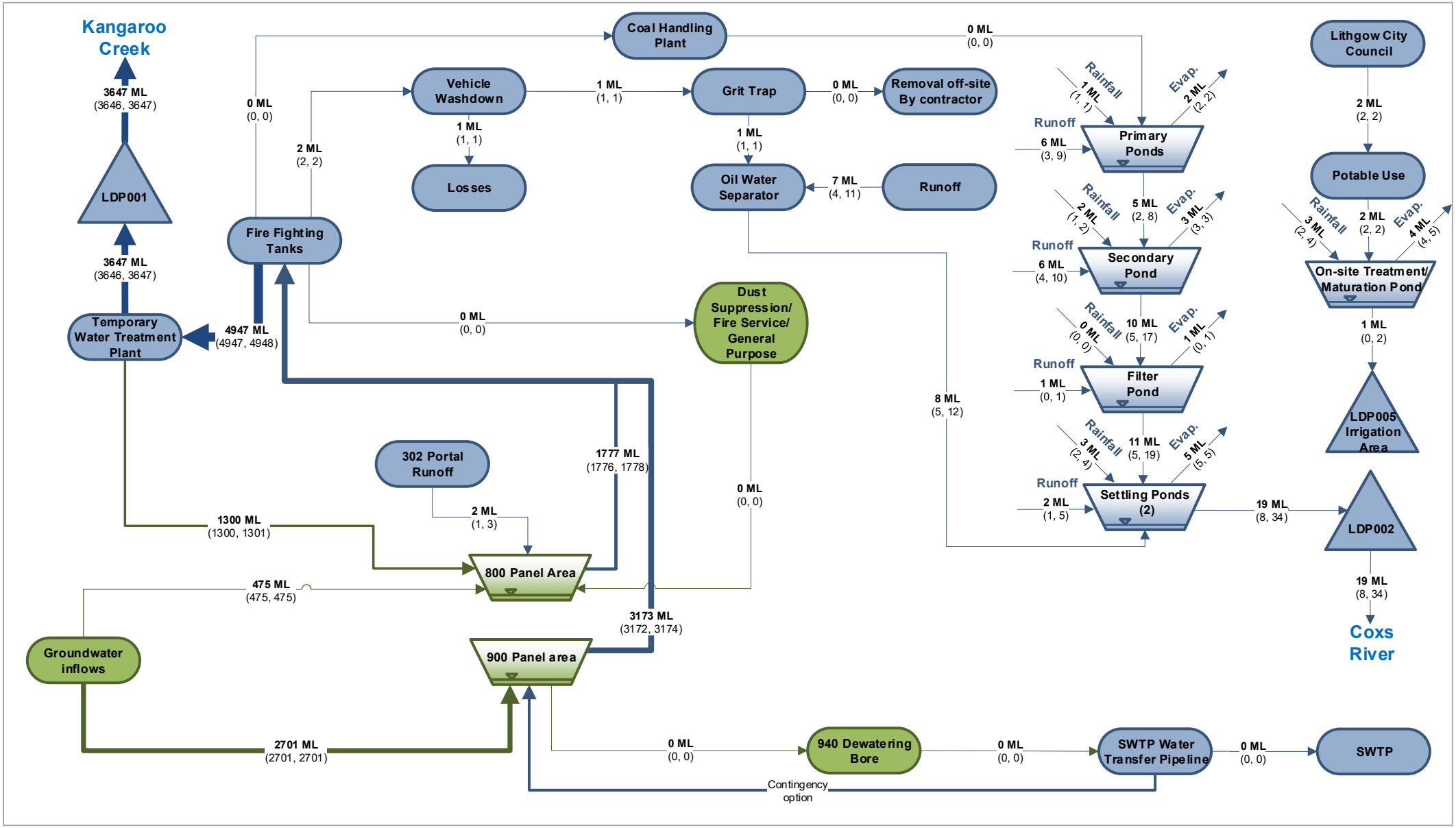


Figure 6-1 Forecast available water storage

Figure 6-1 shows that under both baseline and proposed conditions, the volume of water in the 800 Panel area and 900 Panel area are expected to decrease, thus increasing the available water storage to above 500 days. These areas are expected to be fully dewatered before the commencement of longwall operations at Angus Place Colliery commence in about 2025. For baseline conditions, the available water storage was modelled to remain above 500 days until dewatering was assumed to cease in 2029.

For proposed conditions, as predicted groundwater inflows increase following commencement of longwall operations, the available water storage was modelled to decrease to about 200 days and remain at about this level for the remainder of the Project.

In reality, the actual volume of water in underground storages may vary for operational reasons, including contingency options described in Section 2.5.



Legend

- Underground storage
- Underground process
- Surface storage
- Surface process
- Licensed discharge point
- Entrained moisture
- Surface water flow
- Groundwater flow
- X (X,X) Mean (10th percentile, 90th percentile)

GHD

Centennial Angus Place Pty Ltd
Angus Place Mine Extension Project
Site water and salt balance assessment

Water management schematic
Annual water transfers
Existing conditions (2019)

Project No. 2220268
Revision No. 0
Date 29/08/2019

FIGURE 6-2

Created by: Tyler Tinkler

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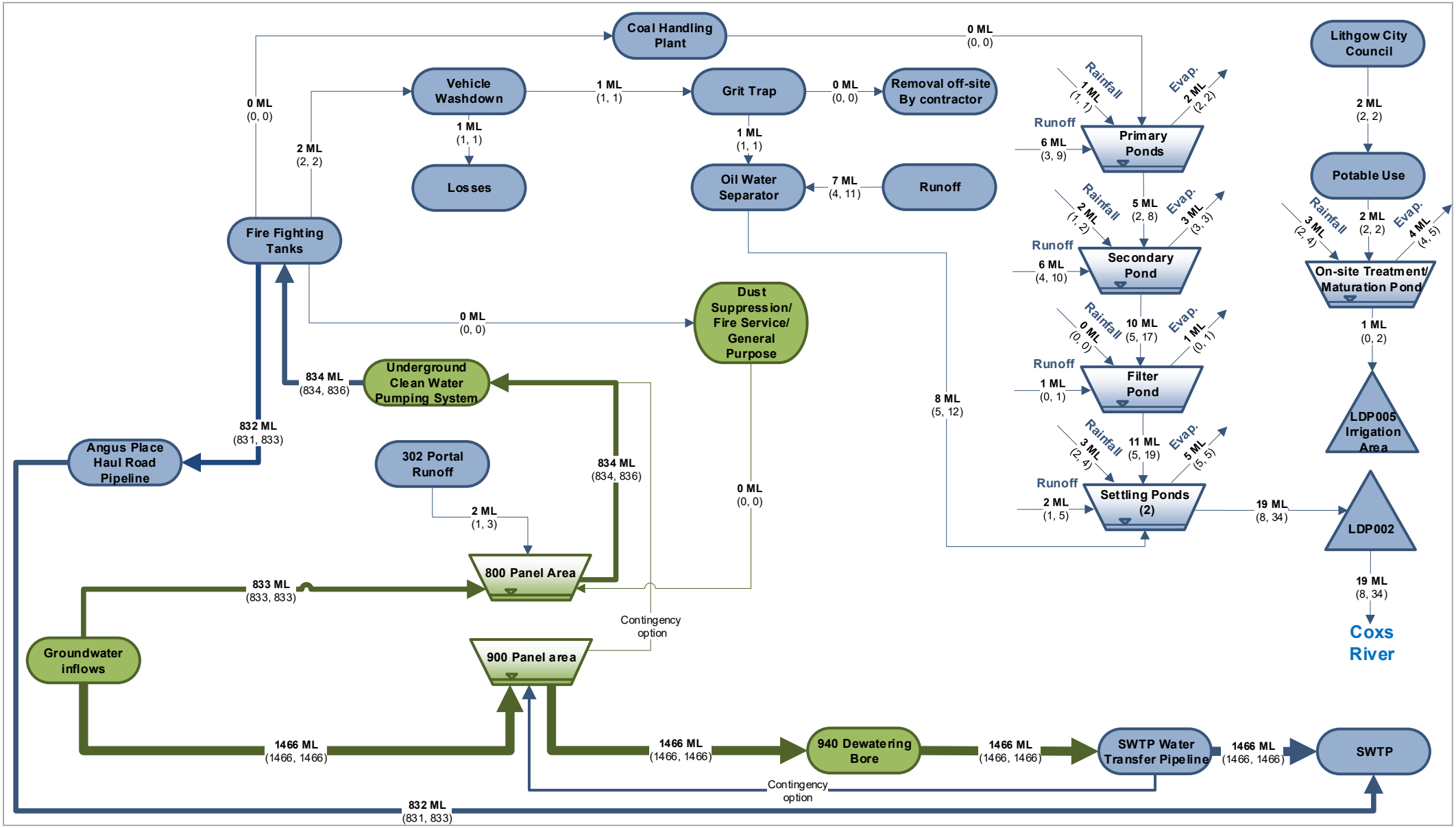

Legend

- Underground storage
- Underground process
- Surface storage
- Surface process
- Licensed discharge point
- Entrained moisture
- Surface water flow
- Groundwater flow
- X (X,X) Mean (10th percentile, 90th percentile)

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Centennial Angus Place Pty Ltd
Angus Place Mine Extension Project
Site water and salt balance assessment

Water management schematic
Annual water transfers
Baseline conditions (2027)

Project No. 2220268
Revision No. 0
Date 29/08/2019

FIGURE 6-3

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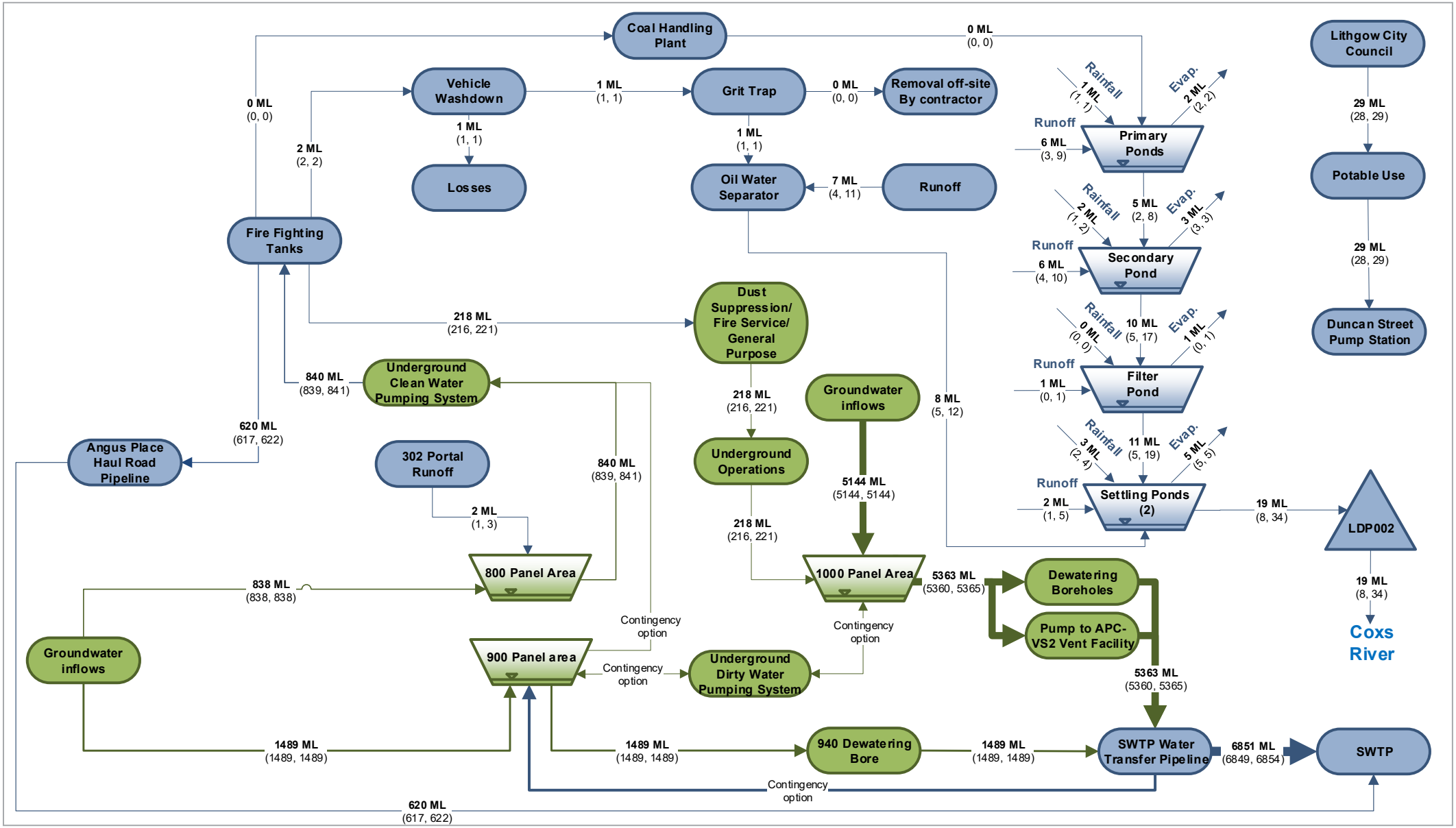

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- Underground process
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- X (X,X) Mean (10th percentile, 90th percentile)

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Site water and salt balance assessment

Water management schematic Annual water transfers Proposed conditions (2027)

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FIGURE 6-4

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6.4 Salt balance

The forecast annual salt transfers for Angus Place Colliery under existing, baseline and proposed conditions are summarised in Figure 6-5, Figure 6-6 and Figure 6-7 respectively. The average annual water balance is summarised in Table 6-2.

Table 6-2 Annual average site salt balance

Water management element	Existing conditions (2019) (tonne/year)	Baseline conditions (2027) (tonne/year)	Proposed conditions (2027) (tonne/year)
INPUTS			
Direct rainfall onto storages	0	0	0
Catchment runoff	5	5	5
Groundwater inflows	2234	1618	5256
External potable water supply	0	0	1
TOTAL INPUTS	**2239**	**1624**	**5262**
OUTPUTS			
Evaporation	0	0	0
Discharge through LDP001	861	0	0
Discharge through LDP002	6	6	6
Discharge through LDP005	0	0	0
Transfer to Ducan Street Pump Station	0	0	1
Transfer to SWTP	0	1618	5255
Losses from operations	1	1	1
TOTAL OUTPUTS	**868**	**1624**	**5262**
CHANGE IN STORAGE			
Surface water storages	0	0	0
Underground water storages	1371	0	0
TOTAL CHANGE IN STORAGE	**1371**	**0**	**0**
BALANCE			
Inputs – outputs – change in storage	0	0	0

Rainfall, runoff and evaporation

Salt associated with direct rainfall, catchment runoff and evaporation of the Angus Place Colliery pit top are expected to remain unchanged from existing conditions.

Groundwater inflows and transfer to SWTP

Salt associated with groundwater inflows are expected to gradually decrease during care and maintenance, corresponding to the decrease between existing and baseline conditions. In proportion to the water balance, the Project is expected to result in an increase in salt associated with groundwater inflows, corresponding to the difference between proposed and baseline conditions.

Potable water

Salt associated with potable water use is expected to remain unchanged during care and maintenance, but increase during operations as a result of the Project.

Discharge via LDP001

Discharges via LDP001 are expected to cease by 2020.

Discharge via LDP002

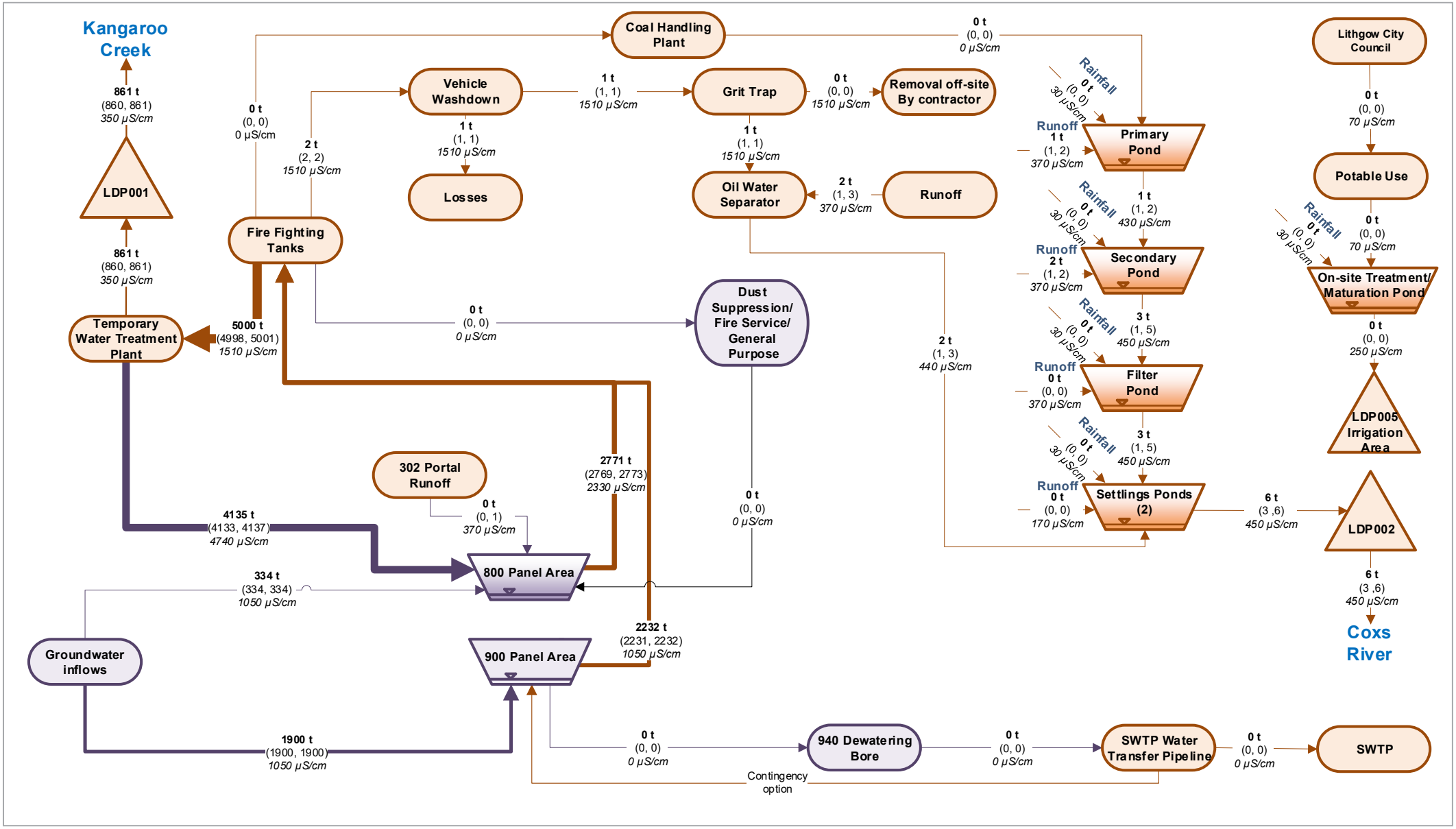
No change to discharges via LDP002 is expected as a result of the Project.

Losses from operations

No change to losses from operations is expected as a result of the Project.

Change in storage

The mass of salt in the underground storage is expected to increase during existing conditions as a result of the operation of the water treatment plant. Following the cessation of the discharge via LDP001, salt stored in the underground storages is expected to decrease over time, reaching an equilibrium with no change by 2027.



Legend

- Underground storage
- Underground process
- Surface storage
- Surface process
- Licensed discharge point
- Entrained moisture
- Surface water flow
- Groundwater flow
- X, •(X,X), XX — Mean (10th percentile, 90th percentile), Mean EC

Centennial Angus Place Pty Ltd
Angus Place Mine Extension Project
Site water and salt balance assessment

Water management schematic
Annual salt transfers
Existing conditions (2019)

Project No. 2220268
Revision No. 0
Date 29/08/2019

FIGURE 6-5

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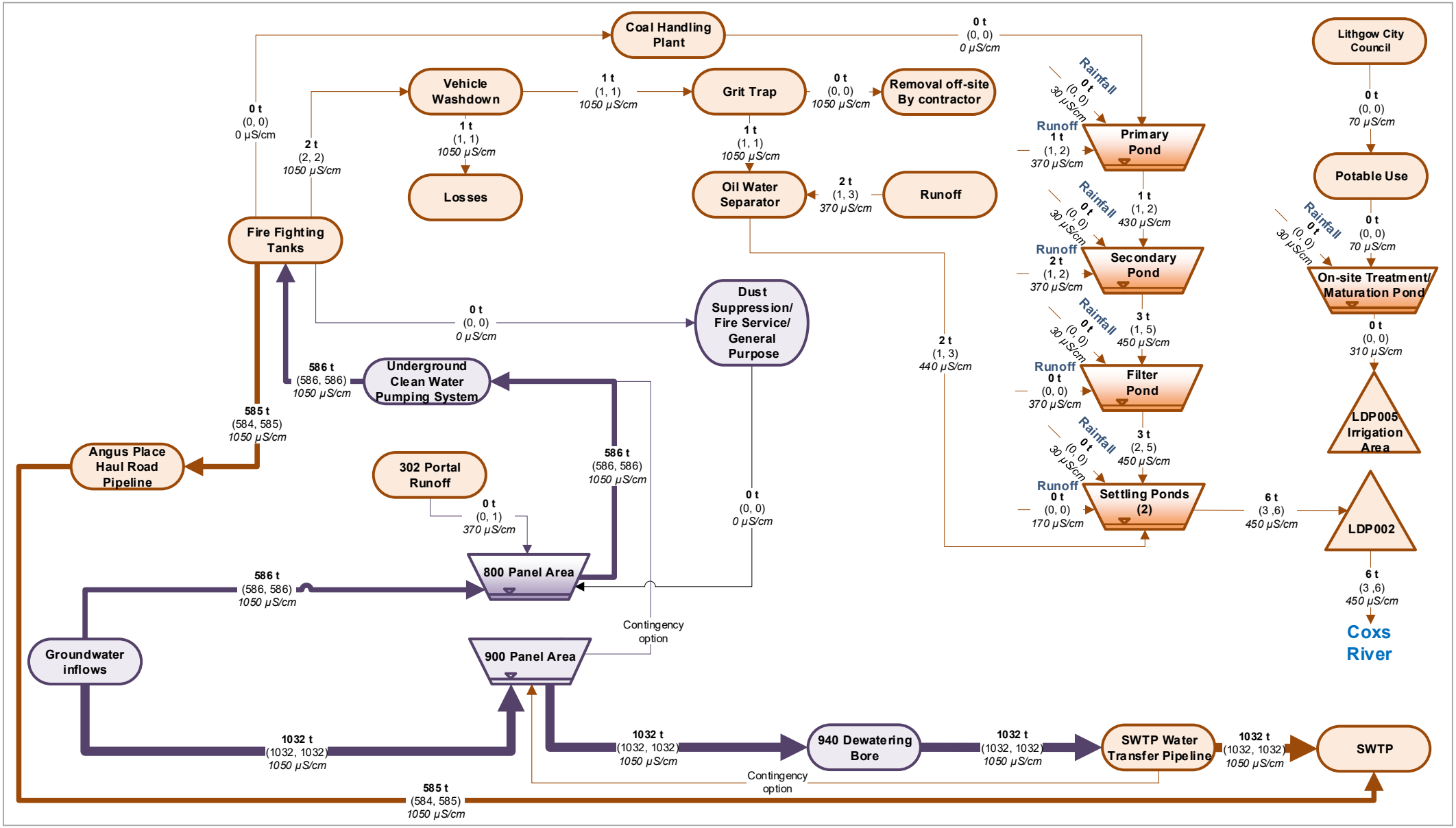

Legend

- Underground storage
- Underground process
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- Surface process
- Licensed discharge point
- Entrained moisture
- Surface water flow
- Groundwater flow
- X •(X,X) XX — Mean (10th percentile, 90th percentile) Mean EC

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Centennial Angus Place Pty Ltd
Angus Place Mine Extension Project
Site water and salt balance assessment

Water management schematic Annual salt transfers Baseline conditions (2027)

Project No. 2220268
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FIGURE 6-6

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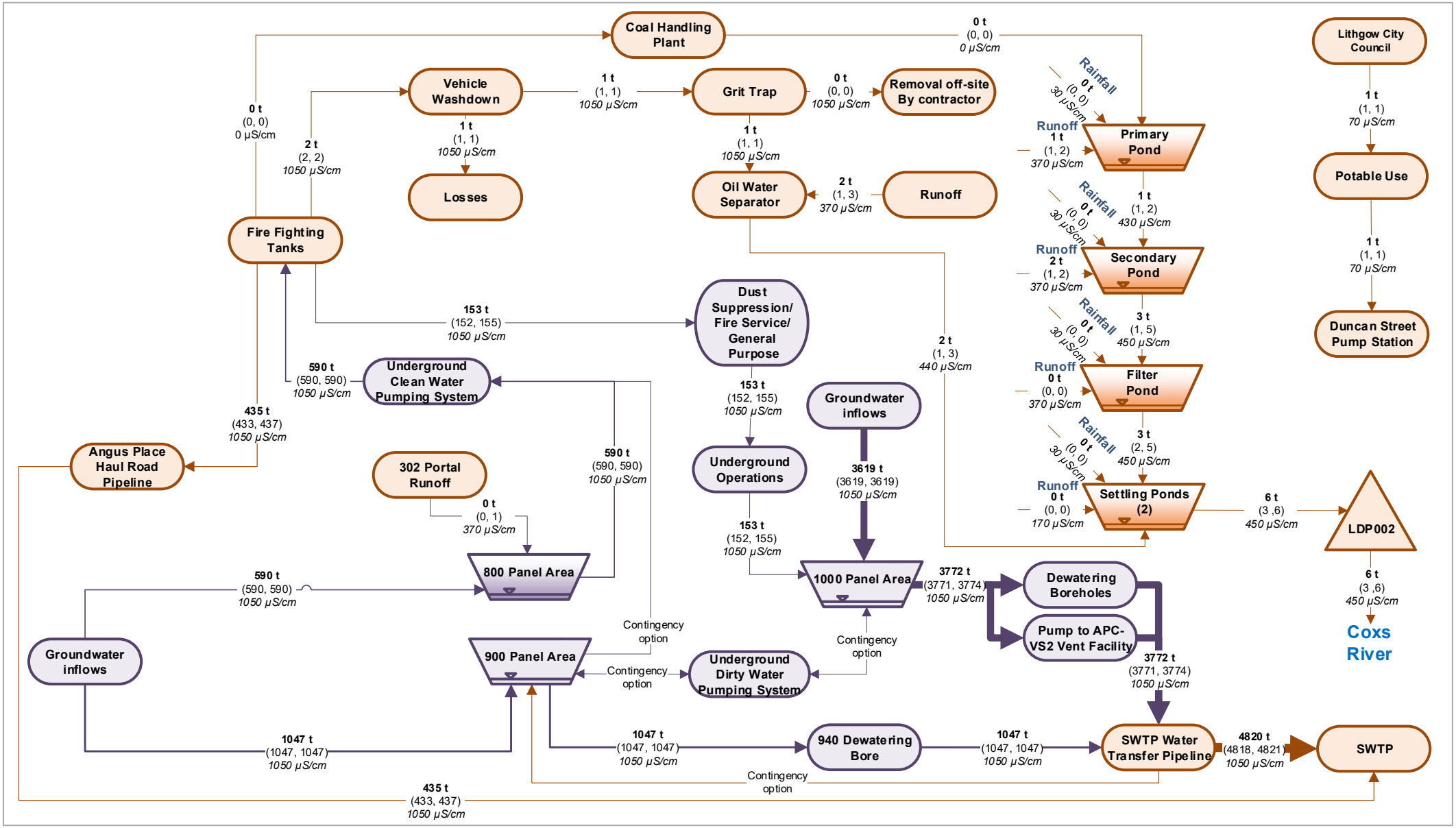

Legend

- Underground storage
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- Surface process
- Licensed discharge point
- Entrained moisture
- Surface water flow
- Groundwater flow
- X •(X,X) XX — Mean (10th percentile, 90th percentile) Mean EC

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Angus Place Mine Extension Project
Site water and salt balance assessment

Water management schematic
Annual salt transfers
Proposed conditions (2027)

Project No. 2220268
Revision No. 0
Date 29/08/2019

FIGURE 6-7

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7. Summary

GHD has prepared the site water and salt balance for the Angus Place Mine Extension Project. The modelling considered existing conditions reflecting that Angus Place Colliery is currently in care and maintenance and is approved to discharge of up to 10 ML/day of treated water via LDP001 until 2020. For the purpose of comparison, proposed conditions associated with the Project were considered relative to a baseline consistent with the null case from the Hydrogeological Model Report (JSB&G 2019) and the cessation of discharges via LDP001 after 2020.

The site water and salt balance considered rainfall, runoff and evaporation, gravity and pumped flows of water and water usage for operational processes at Angus Place Colliery, by means of a computer model implemented in GoldSim. The site water and salt balance model was validated against observed discharge via LDP001 and LDP002.

Water balance modelling indicates that groundwater inflows and dewatering of the underground workings will remain the dominant features of the site water and salt balance at Angus Place Colliery under the Project. Water from the Project will be transferred to the Springvale Water Treatment Project (SWTP) (SSD 7592) via that SWTP Water Transfer Pipeline and the Angus Place Haul Road Pipeline. The transfers are expected to dewater the existing workings so that the underground water storages provide adequate contingency storage and maintain the proposed underground workings in a dewatered state throughout the life of the Project.

No changes to water management of the Angus Place Colliery pit top are expected as a result of the Project, including no change to discharges via the rainfall based discharge point of LDP002. No discharge of mine water from Angus Place Colliery is expected to be required over the life of the Project.

The modelling undertaken for this assessment does not consider the potential effects of climate change. With respect to groundwater: the Hydrogeological Model Report (JBS&G 2019) concludes that there is limited influence of climate on model predictions, and therefore the potential impacts of the Project with respect to groundwater inflows and dewatering requirements are not expected to be sensitive to climate change. No change to the water management of the pit top, including discharges via LDP002, are expected as a result of the Project, and therefore the potential impacts of the Project with respect to rainfall based discharges are not expected to be sensitive to climate change.

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Document Status

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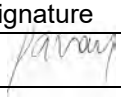
0	T Tinkler	A Wyatt		S Gray		30/8/19

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Appendix E. Springvale Angus Place Swamp Water Balance Model Report

Centennial Angus Place Pty Ltd

Angus Place Mine Extension Project (SSD 06_0021): Amendment Report
Swamp Water Balance Model Report

18 October 2019

JBS&G56421-123002/R02Rev1-SW

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Angus Place Mine Extension Project (SSD 06_0021): Amendment Report
Swamp Water Balance Model Report

18 October 2019

JBS&G56421-123002/R02Rev1-SW

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Appendices

Appendix A Mine Schedule

Appendix B Calibration Parameters

Nomenclature

The following nomenclature has been adopted in this report when describing the magnitude of changes (numerical) due to the Amended Project.

Table NM-1: Definition of Magnitude of Change (Numerical)

Term	Definition
Negligible	change 0 to <2%, that is, no different from background levels
Minor	change is 3 to 5%
Moderate	change is 5 to 15%
Large	change is >15%

EXECUTIVE SUMMARY

The Springvale Angus Place Swamp Water Balance Model (SAPSWBM) was constructed to assess the changes to surface water flow due to mining-induced changes to groundwater contribution to surface water through changes to direct groundwater/surface water interaction or through changes indirectly to outflow from groundwater seepage faces.

Modelling was undertaken using a Proposed Case and a Null Case to assess the change due to the Amended Project on Temperate Highland Peat Swamps on Sandstone (THPSS) (which comprise the Newnes Plateau Shrub Swamp and Newnes Plateau Hanging Swamp listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth)).

Stochastic output from the groundwater model was used as input to the SAPSWMB in order to consider a plausible range of model results. Accordingly, 10th percentile and 90th percentile results (referred to in the report as U10 and U90 results) are presented in this report.

Modelling indicates that the Amended Project is likely to lead to a decrease in flow in Tri-Star, Twin Gully, Birds Rock and Trail Six Swamps. In Wolgan River Swamp and Wolgan River Swamp Upper Swamp, modelling indicates a decrease in flow is also expected, but this is less significant because the existing flow rate in the Wolgan River is higher than that found in the other THPSS. Modelling indicates that there should be negligible change to flow in Crocodile Swamp.

In Tri-Star Swamp, the modelled change ranges between a 2% decrease (negligible change) up to a 23% decrease (large decrease). In Twin Gully Swamp, the modelled change ranges between a 7% increase (moderate increase) and a 7% decrease (moderate decrease). In Birds Rock Swamp, the modelled change ranges between 0% increase (negligible increase) and a 13% decrease (moderate decrease). In Crocodile Swamp, the modelled change ranges between a 5% increase (moderate increase) and a 1% decrease (negligible decrease). In Trail Six Swamp, the modelled change ranges between a 5% increase (minor increase) and a 11% decrease (moderate decrease).

The magnitude of flow in THPSS, with the exception of Wolgan River Swamp and Wolgan River Swamp Upper Swamp, is considered to be low with median modelled flow in the order of 0.2ML/d to 0.4ML/d. Accordingly, although the magnitude of change to groundwater contribution to surface water flow is minor to moderate, the relative change is large in those THPSS.

Of note is that modelled changes continue beyond the end of mine life in 2053.

Glossary

AWBM – Australian Water Balance Model; a rainfall/runoff model

GoldSIM – an industry standard water balance modelling platform

IESC – Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development within the Department of Environment and Energy, Commonwealth of Australia

MODFLOW-USG – Groundwater modelling code of the United States Geological Survey; the Unstructured Grid variant.

NARCliM – New South Wales and Australian Capital Territory Regional Climate Modelling Project.

Null Case – mining does not proceed into the 1000 Panel Area.

NULL_u90 dataset – output from groundwater model uncertainty analysis associated with the Null Case, consistent with the 90th percentile difference (referred to as U90 results in the report) in seepage flows and groundwater/surface water interaction between the Proposed and Null Case simulations.

NULL_u10 dataset – output from groundwater model uncertainty analysis associated with the Null Case, consistent with the 10th percentile (referred to as U10 results in the report) difference in seepage flows and groundwater/surface water interaction between the Proposed and Null Case simulations.

Proposed Case – extension of mining at Angus Place Colliery into the 1000 Panel Area.

PROP_u90 dataset – output from groundwater model uncertainty analysis associated with the Proposed Case, consistent with the 90th percentile (referred to as U90 results in the report) difference in seepage flows and groundwater/surface water interaction between the Proposed and Null Case simulations.

PROP_u10 dataset – output from groundwater model uncertainty analysis associated with the Proposed Case, consistent with the 10th percentile (referred to as U10 results in the report) difference in seepage flows and groundwater/surface water interaction between the Proposed and Null Case simulations.

RWQIAM – Regional Water Quality Impact Assessment Model; initially presented in RPS (2014), with subsequent updates in Jacobs (2015) and JBS&G (2018).

SAPSWBM – Springvale Angus Place Swamp Water Balance Model; a surface water model that is presented in this report.

SILO Climatic Dataset - it is maintained by the Science and Technology Division of the Queensland Department of Environment and Science. The rainfall and evaporation data of the SILO climatic dataset is used in this report.

THPSS – Temperate Highland Peat Swamps on Sandstone

1. Introduction

This chapter presents the context, objective and layout of the report.

1.1 Project Context

Angus Place Colliery is an existing underground coal mine located northwest of Lithgow, NSW with approval to produce up to 4 million tonnes per annum (Mtpa) of run-of-mine (ROM) high quality thermal coal for domestic marks, including the Mount Piper Power Station which produces about 15% of the total electricity generated in New South Wales (NSW).

Angus Place Colliery is currently on Care and Maintenance and has been since March 2015. Development consent for Angus Place Colliery (SSD 06_0021) will expire in August 2024.

The mine is located 15 kilometres (km) to the northwest of the regional city of Lithgow and is 120 km west northwest of Sydney in NSW.

The Angus Place Colliery Pit Top is situated at the foot of the Newnes Plateau and mining occurs beneath the plateau in the Lithgow Seam, which outcrops in the vicinity. The generalised dip of the Lithgow Seam is to the northeast under a gradient of about 2 to 3 degrees.

Angus Place Colliery is owned by Centennial Springvale Pty Limited (50%) and Springvale SK Kores Pty Limited (50%) as participants in the Springvale unincorporated joint venture. Angus Place Colliery is operated by Centennial Angus Place Pty Limited (Centennial Angus Place).

1.2 Angus Place Mine Extension Project: Amended Project

A swamp water balance model has been developed to support the Angus Place Mine Extension Project (SSD 5581) Amendment Report. The elements of the Amended Project of relevance to the swamp water balance report, because of changes to the groundwater model, are as follows:

- An updated mine plan comprising 15 longwalls (LW1001 – LW1015) of varying lengths but all with void widths of 360 m and 55 m chain pillar widths
- Extraction heights of:
  - 2.8 m to 3.4 m for LW1001 – LW1008
  - 1.9 m to 2.5 m for LW1009 – LW1015
- Development of roadways between the Angus Place LW900W area to Springvale Mine mains headings
- Coal production rate of 4.5 Mtpa.

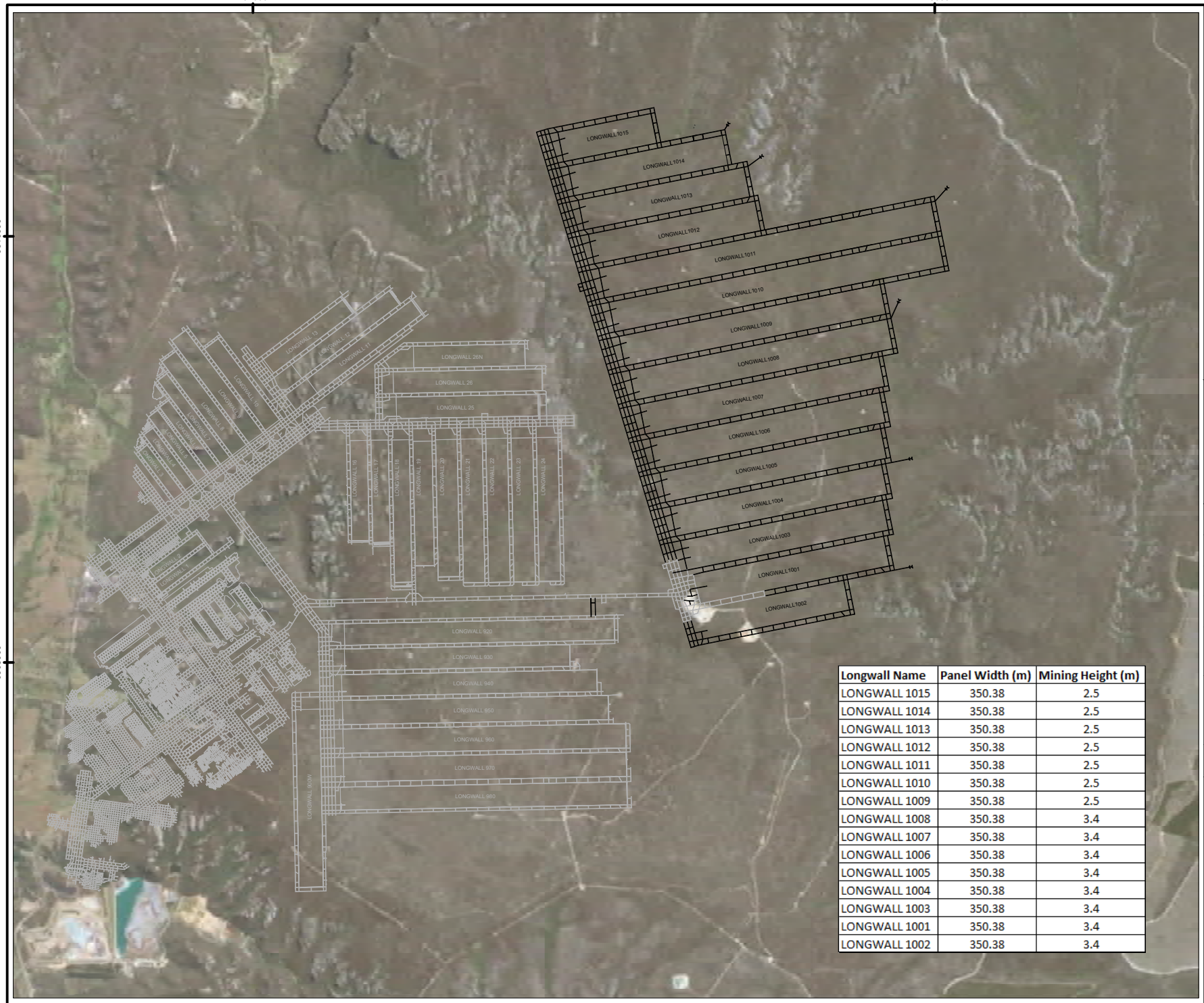
Figure 1.1 presents the layout of mining at Angus Place Colliery, including the panel widths and mine heights. The Mine Schedule, as implemented in the groundwater model, is presented in **Appendix A**.

1.3 IESC Comments on the Angus Place Mine Extension Project

The Angus Place Mine Extension Project received a series of comments from the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mine Development (IESC) on the groundwater model prepared at that time (IESC, 2014).

Comments received from the IESC were as follows:

- Relevant data and information:
  - Requirement to characterise existing surface water, groundwater and ecological conditions for the majority of Temperate Highland Peat Swamps on Sandstone (THPSS) (*IESC01*)



Longwall Name	Panel Width (m)	Mining Height (m)
LONGWALL 1015	350.38	2.5
LONGWALL 1014	350.38	2.5
LONGWALL 1013	350.38	2.5
LONGWALL 1012	350.38	2.5
LONGWALL 1011	350.38	2.5
LONGWALL 1010	350.38	2.5
LONGWALL 1009	350.38	2.5
LONGWALL 1008	350.38	3.4
LONGWALL 1007	350.38	3.4
LONGWALL 1006	350.38	3.4
LONGWALL 1005	350.38	3.4
LONGWALL 1004	350.38	3.4
LONGWALL 1003	350.38	3.4
LONGWALL 1001	350.38	3.4
LONGWALL 1002	350.38	3.4

Legend:

Angus Place Proposed Extension

Angus Place Existing Mine



JBS&G

Job No: 56421

Client: Centennial Angus Place Pty Ltd

Version: R02Rev1 | Date: 17-Oct-2019

Drawn By: JZ | Checked By: JB

Scale 1:60,000

0 1 2

km

Coor. Sys. GDA 1994 MGA Zone 56

Site Location and Longwall Layout

FIGURE: 1.1

File Name: N:\Projects\CentennialCoal\AngusPlaceColliery\56421_AngusPlaceMineExtensionProject\Figures\GIS\Delivery\Maps\R02Rev1_GW\R02Rev1_D000_LWLayout.mxd
Reference: Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

- Seasonal surface water flow and an assessment, or estimation, of the baseflow component of the Coxs River (*IESC02*).

- Application of appropriate methods:
  - Inclusion of all swamps in the groundwater model (*IESC03*)
  - Finer scaled, site specific models, informed by a conceptualisation of the hydrology and hydrogeology, would be needed to have confidence in the predictions of groundwater impacts to individual swamps (*IESC04*)
  - Water quality impact estimations for the Coxs River need to consider the increased discharge volumes to Coxs River resulting from reduced demand from the Wallerawang Power Station (*IESC05*).

- Reasonable values and parameters in calculation:
  - Confidence in groundwater model predictions is limited by a lack of site-specific hydrogeological data and lineament groundwater flow behaviour (*IESC06*).

A response to the comments received from the IESC was provided in RPS (2014b). As well, the issues raised were taken into consideration during the development of the new groundwater and swamp water balance models.

An updated response to matters raised by the IESC are provided in **Section 5.2**.

1.4 Water Management Strategy

1.4.1 Current Approach

Angus Place Colliery is currently operating under Care and Maintenance.

A significant volume of water is currently stored underground at Angus Place Colliery in the 800 and the 900 Panel Area. Water stored in the 900 Panel Area is currently being dissipated through the temporary Angus Place Water Treatment Project (Modification 5 to Angus Place Colliery's project approval (PA 06_0021), now development consent (SSD 06_0021)) with discharge of treated groundwater (treated to 350µS/cm) at a rate up to 10ML/d through Angus Place Licensed Discharge Point 001 (LDP001) to the Coxs River catchment until 31 December 2019. Residuals from the temporary Angus Place Water Treatment Project (as approved) are being diverted to the 800 Panel Area until 31 December 2019. The current stored volume in the 800 Panel Area is being maintained until 31 December 2019.

As presented in JBS&G (2018), from 1 January 2020, discharge from LDP001 will cease and groundwater will be transferred to the Springvale Water Treatment Project for treatment and beneficial re-use within the Mount Piper Power Station cooling water system. From 1 January 2020, dewatering of the 800 Panel Area will commence with transfer to the Springvale Water Treatment Project. That transfer from the 800 Panel Area will include transfer of residuals.

1.4.2 Future Changes

With the extension of Angus Place Colliery into the 1000 Panel Area (this Project), groundwater will continue to be transferred to the Springvale Water Treatment Project for subsequent beneficial re-use at the Mount Piper Power Station.

1.5 Purpose and Objective of the Report

This report presents outcomes of a swamp water balance model that has been prepared to support the Surface Water Impact Assessment being prepared for the Angus Place Mine Extension Project: Amended Project. Accordingly, this report comprises a technical report on the outcomes of modelling and reference is made to the Impact Assessment for details in that regard.

It is noted that a separate, numerical groundwater model has also been prepared for the Angus Place Mine Extension Project: Amended Project and is presented concurrently with this report (this document), but under separate cover.

1.6 Layout of the Report

In the context of the project purpose and objectives, the layout of the report (this document) is as follows:

- Chapter 1 – presents the objective of this report and the layout of the report
- Chapter 2 – notes the limitations of the analysis and the report
- Chapter 3 – presents a brief summary of the hydrological and environmental setting
- Chapter 4 – presents detailed discussion of the swamp water balance, including results
- Chapter 5 – provides conclusions from the analysis
- Chapter 6 – presents relevant references.

2. Limitations

This report has been prepared for use by the client who has commissioned the works in accordance with the project brief only, and has been based in part on information obtained from the client and other parties.

The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental impact assessment, before being used for any other purpose.

JBS&G accepts no liability for use or interpretation by any person or body other than the client who commissioned the works. This report should not be reproduced without prior approval by the client, or amended in any way without prior approval by JBS&G, and should not be relied upon by other parties, who should make their own enquires.

This report does not provide a complete assessment of the environmental status of the site, and it is limited to the scope defined herein. Should information become available regarding conditions at the site including previously unknown issues, JBS&G reserves the right to review the report in the context of the additional information.

3. Hydrological Setting

This chapter provides a brief overview of the hydrological and environmental setting of the project at Angus Place Mine Extension Project.

3.1 Overview

Angus Place Colliery is located in the Western Coalfields of NSW, to the northwest of Lithgow.

Mining occurs at Angus Place Colliery in the Lithgow Seam, which is accessed from the Wolgan Road at Lidsdale at the foot of the Newnes Plateau.

Angus Place Colliery is overlain by the Newnes Plateau. The Newnes Plateau is a surface topographical feature that divides the surface water catchments into the Coxs River (west, southwest), Wolgan River (north) and Bungleboori Creek (east).

Figure 3.1 presents the Digital Elevation Model for the region.

It is noted that the blue outline in **Figure 3.1** encompasses the model domain of the Springvale Angus Place Swamp Water Balance Model (SAPSWBM).

3.2 Rainfall and Evaporation

Rainfall and evaporation data for the region was obtained from the SILO climatic dataset from the Queensland Department of Environment and Science (DES). The gridded dataset (0.05 degrees, equivalent to 5km x 5km cells) was used in the SAPSWBM.

Figure 3.2 presents the distribution of the gridded dataset for rainfall including average annual isohyets for rainfall (mm). **Figure 3.3** presents the equivalent gridded dataset for evaporation.

A summary of average rainfall and evaporation from grid cell H7, located above the proposed 1000 Panel Area, is presented in **Table 3.1**.

Table 3.1: Rainfall and Evaporation Monthly Average for Cell H7 (mm)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Rainfall Mean	89.3	86.9	79.1	57.9	54.7	60.9	55.3	55.6	52.0	65.4	73.0	76.8	807.0
Evaporation Mean	147.1	116.3	101.7	68.9	47.0	32.8	37.5	52.3	75.2	106.0	124.9	146.6	1056.4

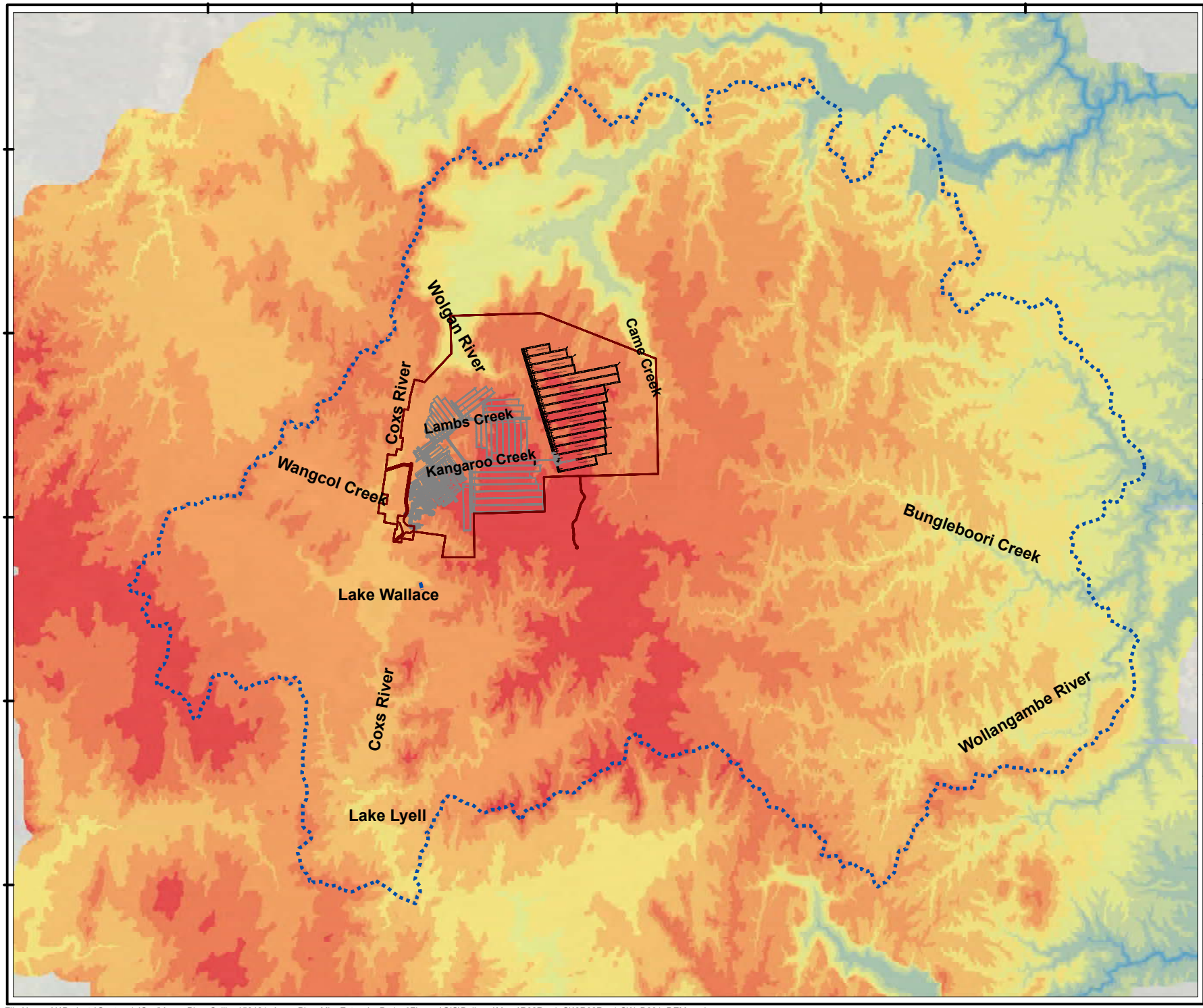
For future predictions using the swamp water balance model, data from the New South Wales and Australian Capital Territory Regional Climate Modelling Project (NARCliM) was accessed.

Of the models available, after adaptation to the SILO grid presented above:

- 'Average' Climate conditions were represented by the ECHAM5_R3 model
- 'Lowest Cumulative Rainfall, Higher Cumulative Evaporation' conditions were represented by the CSIRO-MK3.0_R1 model
- 'Highest Cumulative Rainfall, Lower Cumulative Evaporation' conditions were represented by the MIROC3.2_R2 model.

It is noted that the evaporation outcomes were derived based on mean near-surface temperature derived from NARCliM and all models were found to be quite similar. The largest divergence between climate models was with respect to cumulative rainfall, hence the highest and lowest cumulative rainfall was used to select the model to adopt.

It is highlighted that the abovementioned approach is consistent with the advice from the NARCLiM project, which was to select the climate model based on the expected risk of climate change to the project. For the swamp water balance, the highest risk is a decline in cumulative rainfall, which in turn would lead to a decrease in groundwater model input to surface water.



Legend:

- Angus Place Project Application Area
- Proposed Extension
- Existing Mine
- SAPSWBM Model Boundary

Elevation

- 60 - 200
- 200 - 300
- 300 - 500
- 500 - 600
- 600 - 700
- 700 - 800
- 800 - 900
- 900 - 1,000
- 1,000 - 1,100
- 1,100- 1,300

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Job No: 56421	
Client: Centennial Angus Place Pty Ltd	
Version: R02Rev1	Date: 03-Sep-2019
Drawn By: JZ	Checked By: JB

Scale 1:250,000

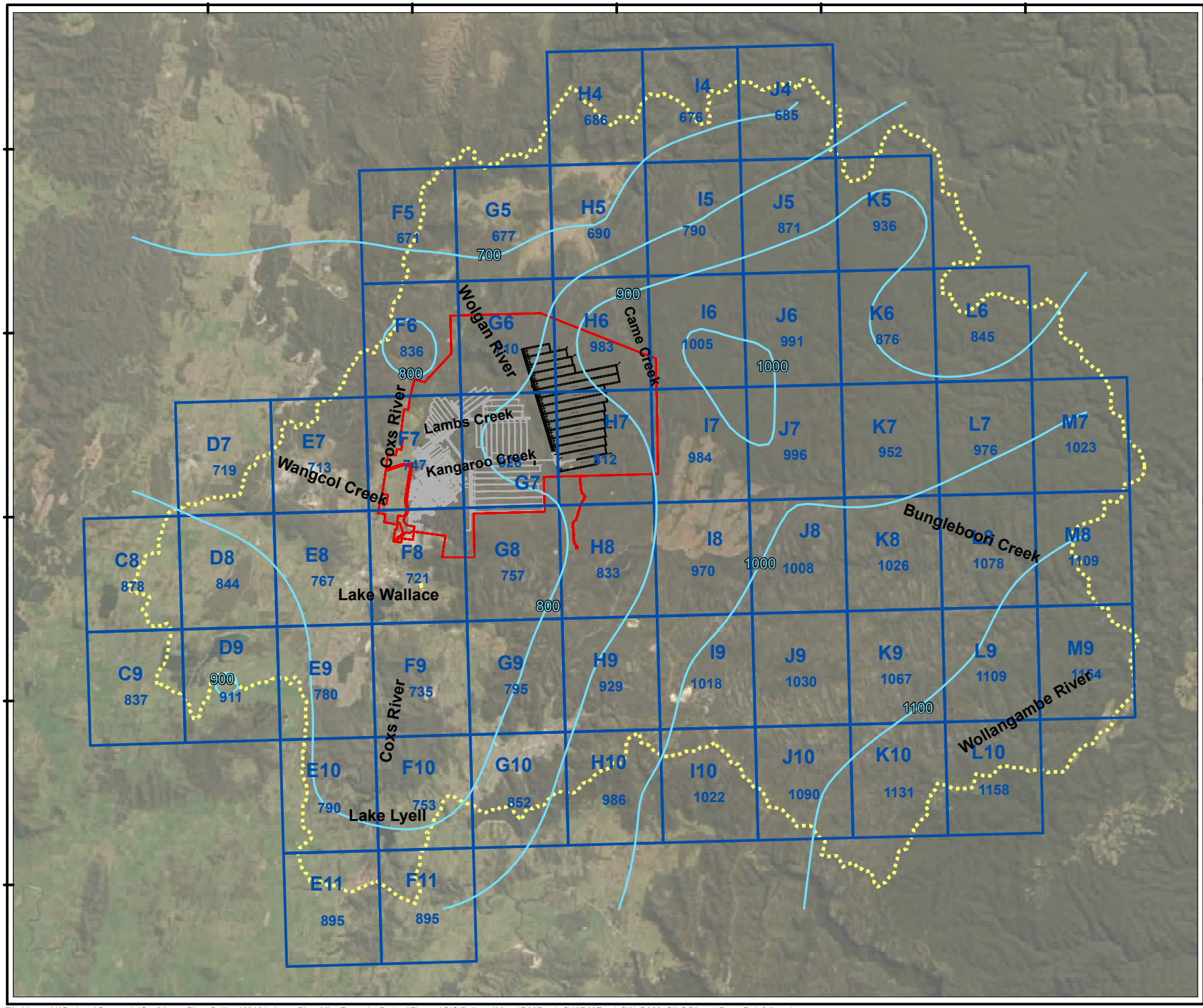
0 5 10
km

Coor. Sys. GDA 1994 MGA Zone 56

Digital Elevation Model - Region

FIGURE: 3.1

File Name: N:\Projects\CentennialCoal\AngusPlaceColliery\56421_AngusPlaceMineExtensionProject\Figures\GIS\Delivery\Maps\R02Rev1_SW\R02Rev1-SW_D001_DEM.mxd
Reference: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend:

- Angus Place Project Application Area
- Proposed Extension
- Existing Mine
- SAPSWBM Model Boundary
- SILO Gridded Climatic Dataset Average Annual Rainfall Value (mm)
- Isohyets of Annual Average Rainfall (mm)

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Scale 1:250,000

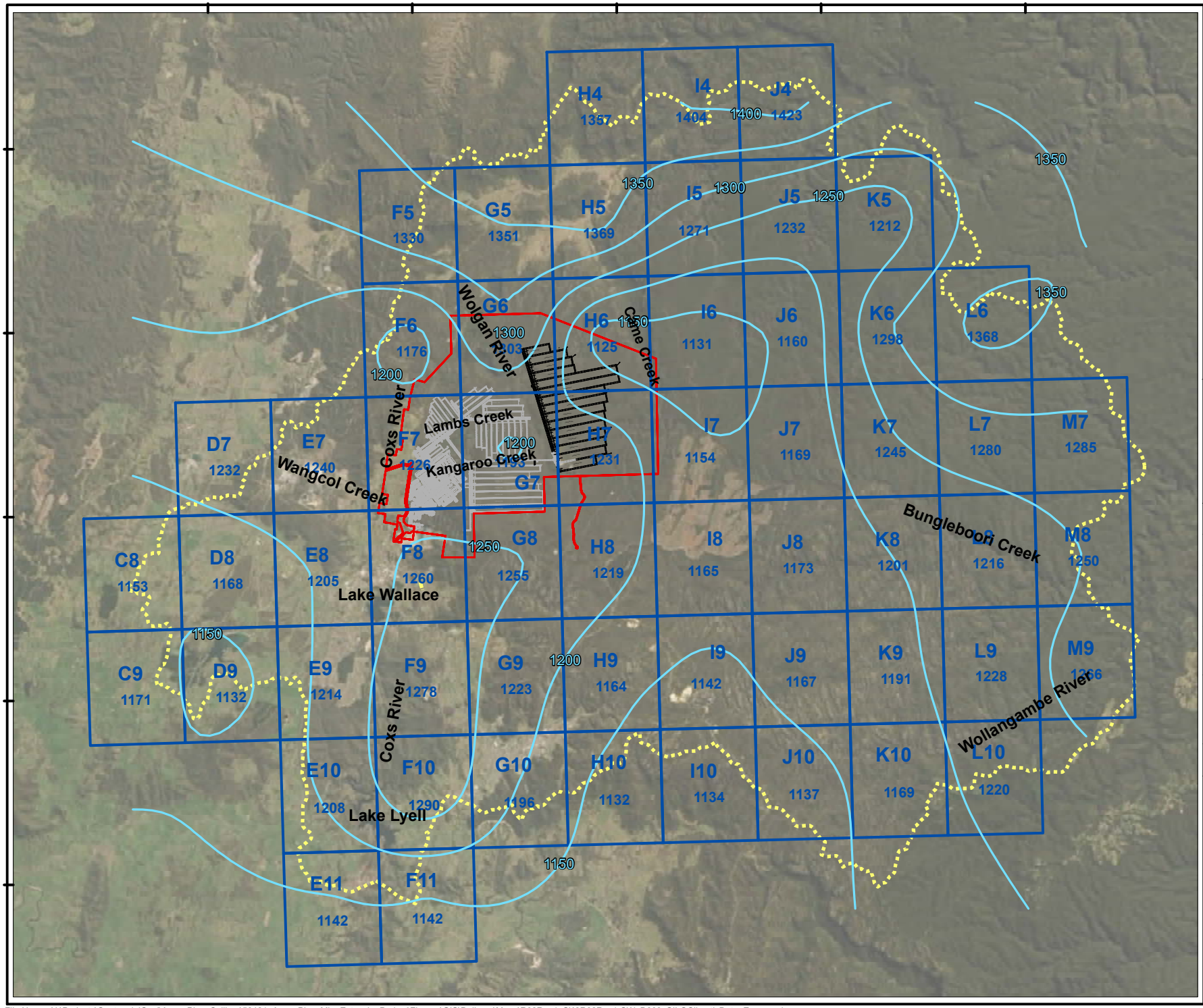
0 5 10
km

Coor. Sys. GDA 1994 MGA Zone 56

SILO Gridded Rainfall Dataset

FIGURE: 3.2

File Name: N:\Projects\CentennialCoal\AngusPlaceColliery\56421_AngusPlaceMineExtensionProject\Figures\GIS\Delivery\Maps\R02Rev1_SW\R02Rev1-SW_D002_SILOClimaticData_Rainfall.mxd
Reference: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend:

- Angus Place Project Application Area
- Proposed Extension
- Existing Mine
- SAPSWBM Model Boundary
- SILO Gridded Climatic Dataset Average Annual Evaporation Value (mm)
- Isohyets of Annual Average Evaporation (mm)

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Drawn By: JZ	Checked By: JB

Scale 1:250,000

0 5 10
km

Coor. Sys. GDA 1994 MGA Zone 56

SILO Gridded Evaporation Dataset

FIGURE: 3.3

File Name: N:\Projects\CentennialCoal\AngusPlaceColliery\56421_AngusPlaceMineExtensionProject\Figures\GIS\Delivery\Maps\R02Rev1_SW\R02Rev1-SW_D003_SILOClimaticData_Evap.mxd
Reference: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

3.3 Groundwater Dependent Ecosystems

The focus of the swamp water balance model is the THPSS that reside on the Newnes Plateau.

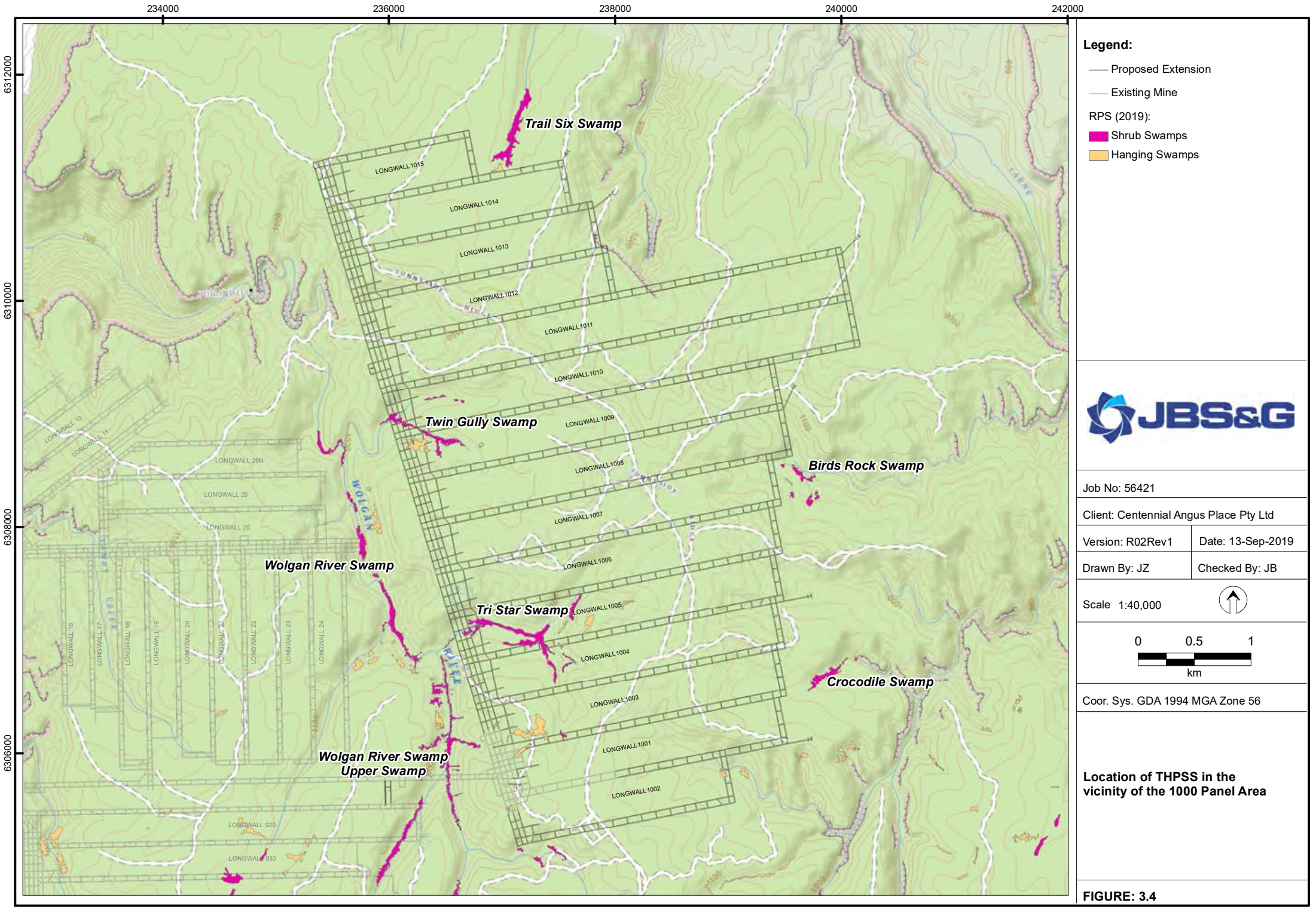
The shrub swamps that are located within 600m of the boundary of the 1000 Panel Area include:

- Wolgan River Swamp Upper Swamp
- Tri-Star Swamp
- Wolgan River Swamp
- Twin Gully
- Crocodile Swamp
- Birds Rock Swamp
- Trail Six/Japan Swamp

It is noted that only Twin Gully and Tri-Star Swamp will be undermined.

It is noted that the order of presentation of results from the swamp water balance model is, generally, from south to north, which is consistent with direction of mine progression.

Figure 3.4 presents the location of the THPSS with respect to proposed extension at Angus Place Colliery. It is noted that the mapped extent of THPSS is based on RPS (2019), rather than DEC (2006).



Legend:

- Proposed Extension
- Existing Mine

RPS (2019):

- Shrub Swamps
- Hanging Swamps

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Job No: 56421

Client: Centennial Angus Place Pty Ltd

Version: R02Rev1	Date: 13-Sep-2019
Drawn By: JZ	Checked By: JB

Scale 1:40,000

0 0.5 1
km

Coor. Sys. GDA 1994 MGA Zone 56

Location of THPSS in the vicinity of the 1000 Panel Area

FIGURE: 3.4

File Name: N:\Projects\CentennialCoal\AngusPlaceColliery\56421_AngusPlaceMineExtensionProject\Figures\GIS\Delivery\Maps\R02Rev1_SW\R02Rev1-SW_D004_Swamps.mxd
Reference: © Department of Finance, Services & Innovation 2018

4. Numerical Analysis

This chapter presents the model objectives, model setup, model calibration and model results incorporating predictive uncertainty.

4.1 Model Objectives

The objectives of the swamp water balance model were as follows:

- prepare water balance for swamp areas which account for daily time-series change to climatic inputs
- incorporate groundwater contribution derived from the numerical groundwater model to resolve the disparity between surface water-only and groundwater-only model approaches
- analyse the magnitude of mining-induced changes on surface water flow in THPSS and the contribution of surface water to the Upper Coxs River and potential for reduction in catchment yield as a result of mining subsidence.

4.2 Model Approach and Code

The SAPSWBM was prepared in GoldSIM, Version 12.1.3 and is based on the Australian Water Balance Model (AWBM) (Boughton, 2010).

The approach to the SAPSWBM synthesises two models that were previously presented using GoldSIM/AWBM, building upon the conclusions of previous work as described below.

4.2.1 Regional Water Quality Impact Assessment Model (RWQIAM)

The RWQIAM was previously prepared for Springvale Mine and Angus Place Colliery. That model, the RWQIAM, was constructed for the purpose of assessing impacts of mine water discharge from Springvale Mine and Angus Place Colliery on the Coxs River. The model was first presented by RPS (2014) during the Response to Submissions on the Springvale Mine Extension Project EIS and was subsequently updated (Jacobs, 2015 and JBS&G, 2018).

The approach adopted in the RWQIAM consisted use of the AWBM as a module within GoldSIM. That AWBM module was then applied, in a spatially distributed manner, reflecting different rainfall/evaporation regions (based on the SILO climatic dataset), as well as land-use types, through delineation into multiple subcatchments. As discussed in RPS (2014), Boughton (2010) identified that spatial distribution of rainfall appeared to be the most important factor in improving calibration of the AWBM for use in ungauged catchments. In addition, the version developed by JBS&G (2018) incorporated a simple surface catchment salt store methodology.

The RWIQAM also includes the storage reservoirs in the Coxs River that comprise the water supply scheme to Wallerawang Power Station (now decommissioned) and Mount Piper Power Station. Those reservoirs included Lake Wallace and Lake Lyell, as well as Thompsons Creek Reservoir. Also included in that model is the Sawyers Swamp Creek Ash Dam. Long term monitoring (flow and salinity) is also available in the Coxs River catchment and was retained in applicable catchments.

4.2.2 Stage 1 Hydrological Model of Shrub Swamps

The model was prepared in 2016 in response to the requirements of the Conditions of Consent (Water Management Plan of the Extraction Plan for LW420-422) for Springvale Mine and focussed on the water balance of THPSS. The GoldSIM/AWBM approach that was developed was not able to adequately represent the behaviour observed at Gang Gang Swamp and at Tri-Star Swamp, insofar as a steady, constant flow regime reflective of the expected requirements of the swamp.

The issue was due to the relatively small catchment areas of the THPSS, and, accordingly, regional groundwater contribution (as opposed to interbank storage through the baseflow 'bucket' in AWBM) is significant in that context and was not accounted for using a rainfall/runoff only process.

Several investigative models, including a local MODFLOW-USG model for Gang Gang Swamp were developed, however, it was concluded that the regional groundwater model (which was scheduled to be commenced) was needed to provide input to the GoldSIM/AWBM approach.

An interim interpretation was presented where an assumed groundwater contribution was applied at Gang Gang Swamp and at Tri-Star Swamp and, acknowledging the limited reliability of the flow gauge station at Gang Gang Swamp (and presumably Tri-Star Swamp), the model was then able to emulate the observed flow regime.

4.2.3 Springvale Angus Place Swamp Water Balance Model (SAPSWBM)

The approach to the SAPSWBM comprised extension of the RWQIAM to the northeast and southeast to encompass the Wolgan River and Bungleboori Creek catchments respectively.

The whole RWQIAM extent was not required in the SAPSWBM, hence the catchments from the RWQIAM below Lake Lyell were trimmed from the model.

As will be explained in detail below, the approach to applying the rainfall and evaporation climatic datasets was also changed in the SAPSWBM compared to the RWQIAM and the Stage 1 Hydrological Model of Shrub Swamps, namely that the SAPSWBM used gridded SILO output, so as to match the approach adopted in the groundwater model, rather than patched/infilled individual rainfall and evaporation stations distributed via thiessen polygons.

For future predictions, median rainfall conditions were derived from the NARCliM dataset and used in the prediction simulation period of June 2019 through to 31 December 2061.

For the climate change simulations, presented further below, as noted in **Section 3.2**, the NARCliM dataset was utilised to obtain a 'Lowest Cumulative Rainfall, Higher Cumulative Evaporation' scenario as well as a 'Highest Cumulative Rainfall, Lower Cumulative Evaporation' scenario.

The SAPSWBM also included groundwater contribution obtained from drain (DRN) seepage faces and surface water/groundwater contribution throughout the model domain. Of the 998 catchments in the SAPSWBM, 864 included a groundwater contribution, although not all seepages were actually active from the groundwater model. The groundwater contribution was not dynamically linked to the MODFLOW-USG groundwater model, rather the outcomes of predictive uncertainty analysis from the groundwater model were used as inputs to the SAPSWBM.

As would be expected, the relative magnitude of groundwater contribution in the Coxs River catchment is small compared to standard rainfall/runoff processes represented by the AWBM; however, that groundwater contribution is significant in the Wolgan River, Bungleboori Creek and Marrangaroo Creek catchments which contain the THPSS.

4.3 Model Domain

Figure 4.1 presents the model domain of the SAPSWBM. As noted, the model includes the Coxs River above Lake Lyell, Marrangaroo Creek and the Wolgan River and Bungleboori Creek catchments.

The extent of the domain with respect to the Wolgan River and Bungleboori Creek catchments were informed by the groundwater model domain extent.

4.4 Model Geometry

Figure 4.1 presents the domain of the SAPSWBM. As noted above, there are 998 sub-catchments in the SAPSWBM. Due to a limitation in the groundwater model utility ZonBudUSG.EXE, the original catchment numbers from the RWQIAM (as reported in RPS (2014b), Jacobs (2015) and JBS&G

(2018)) could not be retained and a translation between the two models has been provided where relevant.

Due to the size of the GoldSIM/AWBM model, it has been necessary to split the model into three regions. The first is the western region (Coxs River, including Marrangaroo Creek, Lake Wallace and Lake Lyell); the second is the northeast region (Wolgan River) and the third and final is the southeast region (Bungleboori Creek).

Figure 4.2 presents the layout of the SAPSWBM in the vicinity of Lake Wallace. There is a long-term flow gauging station located immediate upstream of Lake Wallace (DoI:Water Gauge No. 212054; Node 032a; previously Node 047).

Figure 4.3 presents the layout of the SAPSWBM in the vicinity of Wolgan River Swamp Upper Swamp. As noted in **Section 3.3**, the results from the SAPSWBM are presented, generally, from south to north, which is consistent with the direction of mine progression. **Figure 4.4** presents the layout of the SAPSWBM in the vicinity of Tri-Star Swamp. **Figure 4.5** presents the layout of the model at Wolgan River Swamp and **Figure 4.6** presents the layout at Twin Gully Swamp.

Figure 4.7 presents the layout of the SAPSWBM at Crocodile Swamp and **Figure 4.8** presents the layout of the model at Birds Rock Swamp. **Figure 4.9** presents the layout of the model at Trail Six Swamp.

Each of the sub-catchments was assigned a land-use type. As per the approach used in the RWQIAM, different land-use types had slightly different parameter values for the respective AWBM modules.

It is noted that the RWQIAM, and the SAPSWBM, use the clone element function within GoldSIM such that the AWBM modules associated with a particular rainfall/evaporation zone and land-use type can be altered together, rather than needing to make changes to 998 individual sub-catchments.

As will be presented further below, whilst AWBM rainfall/runoff parameters were kept the same for each model region, the catchment salinity parameters were individually tailored to each region.

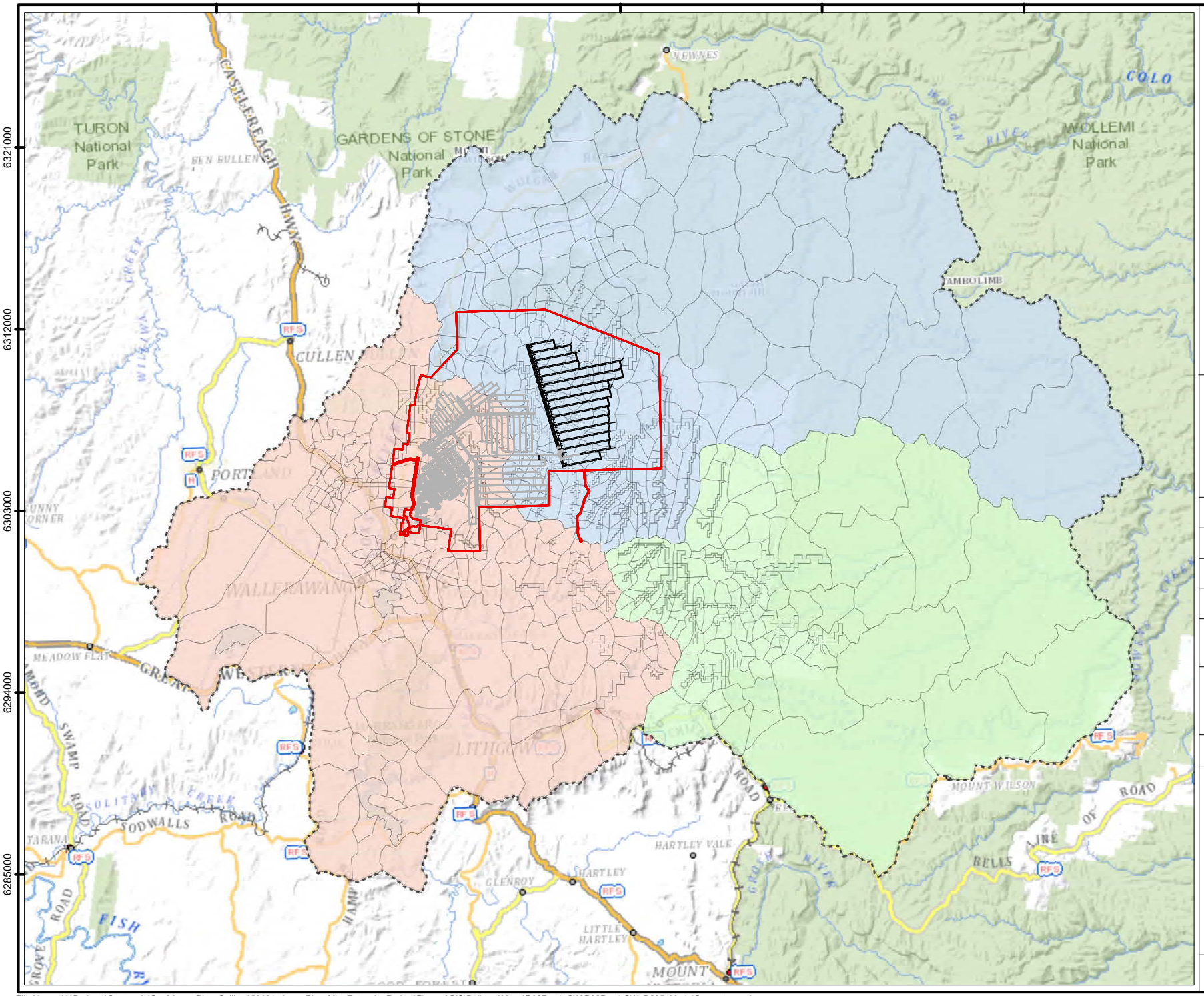
4.5 Model Duration

The duration of simulation of the SAPSWBM was from 1 January 1994 through to 31 December 2061, as a continuous model, rather than as a distinct calibration and prediction phase.

This was a different approach to that adopted in the RWQIAM and Stage 1 Hydrological Model of Shrub Swamps, insofar as a distinct calibration and prediction phase was used in those models.

Whilst not significant, a continuous simulation was required because the groundwater model was constrained by needing a continuous simulation. That was due to the groundwater model needing to solve the Richards Equation and hence, it was not able to be restarted part way through a run.

It is highlighted that the current version of the calibration simulation of the RWQIAM, as reported in JBS&G (2018), commenced on 1 January 1979 and completed on 17 August 2017. The RWQIAM prediction simulation was then 18 August 2017 through to completion of mining associated with the Angus Place Mine Extension Project, in the model set to 31 December 2035.



Legend:

- Angus Place Project Application
- Proposed Extension
- Existing Mine
- SAPSWBM Model Boundary
- Northeast Region - Wolgan River Catchments
- Southeast Region - Bungleboori River Catchments
- Western Region - Coxs River Catchments

JBS&G

Job No: 56421

Client: Centennial Angus Place Pty Ltd

Version: R02Rev1	Date: 11-Sep-2019
Drawn By: JZ	Checked By: JB

Scale 1:250,000

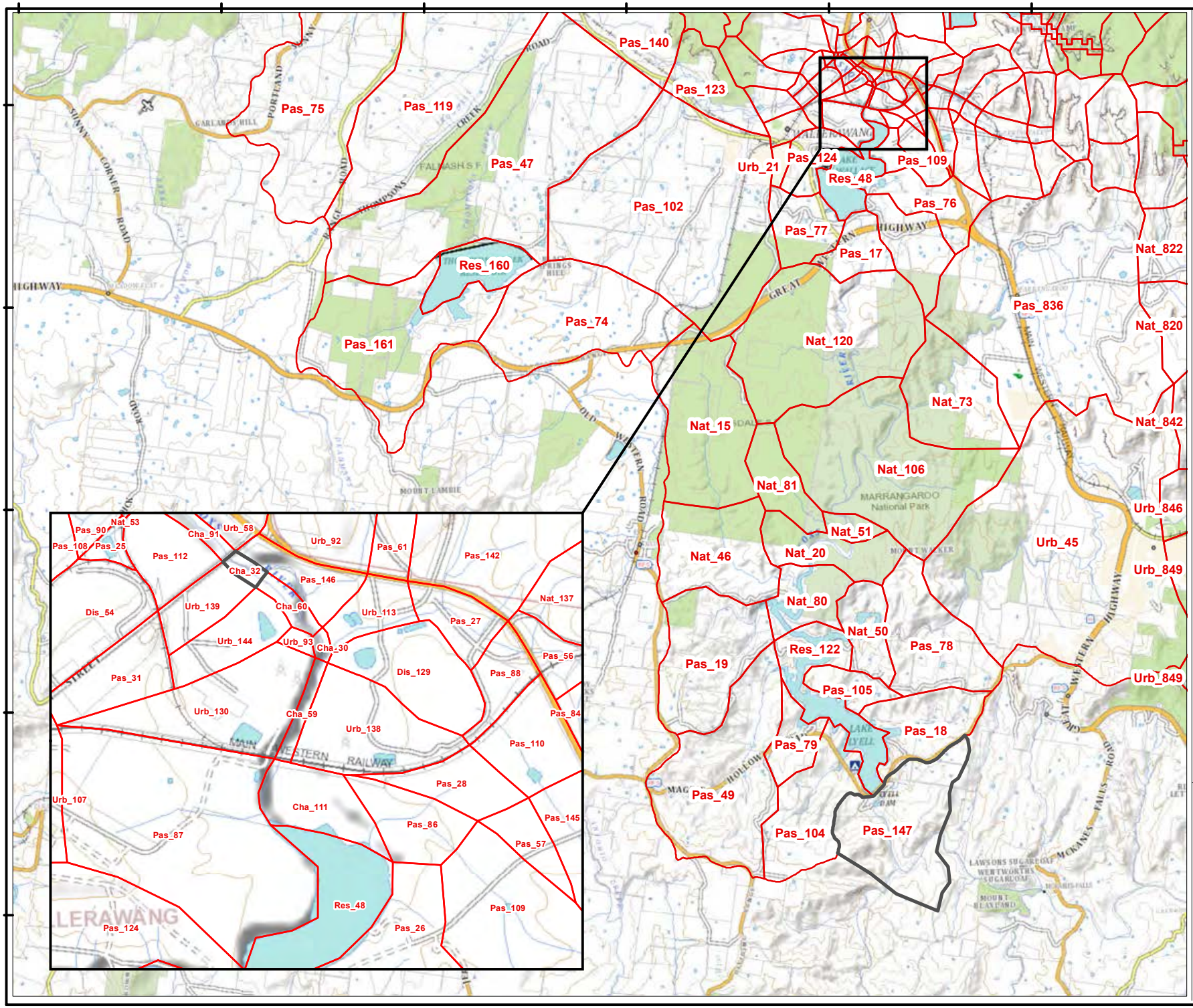
0 5 10
km

Coor. Sys. GDA 1994 MGA Zone 56

SAPSWBM Model Geometry

FIGURE: 4.1

File Name: N:\Projects\CentennialCoal\AngusPlaceColliery\56421_AngusPlaceMineExtensionProject\Figures\GIS\Delivery\Maps\R02Rev1_SW\R02Rev1-SW_D005_ModelGeometry.mxd
Reference: © Department of Finance, Services & Innovation 2018



Legend:

- SAPSWBM Catchments
- Key Calibration Nodes

JBS&G

Job No: 56421

Client: Centennial Angus Place Pty Ltd

Version: R02Rev1	Date: 03-Sep-2019
Drawn By: JZ	Checked By: JB

Scale 1:100,000

0 1,000 2,000

Meters

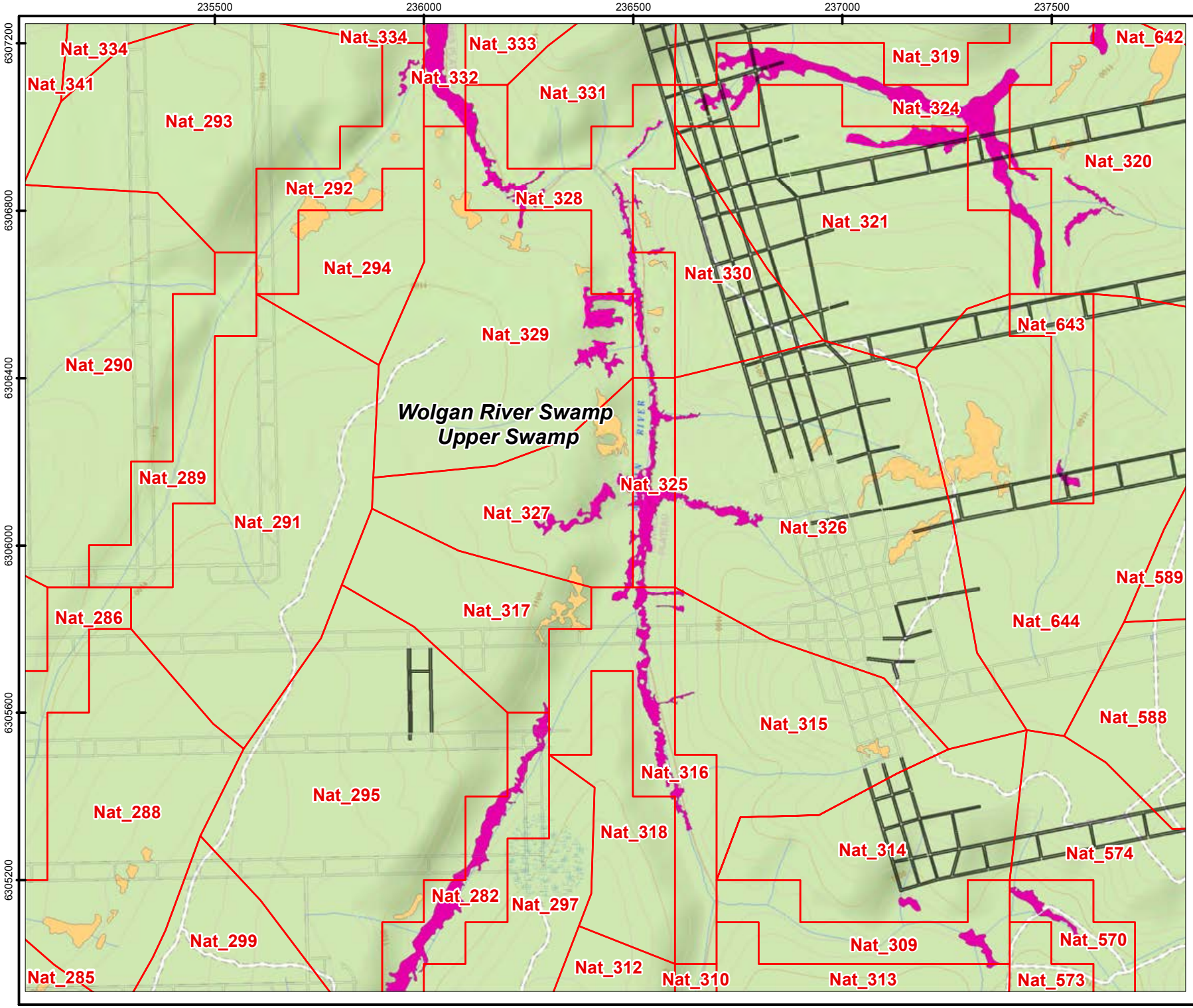
Coor. Sys. GDA 1994 MGA Zone 56

Layout of the SAPSWBM at Lake Wallace

FIGURE: 4.2

File Name: N:\Projects\CentennialCoal\AngusPlaceColliery\56421_AngusPlaceMineExtensionProject\Figures\GIS\Delivery\Maps\R02Rev1_SW\R02Rev1-SW_D006_LakeWallace.mxd

Reference: © Department of Finance, Services & Innovation 2018



Legend:

- SAPSWBM Catchments
- Proposed Extension
- Existing Mine

RPS (2019):

- Shrub Swamps
- Hanging Swamps

JBS&G

Job No: 56421

Client: Centennial Angus Place Pty Ltd

Version: R02Rev1	Date: 13-Sep-2019
Drawn By: JZ	Checked By: JB

Scale 1:12,000

0 100 200 300

Meters

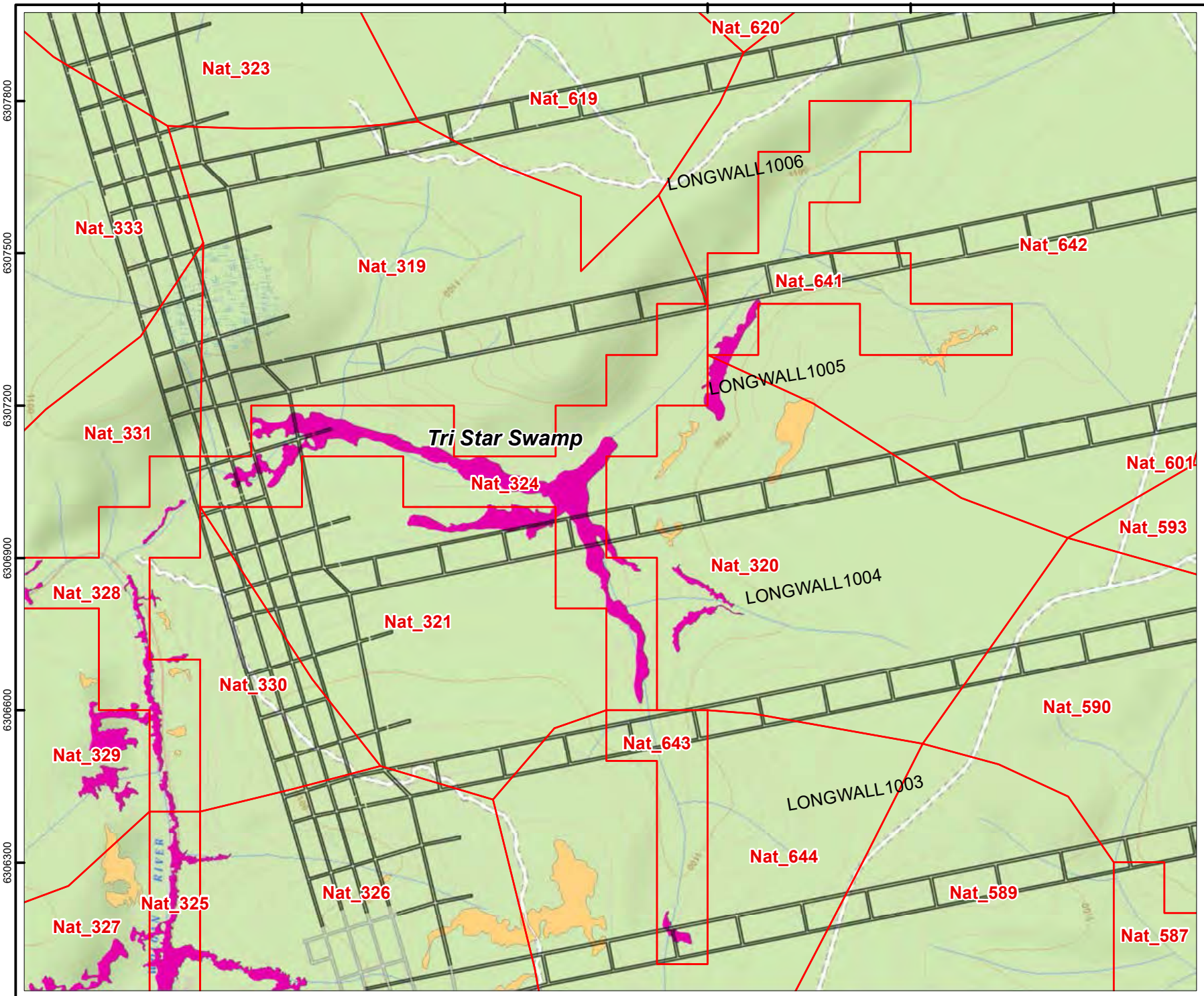
Coor. Sys. GDA 1994 MGA Zone 56

Layout of the SAPSWBM at Wolgan River Swamp Upper Swamp

FIGURE: 4.3

File Name: N:\Projects\CentennialCoal\AngusPlaceColliery\56421_AngusPlaceMineExtensionProject\Figures\GIS\Delivery\Maps\R02Rev1_SW\R02Rev1-SW_D012_WR_Upper.mxd

Reference: © Department of Finance, Services & Innovation 2018



Legend:

- SAPSWBM Catchments
- Proposed Extension
- Existing Mine

RPS (2019):

- Shrub Swamps
- Hanging Swamps

JBS&G

Job No: 56421	
Client: Centennial Angus Place Pty Ltd	
Version: R02Rev1	Date: 13-Sep-2019
Drawn By: JZ	Checked By: JB

Scale 1:10,000

0 100 200 300

Meters

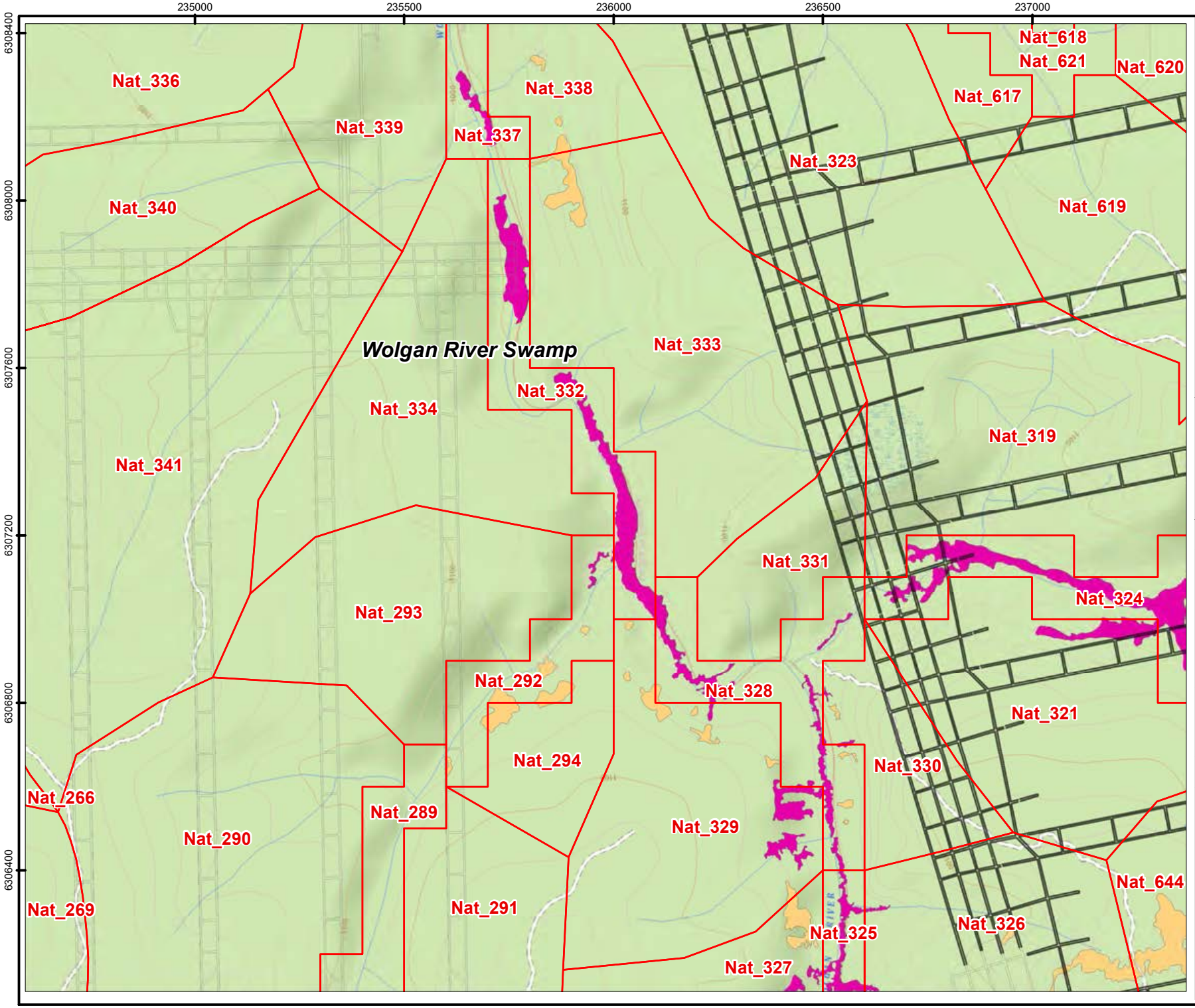
Coor. Sys. GDA 1994 MGA Zone 56

Layout of the SAPSWBM at Tri-Star Swamp

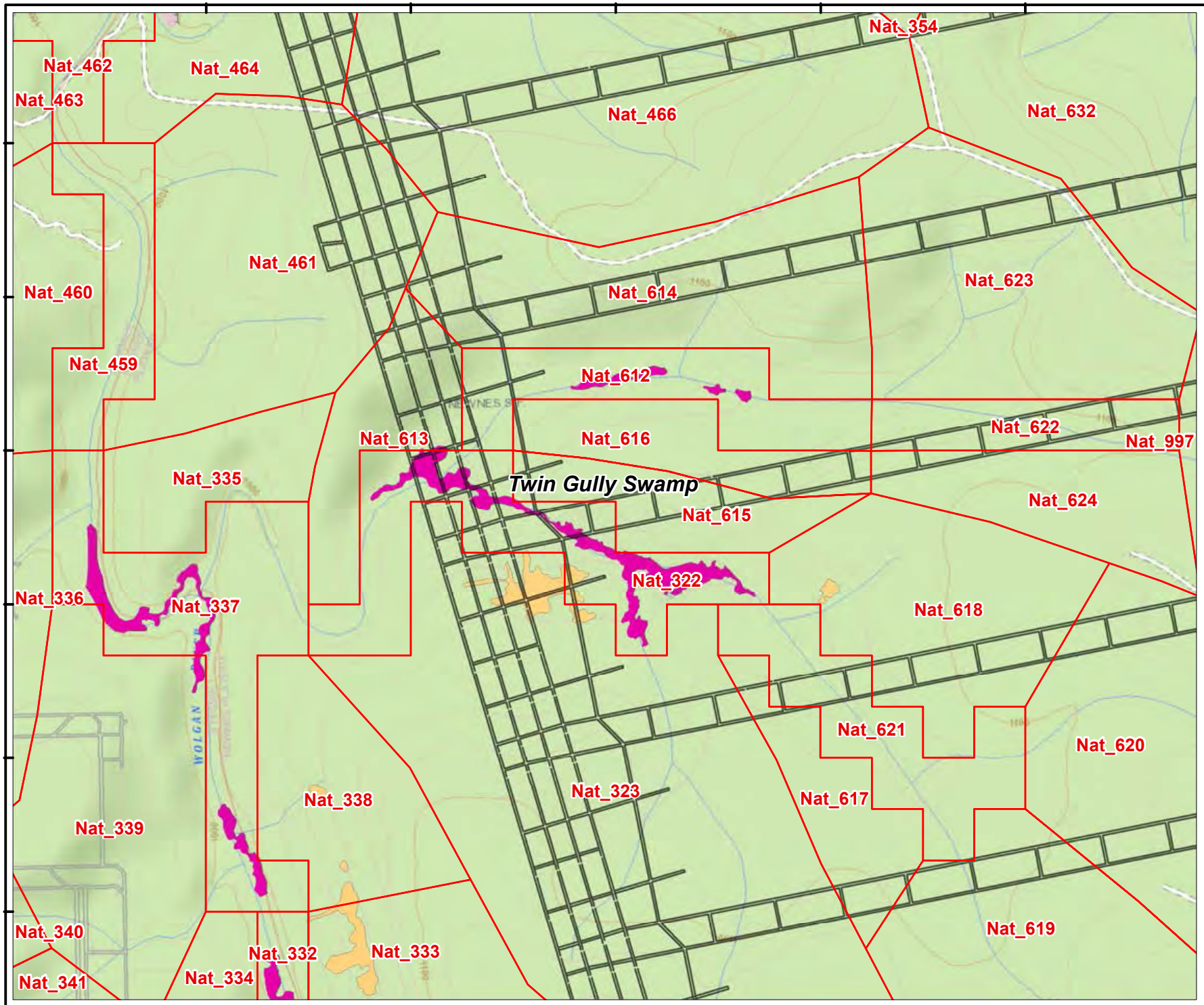
FIGURE: 4.4

File Name: N:\Projects\CentennialCoal\AngusPlaceColliery\56421_AngusPlaceMineExtensionProject\Figures\GIS\Delivery\Maps\R02Rev1_SW\R02Rev1-SW_D007_Tri-Star.mxd

Reference: © Department of Finance, Services & Innovation 2018



File Name: N:\Projects\CentennialCoal\AngusPlaceColliery\56421_AngusPlaceMineExtensionProject\Figures\GIS\Delivery\Maps\R02Rev1_SW\R02Rev1-SW_D013_WRS.mxd
Reference: © Department of Finance, Services & Innovation 2018



Legend:

- SAPSWBM Catchments
- Proposed Extension
- Existing Mine

RPS (2019):

- Shrub Swamps
- Hanging Swamps

JBS&G

Job No: 56421

Client: Centennial Angus Place Pty Ltd

Version: R02Rev1	Date: 13-Sep-2019
Drawn By: JZ	Checked By: JB

Scale 1:10,000

0 100 200 300

Meters

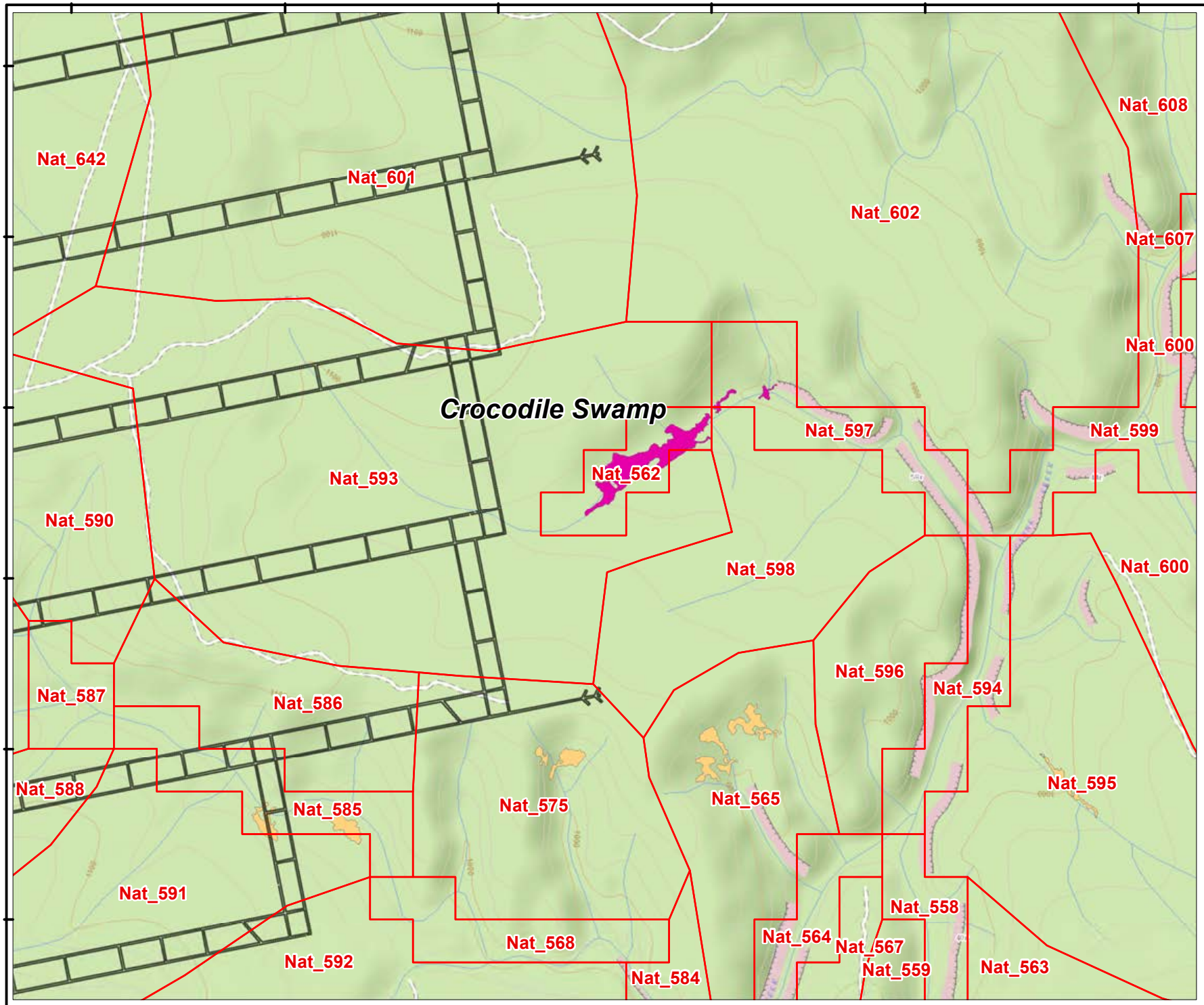
Coor. Sys. GDA 1994 MGA Zone 56

Layout of the SAPSWBM at Twin Gully Swamp

FIGURE: 4.6

File Name: N:\Projects\CentennialCoal\AngusPlaceColliery\56421_AngusPlaceMineExtensionProject\Figures\GIS\Delivery\Maps\R02Rev1_SW\R02Rev1-SW_D008_TwinGully.mxd

Reference: © Department of Finance, Services & Innovation 2018



Legend:

- SAPSWBM Catchments
- Proposed Extension

RPS (2019):

- Shrub Swamps
- Hanging Swamps

JBS&G

Job No: 56421

Client: Centennial Angus Place Pty Ltd

Version: R02Rev1	Date: 13-Sep-2019
Drawn By: JZ	Checked By: JB

Scale 1:12,000

0 100 200 300

Meters

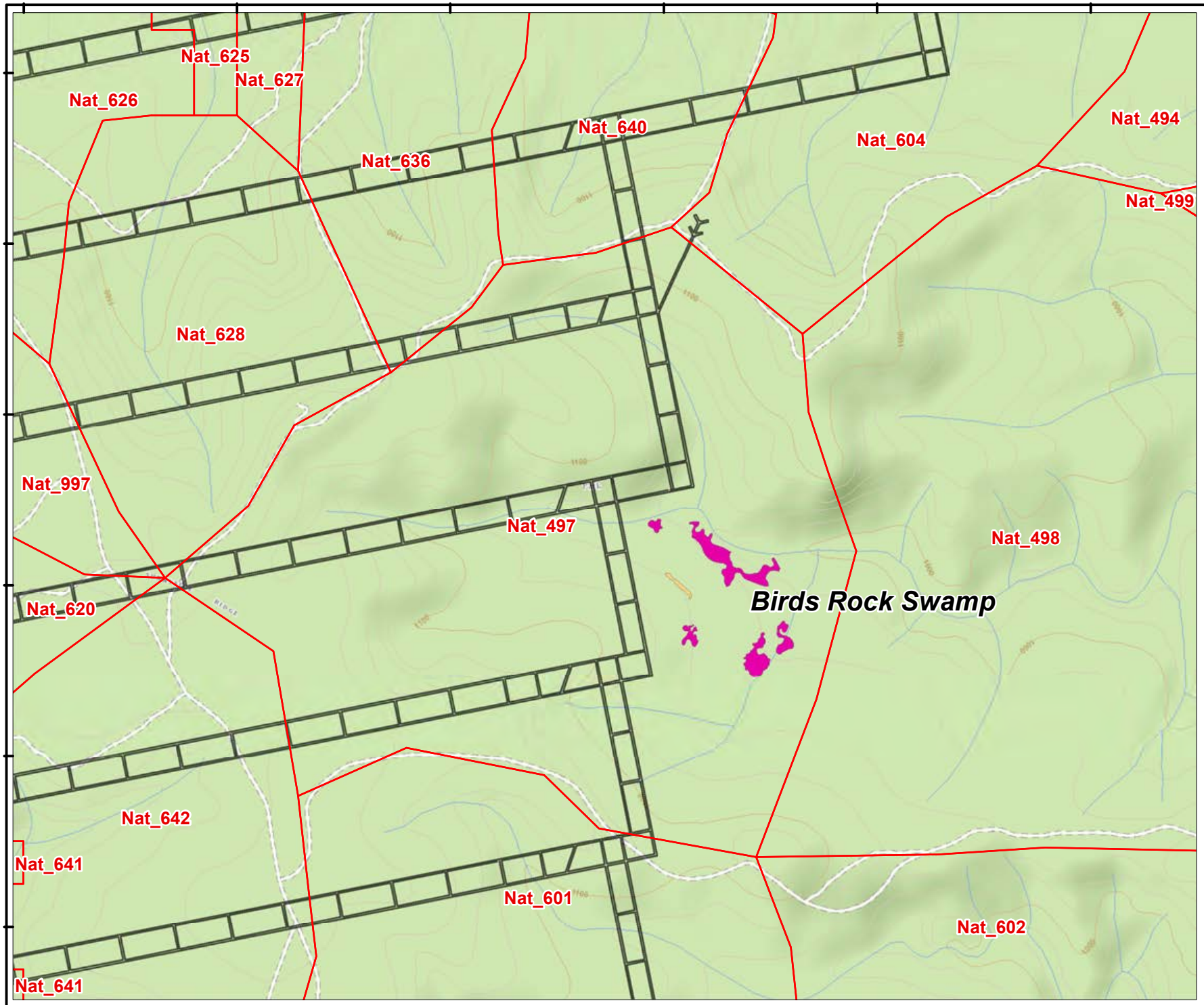
Coor. Sys. GDA 1994 MGA Zone 56

Layout of the SAPSWBM at Crocodile Swamp

FIGURE: 4.7

File Name: N:\Projects\CentennialCoal\AngusPlaceColliery\56421_AngusPlaceMineExtensionProject\Figures\GIS\Delivery\Maps\R02Rev1_SW\R02Rev1-SW_D011_Crocodile.mxd

Reference: © Department of Finance, Services & Innovation 2018



Legend:

- SAPSWBM Catchments
- Proposed Extension

RPS (2019):

- Shrub Swamps
- Hanging Swamps

JBS&G

Job No: 56421

Client: Centennial Angus Place Pty Ltd

Version: R02Rev1	Date: 13-Sep-2019
Drawn By: JZ	Checked By: JB

Scale 1:12,000

0 100 200 300

Meters

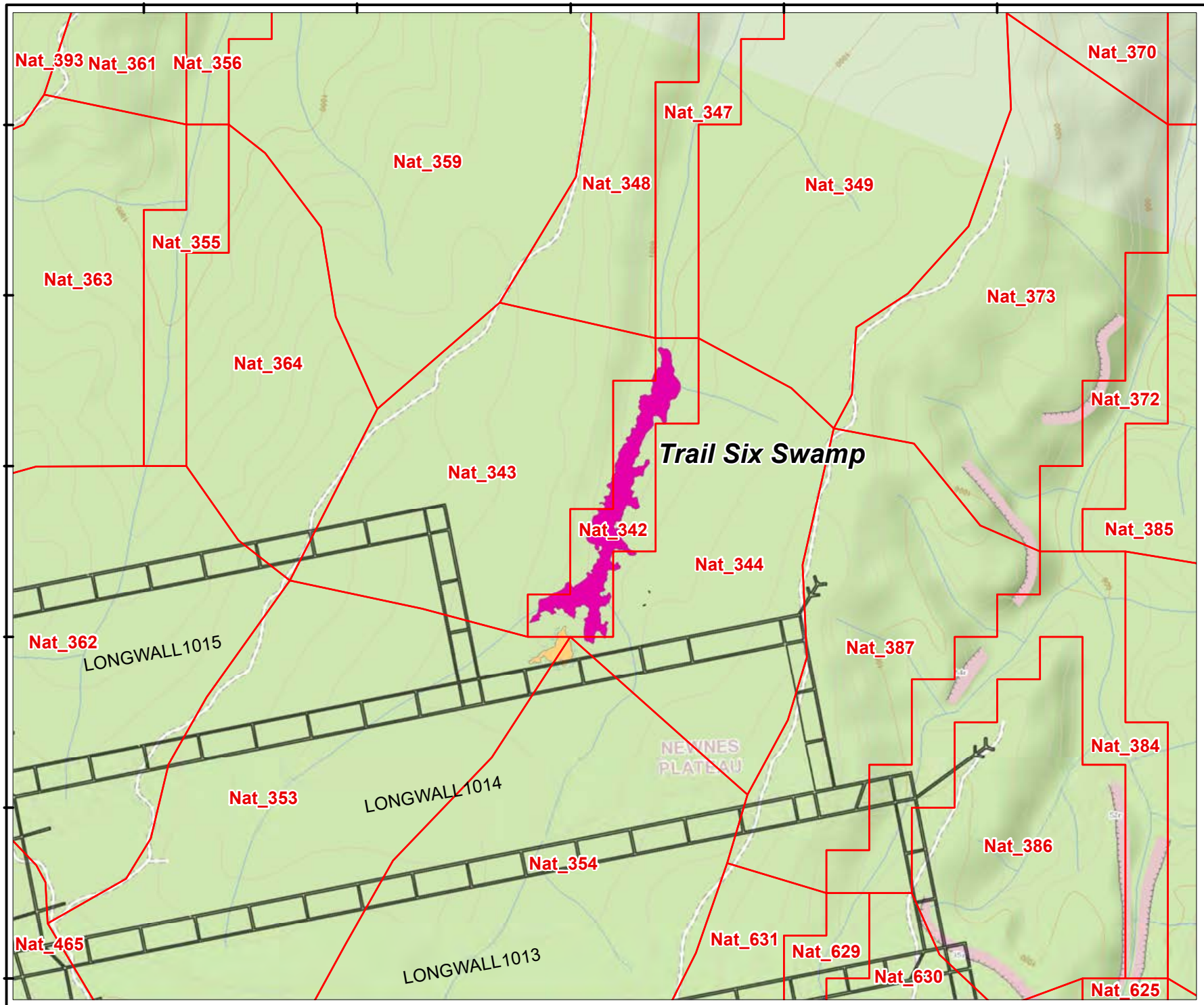
Coor. Sys. GDA 1994 MGA Zone 56

Layout of the SAPSWBM at Birds Rock Swamp

FIGURE: 4.8

File Name: N:\Projects\CentennialCoal\AngusPlaceColliery\56421_AngusPlaceMineExtensionProject\Figures\GIS\Delivery\Maps\R02Rev1_SW\R02Rev1-SW_D010_BirdsRock.mxd

Reference: © Department of Finance, Services & Innovation 2018



Legend:

- SAPSWBM Catchments
- Proposed Extension

RPS (2019):

- Shrub Swamps
- Hanging Swamps

JBS&G

Job No: 56421	
Client: Centennial Angus Place Pty Ltd	
Version: R02Rev1	Date: 13-Sep-2019
Drawn By: JZ	Checked By: JB

Scale 1:12,000

0 100 200 300

Meters

Coor. Sys. GDA 1994 MGA Zone 56

Layout of the SAPSWBM at Trail Six/Japan Swamp

FIGURE: 4.9

File Name: N:\Projects\CentennialCoal\AngusPlaceColliery\56421_AngusPlaceMineExtensionProject\Figures\GIS\Delivery\Maps\R02Rev1_SW\R02Rev1-SW_D009_TrailSix_Japan.mxd

Reference: © Department of Finance, Services & Innovation 2018

4.6 Model Boundary Conditions

4.6.1 Inputs

Rainfall

The approach to application of rainfall and evaporation to the SAPSWBM is slightly different to that used in the RWQIAM and the Stage 1 Hydrological Model of Shrub Swamps.

To match the approach adopted in the groundwater model, SILO gridded data was used instead of patched point data applied via thiessen polygons. The layout of the SILO grid is presented in **Figure 3.2**.

In the prediction simulation, median rainfall conditions were derived from the NARCliM dataset and used for the prediction simulation period of June 2019 through to 31 December 2061.

Climate change scenarios were also considered, based on the NARCliM dataset and further detail is provided below.

Mine Water Discharge

Mine water discharge to the model currently occurs from Angus Place Colliery via their Licensed Discharge Point (LDP) 001 (Node 197a; previously Node 095), at Springvale Mine via their LDP009 (Node 831a; previously Node 014) and LDP001 (Node 996a; previously Node 151).

The rate of mine water discharge was maintained at the values presented in JBS&G (2018).

From 1 January 2020, mine water discharge from Angus Place Colliery will cease.

Groundwater Contribution

As discussed in **Section 4.2**, a limitation of the AWBM is that, in small catchments, rainfall/runoff processes by themselves, do not adequately account for observed flow rate. In small catchments, such as on the Newnes Plateau upstream of the THPSS, the contribution from regional groundwater via seepages and groundwater/surface water interaction is such that it needs to be included, as per the findings from the Stage 1 Hydrological Model of Shrub Swamps.

For the assessment presented in this report, the following approach was adopted.

Outcomes from predictive uncertainty analysis of the groundwater model were processed to generate probabilistic differences between the Proposed Case and the Null Case. In the ***Proposed Case*** mining at Angus Place Colliery continues into the 1000 Panel Area and dewatering activity continues until December 2053. In the ***Null Case***, mining at Angus Place Colliery does not proceed into the 1000 Panel Area and only the 910N panel is extracted. Dewatering activity in the Null Case ceases in December 2029.

The 10th percentile and 90th percentile difference to groundwater seepage (referred to as the U10 and U90 results respectively), and surface water/groundwater along surface watercourses within each of the SAPSWBM catchments were calculated and the respective seepage rates (PROP_u10 (Proposed U10 results) and NULL_u10 (Null U10 results)) and (PROP_u90 (Proposed U90 results) and NULL_u90 (Null U90 results)) were noted. In this way, the circumstance that the 90th percentile change due to continuation of mining occurred during periods of low flow could be accommodated. Also, given that the predictive uncertainty analysis from the groundwater model comprised 299 sets of Proposed and Null Case simulations, the 10th percentile and 90th percentile difference were 'enveloped', to account for the fact that a single run is unlikely to be associated with the 10th percentile or 90th percentile difference at every point in modelled time.

To account for the loss in seepage flow from the point of discharge to the point of accumulation of surface flow, output from the groundwater model was also scaled. The scaling factor was calibrated

and found to be 80% loss. i.e. output from the groundwater model was multiplied by 0.2 before being applied to the SAPSWBM.

A final assumption with groundwater contribution was that the salinity of groundwater was calibrated to landuse and location. Due to local interaction with outcropping Permian Coal Measures, a higher value for groundwater salinity was expected, whereas on the Newnes Plateau, an very low value for groundwater salinity is expected.

4.6.2 Outputs

Evaporation

Evaporation from the model, through the AWBM module, was also applied using the SILO gridded data approach. The layout of the SILO grid is presented in **Figure 3.2**.

As per the value adopted in the current version of the RWQIAM (JBS&G, 2018), a pan factor of 1.0 is used.

In the prediction simulation, evaporation data was derived from the NARCliM dataset and used for the prediction simulation period of June 2019 through to 31 December 2061.

Regional Outflow

As indicated in **Figure 4.1**, the domain of the SAPSWMB is extensive, however, does not include the entire Wolgan River, Bungleboori Creek and Coxs River catchments. At the last downstream catchment of the SAPSWBM, it is assumed that flow continues regionally.

Power Station Consumption

As explained in detail in RPS (2014b), Jacobs (2015) and JBS&G (2018), the water supply scheme to Wallerawang Power Station (now decommissioned) and Mount Piper Power Station is included in the SAPSWBM from the RWQIAM. The water supply scheme comprises Lake Wallace, Lake Lyell and Thompsons Creek Reservoir. Accordingly, catchments and reservoirs above Lake Lyell were included in the SAPSWBM such that the mechanism was retained.

4.7 Model Calibration

4.7.1 Calibration Approach

As noted in **Section 4.5**, the SAPSWBM uses a combined calibration and prediction simulation approach, rather than a distinct calibration phase and prediction phase.

The calibration dataset comprised the following:

- Coxs River monitoring points
- Tri-Star Swamp
- Twin Gully Swamp.

It is noted that Tri-Star automatic gauging was considered unreliable (Jacobs, pers. comms. 2019) and was therefore not used during model calibration.

4.7.2 Calibration Results

The model control files associated with the model simulation presented in this report are:

- R02RevB_SIM_NE_01a.gsm
- R02RevB_SIM_SE_01a.gsm
- R02RevB_SIM_W_01a.gsm.

4.7.2.1 Model Parameters

Table 4.1 presents the calibrated values of the AWBM parameters used in the SAPSWBM.

In **Table 4.1**, for the salinity parameters, Minimum Salinity and Maximum Salinity, mg/L, the first set of values were applied to the western region of the SAPSWBM and the second set of values were applied to the northeastern and southeastern region of the SAPSWBM. For example, the minimum salinity for the channel land-use type in the western region is 190mg/L, whereas it is 40mg/L in the northeastern and southeastern region.

Table 4.1: Calibrated Values of AWBM and Water Quality Parameters in the SAPSWBM

Parameter	Description	Channel	Disturbed	Natural	Pasture	Urban
AWBM Parameters						
Cave(mm)[1]	Average surface storage capacity	27	79	168	192	27
BFI	Baseflow Index	0.25	0.25	0.25	0.25	0.25
Kb	Baseflow store recession constant	0.98	0.98	0.98	0.98	0.98
Ks	Surface store recession constant	0.6	0.3	0.3	0.3	0.6
BVI	Baseflow Visibility Index	0.98	0.95	0.98	0.98	0.95
Salinity Model Parameters						
Minimum Salinity (mg/L)	Assumed minimum salinity (representing 'flushed' runoff conditions)	190/40	300/80	170/10	210/40	400/90
Surface Runoff Threshold (mm/d)	Runoff rate below which salinity will start to cumulatively increase	0.001	0.001	0.001	0.001	0.001
Salinity Multiplier	Factor that previous day's salinity is multiplied by, if surface runoff continues to be below the specified threshold.	1.040	1.027	1.027	1.040	1.027
Salinity Divider	Factor that previous day's salinity is divided by, if surface runoff exceeds the specified runoff threshold.	0.80	0.90	0.80	0.80	0.90
Maximum Salinity (mg/L)	Assumed maximum salinity (representing seepage from local groundwater dominating runoff conditions)	500/150	700/400	550/110	600/150	700/325
Groundwater Salinity	Assumed salinity of groundwater contribution to surface water catchments. This will be spatially distributed in a future version of the SAPSWBM.	Presented in **Appendix A**				

Note 1. The disaggregation of Cave is the default in AWBM, where C1 = 0.075*Cave, C2 = 0.762*Cave and C3 = 1.524*Cave;

4.7.2.2 Coxs River Catchment

For the purpose of illustration of the current state of calibration of the SAPSWBM, **Figure 4.10** presents the modelled versus observed flow and salinity at the DoI:Water Gauge (No. 212054) located immediately upstream of Lake Wallace (Node 032a; previously Node 047).

Figure 4.11 presents the statistical distribution of model output with respect to available observation data. In **Figure 4.11**, comparison is made between the model result at the same time as an observation is available.

Table 4.2 presents a summary of the statistical distribution of model output presented in **Figure 4.11**.

From **Figure 4.10** and **Figure 4.11**, modelled flow and salinity are both reasonably represented.

Figure 4.12 presents the modelled versus observed flow and salinity at DoI: Water Gauge (No. 212011) located immediately downstream of Lake Lyell (Node 147a; previously Node 209).

Figure 4.13 presents the statistical distribution of model output with respect to available observation data and **Table 4.3** presents a summary of that distribution.

From **Figure 4.12** and **Figure 4.13**, modelled flow and salinity are reasonably represented.

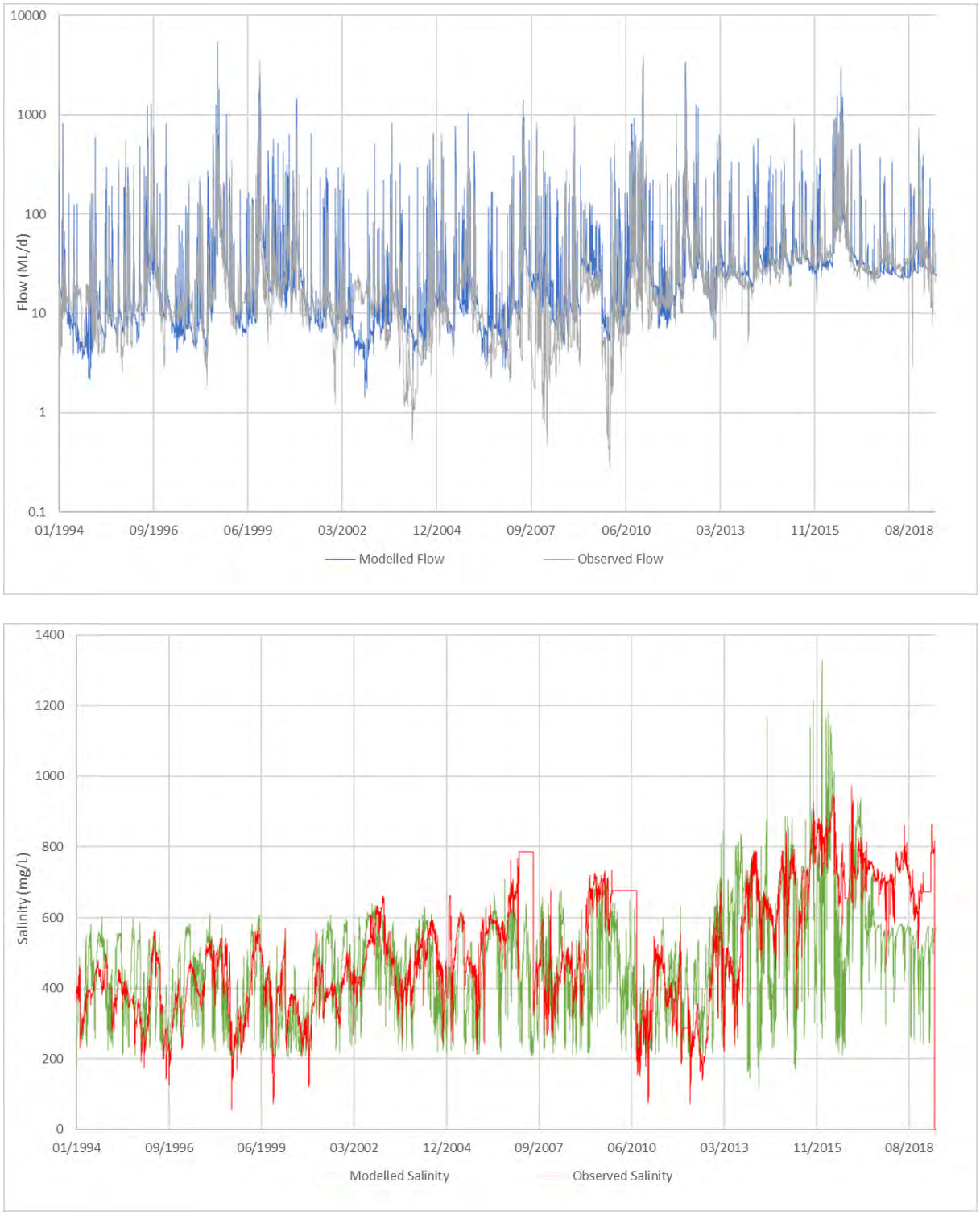
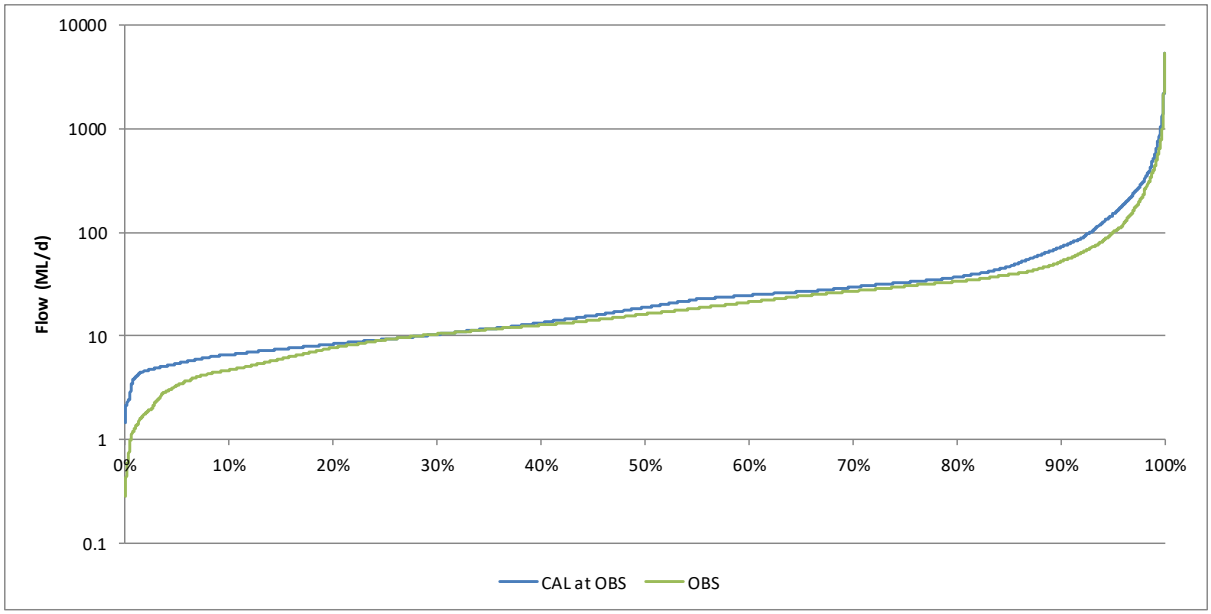


Figure 4.10: Observed versus Modelled Flow (ML/d) and Salinity (mg/L): Coxs River immediately upstream of Lake Wallace (DoI:Water Gauge No. 212054; Node 032a, previously Node 047)



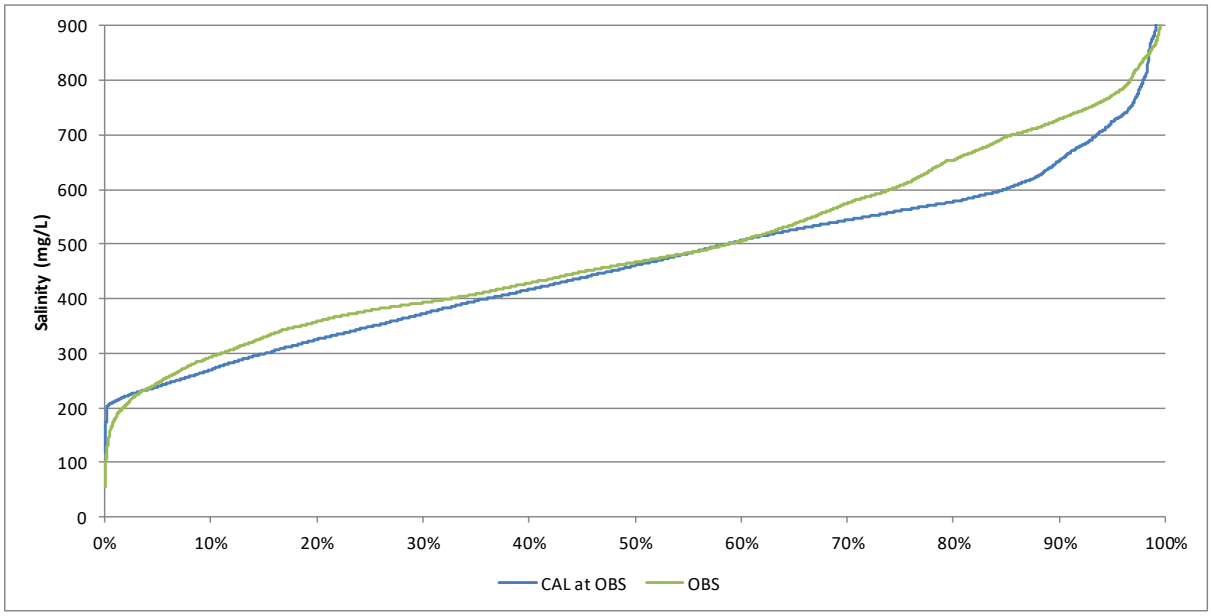


Figure 4.11: Statistical Distribution of Model Output – Coxs River immediately upstream of Lake Wallace (DoI:Water Gauge No. 212054; Node 032a, previously Node 047)

Table 4.2: Summary of Statistical Distribution of Model Output – Coxs River immediately upstream of Lake Wallace (DoI:Water Gauge No. 212054; Node 032a, previously Node 047)

	Salinity (mg/L)			Flow (ML/d)		
Percentile	OBSD	CAL at OBSD	CAL	OBSD	CAL at OBSD	CAL
Min	55	119	119	0.3	1.4	1.4
5%	245	239	226	3.3	5.4	3.0
10%	293	270	245	4.7	6.6	3.9
20%	358	325	279	7.7	8.3	5.5
50%	466	461	388	16.2	18.8	11.3
80%	654	578	514	33.4	36.9	33.9
90%	728	652	558	52.0	71.5	71.1
95%	773	724	607	98	146	145
Max	971	1,329	1,329	5,321	5,438	8,249

Note. “OBS” is observation; “CAL at OBS” is the model result at the same time as observation; “CAL” is all model output.

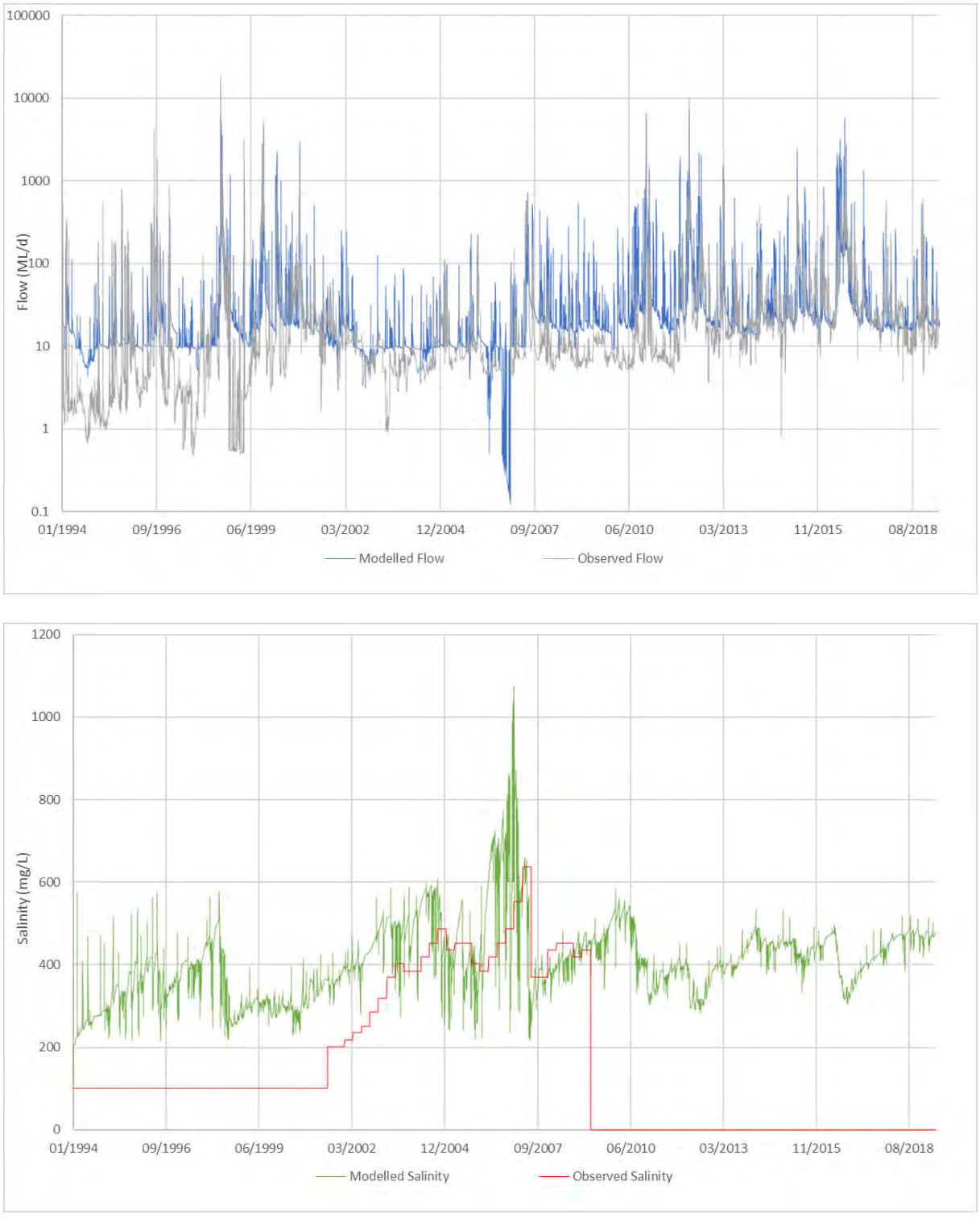
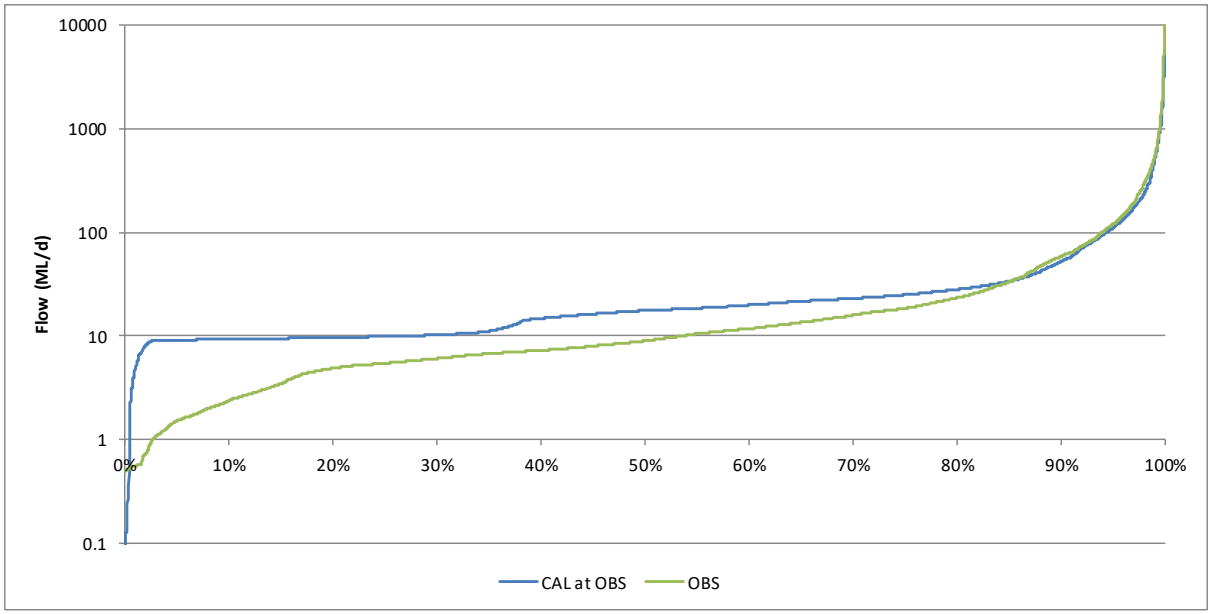


Figure 4.12: Observed versus Modelled Flow (ML/d) and Salinity (mg/L): Coxs River below Lake Lyell (DoI:Water Gauge No. 212011; Node 147a, previously Node 209)



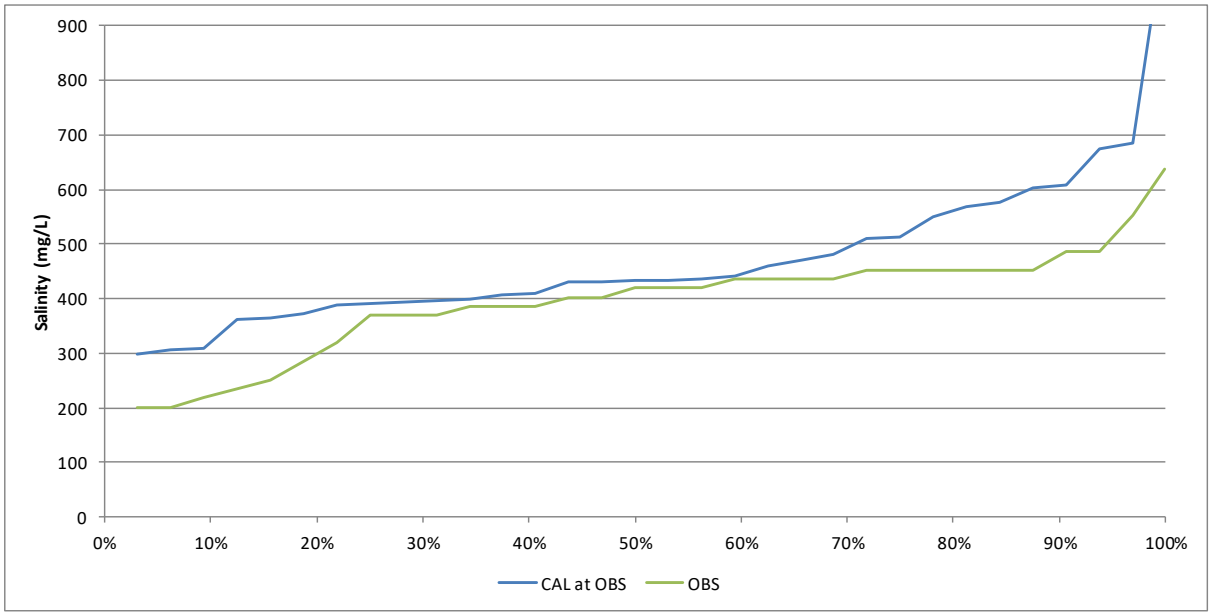


Figure 4.13: Statistical Distribution of Model Output – Coxs River below Lake Lyell (DoI:Water Gauge No. 212011; Node 147a, previously Node 209)

Table 4.3: Summary of Statistical Distribution of Model Output – Coxs River below Lake Lyell (DoI:Water Gauge No. 212011; Node 147a, previously Node 209)

	Salinity (mg/L)			Flow (ML/d)		
Percentile	OBSD	CAL at OBSD	CAL	OBSD	CAL at OBSD	CAL
Min	201	297	112	0.0	0.1	0.1
5%	210	308	266	1.5	8.0	5.0
10%	236	363	286	2.4	9.4	7.1
20%	328	389	308	5.0	9.8	9.7
50%	419	434	362	12	17	17
80%	452	564	420	57	30	34
90%	482	607	460	132	64	101
95%	516	678	495	246	142	205
Max	637	1,075	1,075	38,188	7,172	21,216

Note. “OBS” is observation; “CAL at OBS” is the model result at the same time as observation; “CAL” is all model output.

4.7.2.3 Wolgan River Catchment

In the Wolgan River catchment, there are two flow gauge stations operated by Angus Place Colliery.

Tri-Star Swamp

Figure 4.14 presents the observed versus modelled flow for Tri-Star Swamp (Node 324a) in the period 2011 to 2019.

Figure 4.15 presents the statistical distribution of model output with respect to available observation data and **Table 4.4** presents a summary of that distribution.

From **Table 4.4**, the modelled median daily flow at the time of available observations is 0.52ML/d compared to an observed median daily flow of 0.29ML/d. Accordingly, the SAPSWBM overpredicts the median daily flow. This is also apparent in **Figure 4.15** and more generally in **Figure 4.14**. Given the limitations of manual gauging the demonstrated fit is, however, considered acceptable.

Twin Gully Swamp

Figure 4.16 presents observed and modelled flow for Twin Gully Swamp (Node 322a) in the period 2011 to 2019.

The statistical distribution of model results at the time of observation is presented in **Figure 4.17** and **Table 4.5** presents a summary of that distribution.

From **Table 4.5**, the modelled median daily flow at the time of available observations is 0.32ML/d compared to an observed median daily flow of 0.10ML/d. Accordingly, the SAPSWBM is overpredicting the rate of flow; however, it is of the right magnitude and the shape of the model response in **Figure 4.16** is satisfactory.

4.7.3 Summary of Model Calibration

The SAPSWBM adopted the parameterisation (AWBM) of the RWQIAM (JBS&G, 2018) and has been shown to adequately match observed flow and salinity in the Coxs River catchment.

Due to the significant size of the Coxs River catchment, which leads to significant surface water flows, the groundwater transmission loss factor was calibrated using the northeast region of the SAPSWBM and then applied to the western and southeastern regions.

The SAPSWBM for the northeast and southeast region uses the same parameterisation (AWBM) as that adopted for the western region. The groundwater loss factor was calibrated to manual flow gauging conducted on the Newnes Plateau at Tri-Star and Twin Gully Swamps. The groundwater transmission loss factor was found to be 80%. i.e. the contribution to surface water from regional groundwater was multiplied by 0.2 before being included in the SAPSWBM.

It is highlighted that the AWBM also includes a baseflow store and, as presented in **Section 4.6.1**, consideration of the contribution to surface water from regional groundwater, in addition to the role played by the baseflow store in the AWBM, was found to be important.

The catchment salinity store parameters were introduced in Angus Place Colliery Modification 5 (JBS&G, 2018). Those parameters were updated in the western, northeast and southeast regions to account for the differences between regions with respect to near-surface geology and aspect.

Lastly, the assumed salinity of regional groundwater was set based on near-surface geology and land-use. Land-use was considered in the context of enhanced water-rock interaction as groundwater enters the surface water system.

The fit of the SAPSWBM to observed flow is considered to be acceptable. Accordingly, it is considered reasonable to use the SAPSWBM for the purpose of assessing the change to flow due to the Amended Project. As the Amended Project will not lead to a change in salinity, the fit to salinity is not presented in the northeast and southeast, since it is not required.

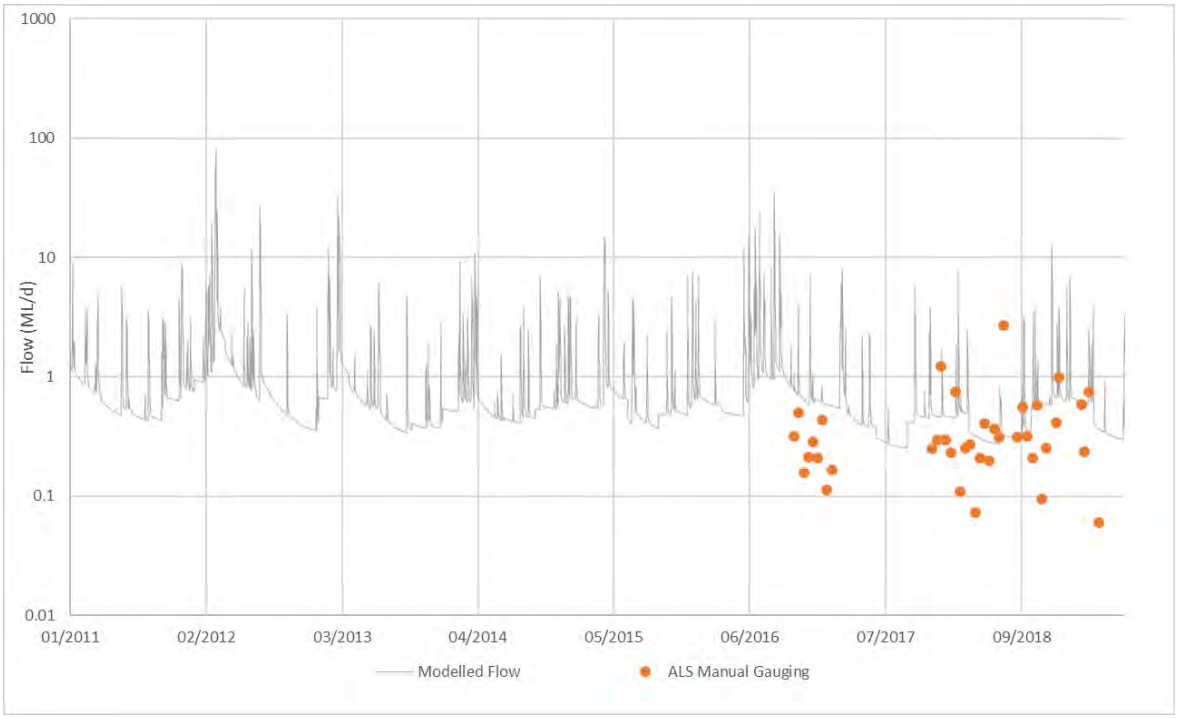


Figure 4.14: Modelled versus Observed Flow (ML/d) – Tri-Star Swamp (Node 324a)

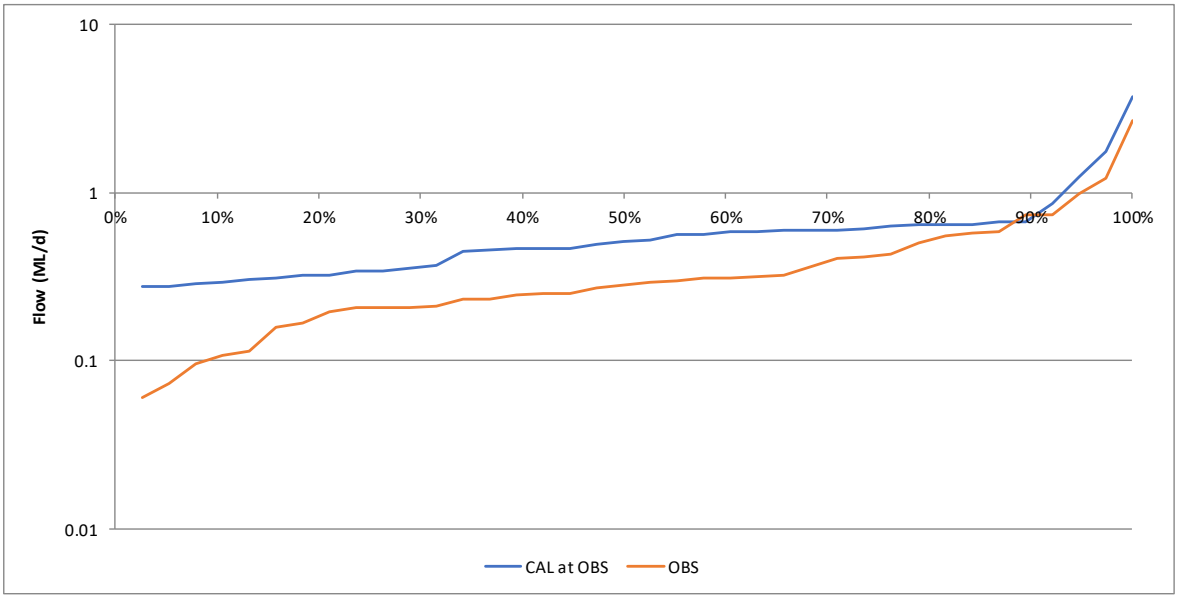


Figure 4.15: Statistical Distribution of Model Output – Tri-Star Swamp (Node 324a)

Table 4.4: Summary of Statistical Distribution of Model Output – Tri-Star Swamp (Node 324a)

	Salinity (mg/L)			Flow (ML/d)		
Percentile	OBSD	CAL at OBSD	CAL	OBSD	CAL at OBSD	CAL
Min	-	-	-	0.06	0.27	0.16
5%	-	-	-	0.09	0.28	0.28
10%	-	-	-	0.11	0.30	0.31
20%	-	-	-	0.20	0.33	0.37
50%	-	-	-	0.29	0.52	0.49
80%	-	-	-	0.53	0.64	0.85
90%	-	-	-	0.74	0.73	1.61
95%	-	-	-	1.02	1.32	2.95
Max	-	-	-	2.68	3.76	174.90

Note. “OBS” is observation; “CAL at OBS” is the model result at the same time as observation; “CAL” is all model output.

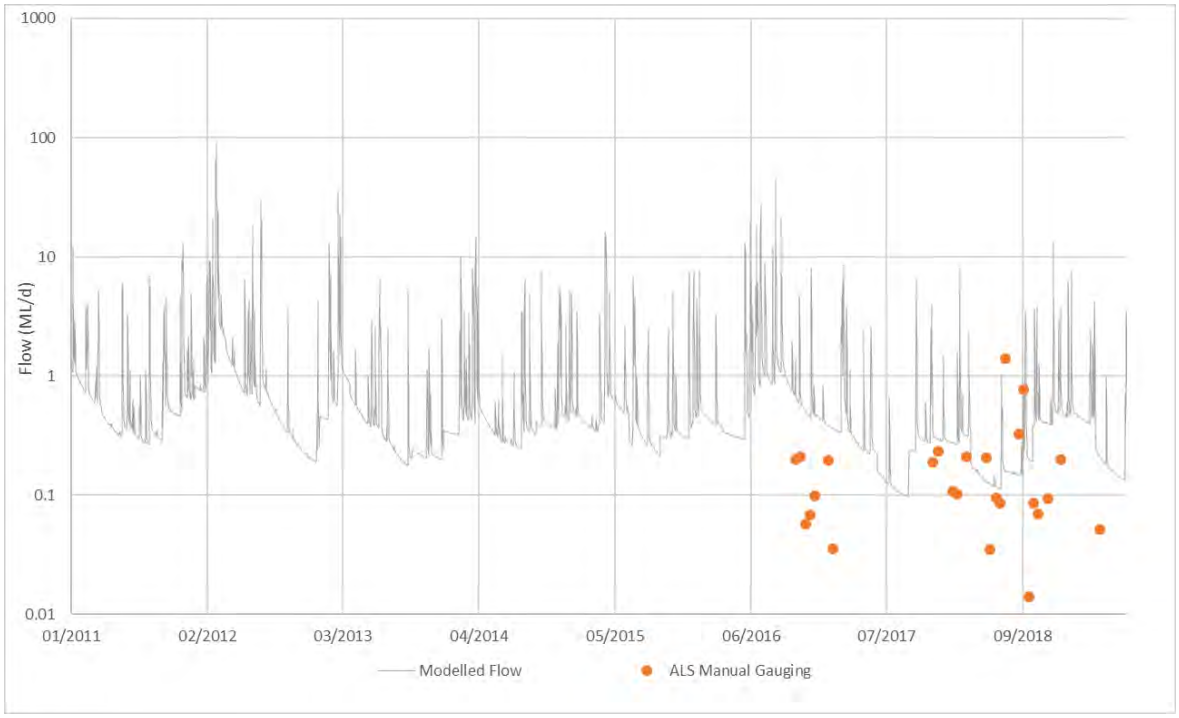


Figure 4.16: Modelled versus Observed Flow (ML/d) – Twin Gully Swamp (Node 322a)

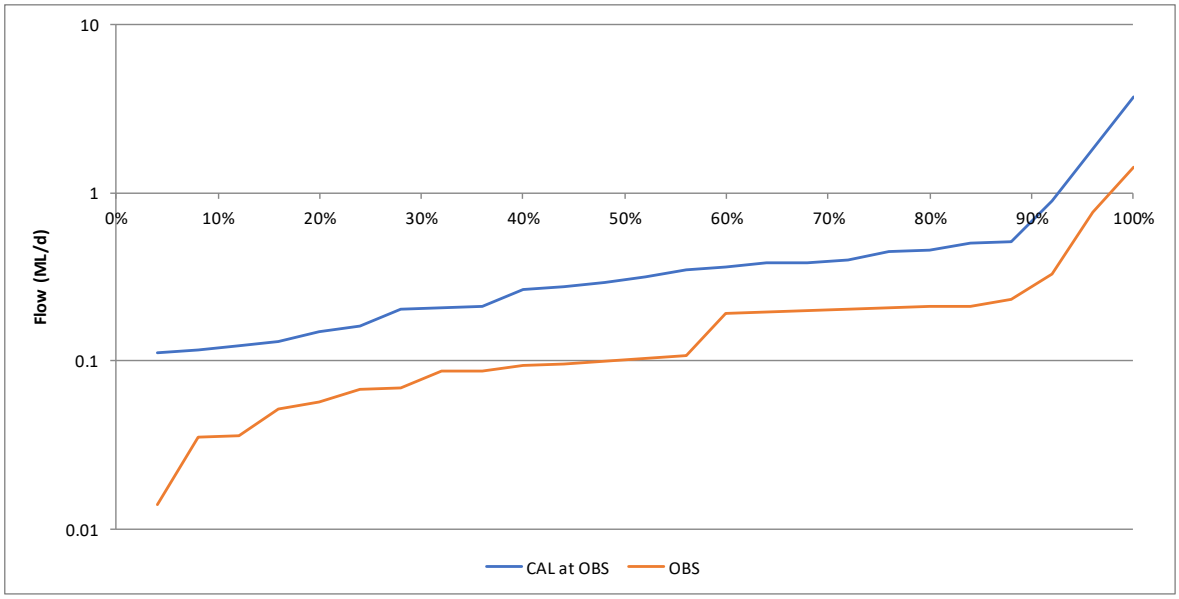


Figure 4.17: Statistical Distribution of Model Output – Twin Gully Swamp (Node 322a)

Table 4.5: Summary of Statistical Distribution of Model Output – Twin Gully Swamp (Node 322a)

	Salinity (mg/L)			Flow (ML/d)		
Percentile	OSBD	CAL at OSBD	CAL	OSBD	CAL at OSBD	CAL
Min	-	-	-	0.01	0.11	0.09
5%	-	-	-	0.04	0.12	0.16
10%	-	-	-	0.04	0.13	0.20
20%	-	-	-	0.07	0.16	0.25
50%	-	-	-	0.10	0.32	0.38
80%	-	-	-	0.21	0.46	0.78
90%	-	-	-	0.29	0.74	1.68
95%	-	-	-	0.68	1.65	3.30
Max	-	-	-	1.41	3.70	193.30

Note. “OBS” is observation; “CAL at OBS” is the model result at the same time as observation; “CAL” is all model output.

4.8 Model Results incorporating Predictive Uncertainty

4.8.1 Approach to Uncertainty Analysis

The ***Proposed Case*** consisted continuation of mining at Angus Place Colliery into the 1000 Panel Area. The ***Null Case*** consisted cessation of dewatering activity at Angus Place Colliery at the end of December 2029.

As presented in the Hydrogeological Model Report (JBS&G, 2019), a range of model parameters were considered in the groundwater model and the 10th and 90th percentile outputs (groundwater contribution to surface water flow) were generated. For the purpose of clarity, these results are referred to in this report as the U10 and U90 model results respectively.

4.8.2 Model Setup

The Proposed Case flow and Null Case flow through each of the groundwater DRN cells were extracted as described in **Section 4.6.1**, and applied in the SAPSWBM after multiplication by a factor of 0.2 to account for transmission loss between point of discharge from groundwater to point of accumulation as surface flow.

4.8.3 Predictive Uncertainty Results

The model control files associated with the prediction simulations presented in this report are:

- R02RevB_NE_SIM200_02a
- R02RevB_SE_SIM200_02a
- R02RevB_W_SIM200_02a

Predictive uncertainty results are presented with respect to each of the THPSS identified in **Section 3.3**. The order that the results are presented is, generally, from south to north, so as to be consistent with the expected schedule of mining of the 1000 Panel Area.

Results are presented with respect to change to modelled flow and then, secondly, with respect to the magnitude of that change compared to daily flow hydrographs and flow duration statistics.

4.8.3.1 Change in Modelled Flow

<u>Wolgan River Swamp Upper Swamp</u>

Figure 4.18 presents the modelled change in flow due to the Amended Project in Wolgan River Swamp Upper Swamp. **Figure 4.18** was calculated by subtracting the Proposed Case modelled flow from the SAWSWBM from the Null Case modelled flow at a respective model node. Accordingly, **Figure 4.18** presents the change in groundwater contribution, as all other parameters were held at the same value.

It is noted that the U10 and U90 model results are presented in **Figure 4.18**, as well as the results from the simulation prediction (referred to as "SIM0") using calibrated parameters. The simulation prediction is described in further detail in the Hydrogeological Model Report (JBS&G, 2019) and can be thought of as the traditional way that model output is presented. i.e. a model is calibrated and then those parameters are used for a single deterministic model simulation. In predictive uncertainty analysis, instead of single set of model parameters, a stochastic distribution of model parameters is used instead.

From **Figure 4.18**, there is a sharp reduction, of up to 0.4ML/d (4.6L/s), in 2030. This sharp reduction is associated with the mining of the western end of LW1005 and LW1006, wherein the depth of cover is less than 350m in the vicinity of Tri-Star Swamp. That sharp reduction is dissipated by 2034.

It is noted that the large 'spike' in groundwater contribution in 2053 in **Figure 4.18**, and in equivalent figures discussed immediately below, is due to the change in the groundwater model between active

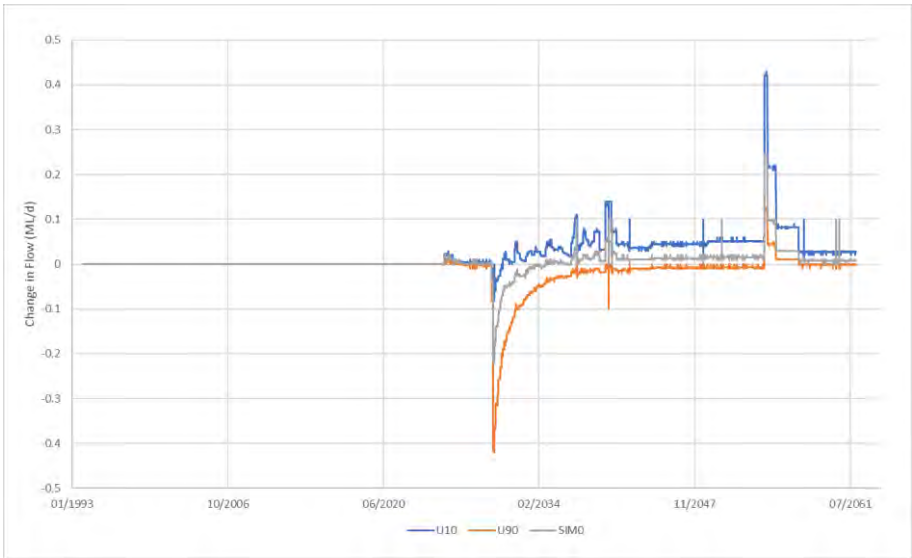


Figure 4.18: Modelled Change in Flow – Wolgan River Swamp Upper Swamp (Node 325a)

dewatering and application of a 'full' profile of mine subsidence changes to hydraulic properties. Whilst not important to the SAPSWBM, detailed discussion of this aspect is presented in the Hydrogeological Model Report (JBS&G, 2019).

Tri-Star Swamp

Figure 4.19 presents the modelled change in flow due to the Amended Project in Tri-Star Swamp.

From **Figure 4.19**, the change in groundwater contribution in Tri-Star for the U10 model results is an initial increase by up to 0.15ML/d, due to changes to hydraulic properties above the active mining cell in the groundwater model that release more groundwater to surface water, followed by a decrease in groundwater contribution down to a loss of 0.04ML/d at later time. From **Figure 4.19**, for the 90th percentile model output, there is an initial loss of 0.05ML/d in groundwater contribution in early time, which then increases to a loss of 0.17ML/d at later time.

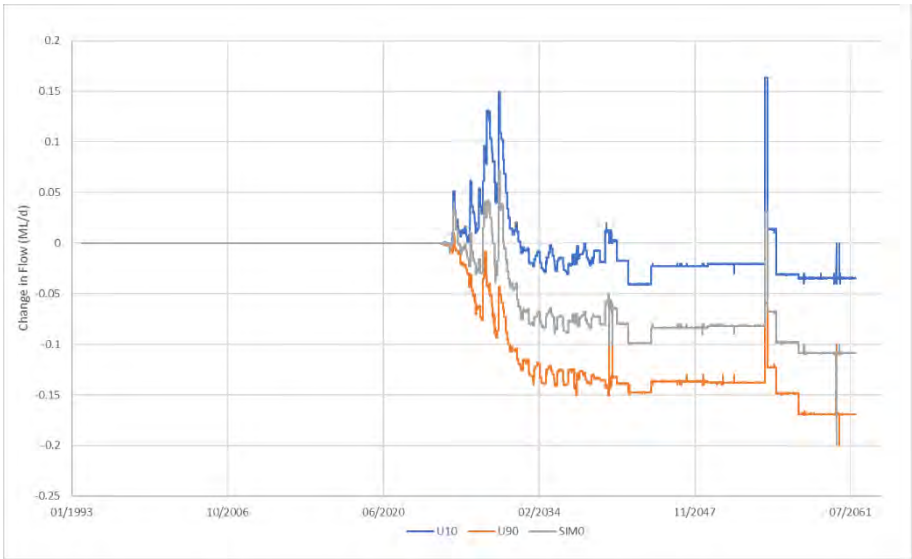


Figure 4.19: Modelled Change in Flow – Tri Star Swamp (Node 324a)

Wolgan River Swamp

Figure 4.20 presents the modelled change in groundwater contribution to Wolgan River Swamp.

From **Figure 4.20**, there is a sharp reduction, to 0.6ML/d (7L/s) in groundwater contribution in 2030 in Wolgan River Swamp. As per the discussion with respect to Wolgan River Swamp Upper Swamp, this is due to the mining at the western end of LW1005 and LW1006, where the depth of cover is less than 350m in the vicinity of Tri-Star Swamp. The sharp reduction is dissipated by 2034.

It is noted that the instantaneous drops in the SIM0 simulation (grey line in **Figure 4.20**) in 2040 and in 2060, to -1ML/d, are numerical artefacts in the model output and are not significant.

Twin Gully Swamp

Figure 4.21 presents the change in groundwater contribution in Twin Gully Swamp from the U10 and U90 model output.

From **Figure 4.21**, for the U10 model output, there is an initial increase of up to 0.1ML/d in early time, which becomes an increase of 0.01ML/d at later time. For the U90 model output, there is an increase decrease in groundwater contribution of 0.02ML/d, which increases to a loss of 0.05ML/d at later time.

Crocodile Swamp

Figure 4.22 presents change in modelled groundwater contribution to Crocodile Swamp due to the Amended Project.

From **Figure 4.22**, the modelled change ranges between +0.01ML/d in the U10 results to -0.05ML/d in the U90 results. The magnitude of the modelled change is considered negligible.

Birds Rock Swamp

Figure 4.23 presents the change in groundwater contribution in Birds Rock Swamp.

From **Figure 4.23**, in the U10 results, the modelled change is an initial increase by 0.1ML/d (~1L/s) followed by negligible change at later time. From **Figure 4.23**, for the U90 results, the modelled change is a decrease of up to 0.05ML/d (~(0.6L/s).

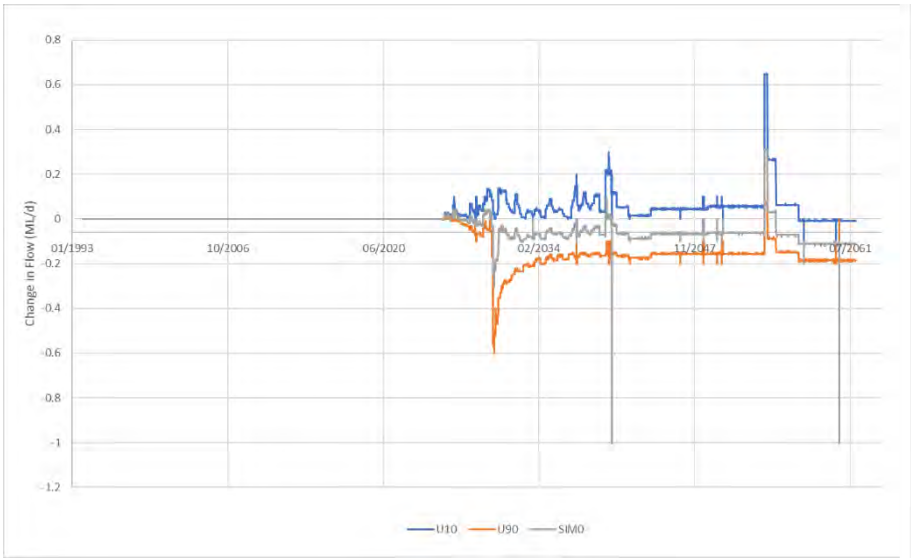


Figure 4.20: Modelled Change in Flow – Wolgan River Swamp (Node 332a)

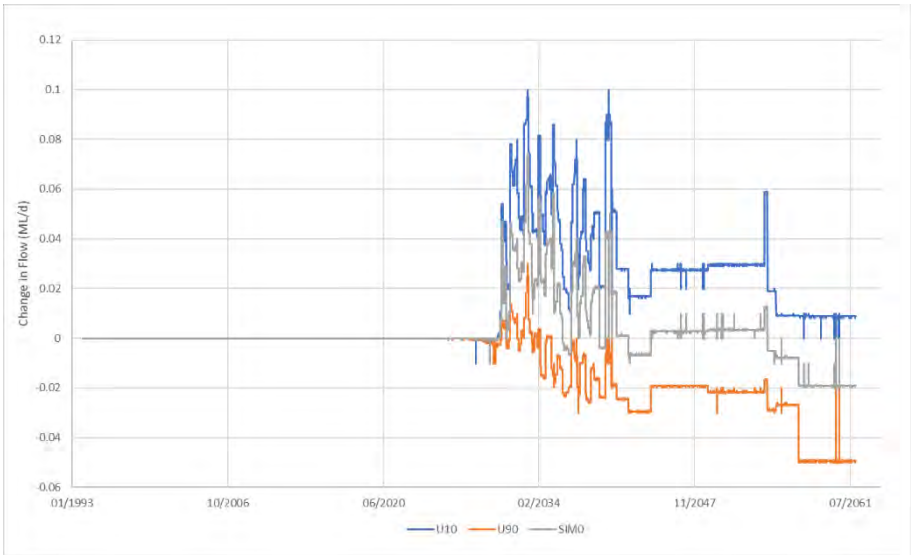


Figure 4.21: Modelled Change in Flow – Twin Gully Swamp (Node 322a)

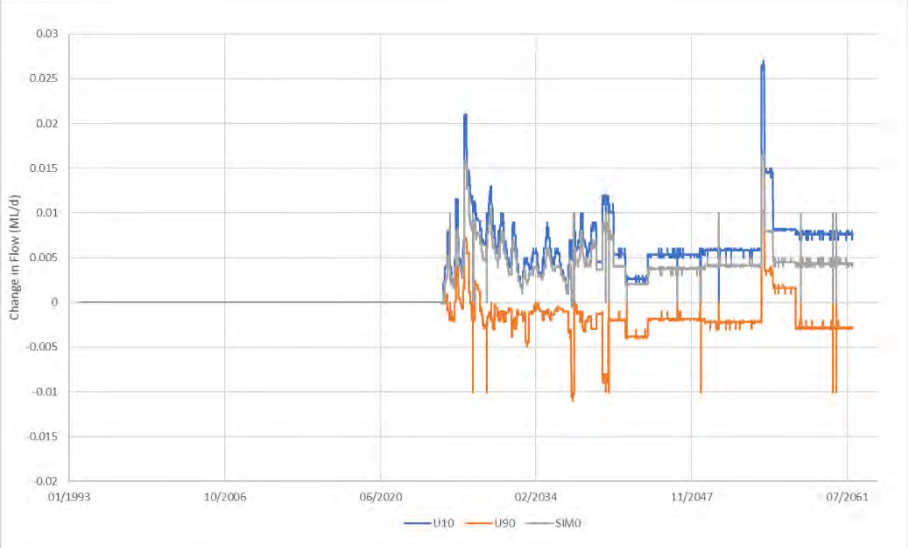


Figure 4.22: Modelled Change in Flow – Crocodile Swamp (Node 562a)

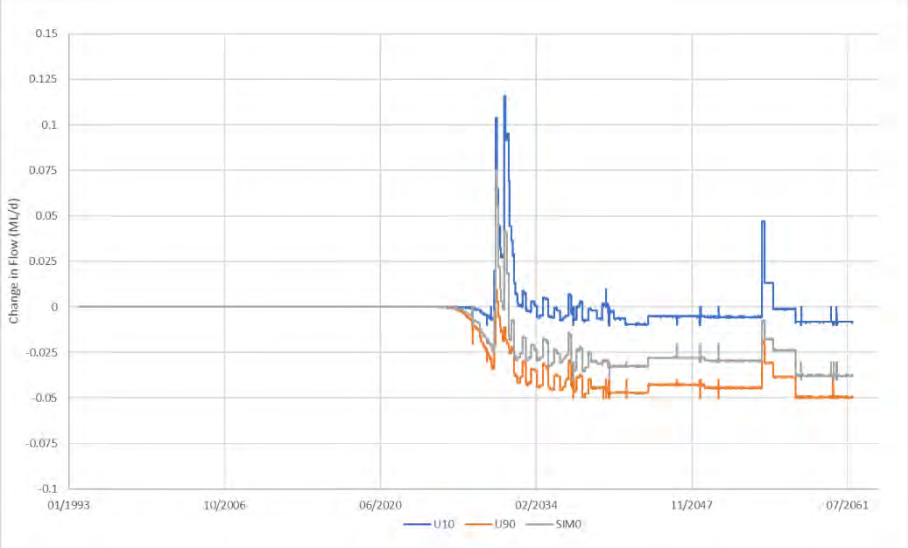


Figure 4.23: Modelled Change in Flow – Birds Rock Swamp (Node 497a)

Trail Six Swamp

Figure 4.24 presents the change in groundwater contribution in Trail Six Swamp for the U10 and U90 model output.

From **Figure 4.24**, for the U10 percentile model output, there is an increase in groundwater contribution of 0.1ML/d in early time. At later time, this dissipates to an increase of only 0.01ML/d.

From **Figure 4.24**, for the U90 model output, there is an initial loss of 0.02ML/d, which increases to a loss of 0.06ML/d.

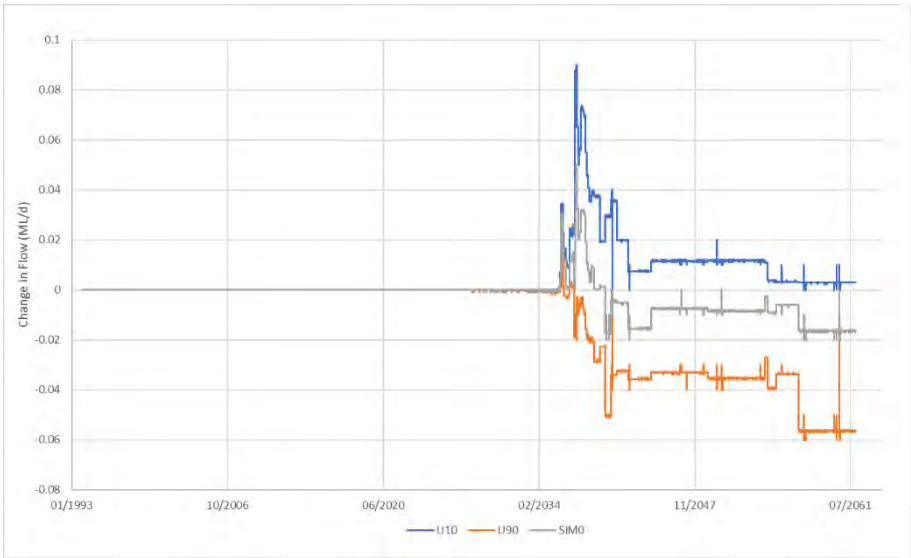


Figure 4.24: Modelled Change in Flow – Trail Six Swamp (Node 342a)

4.8.3.2 Change to Daily Flow Hydrographs and Flow Duration Statistics

Wolgan River Swamp Upper Swamp

Figure 4.25 presents time-series output from the SAPSWBM at Wolgan River Swamp Upper Swamp (Node 325a) in the period 2025 to 2061. Output from the model is presented in **Figure 4.25** with respect to both the Proposed Case and Null Case.

The sharp reduction in groundwater contribution in 2030 that is identified in **Figure 4.18**, is discernible in **Figure 4.25**, however, is only a moderate, short-term, change compared to flow rate at that time.

Figure 4.26 presents the statistical distribution of model output in the form of a flow-duration curve and **Table 4.6** presents a summary of that statistical distribution.

From **Table 4.6**, the median modelled flow is 1.1ML/d and the 10th% flow is 0.6 to 0.7ML/d. From **Table 4.6**, the change in modelled median flow, across the period 2025 to 2061, ranges between +4% in the U10 model results to -1% in the U90 model results.

From **Table 4.6**, the change in modelled flow rate at the 10th% level is a 7% increase in the U10 model results and is a 1% decrease in the U90 results.

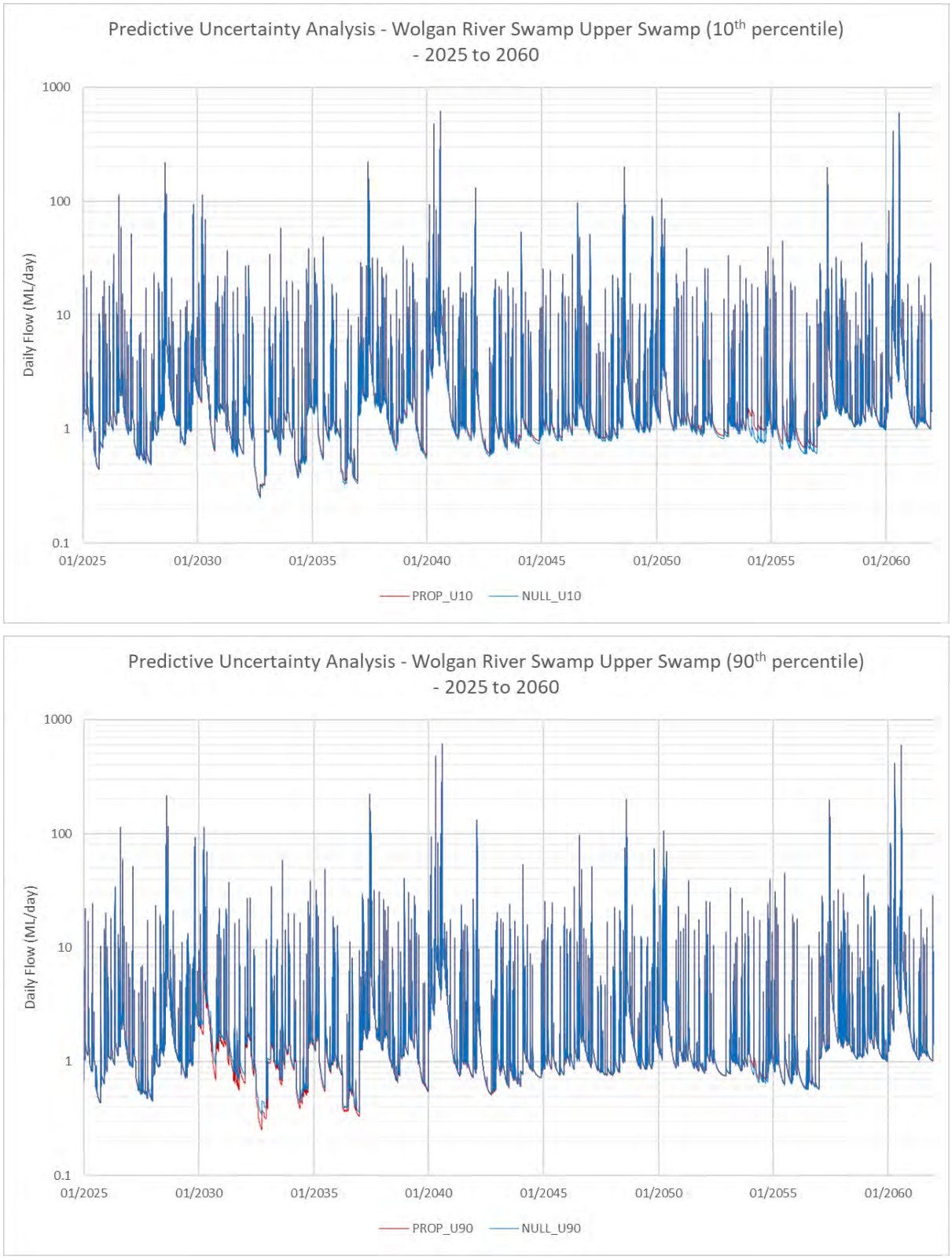


Figure 4.25: Time-Series Model Output – Wolgan River Swamp Upper Swamp (Node 325a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

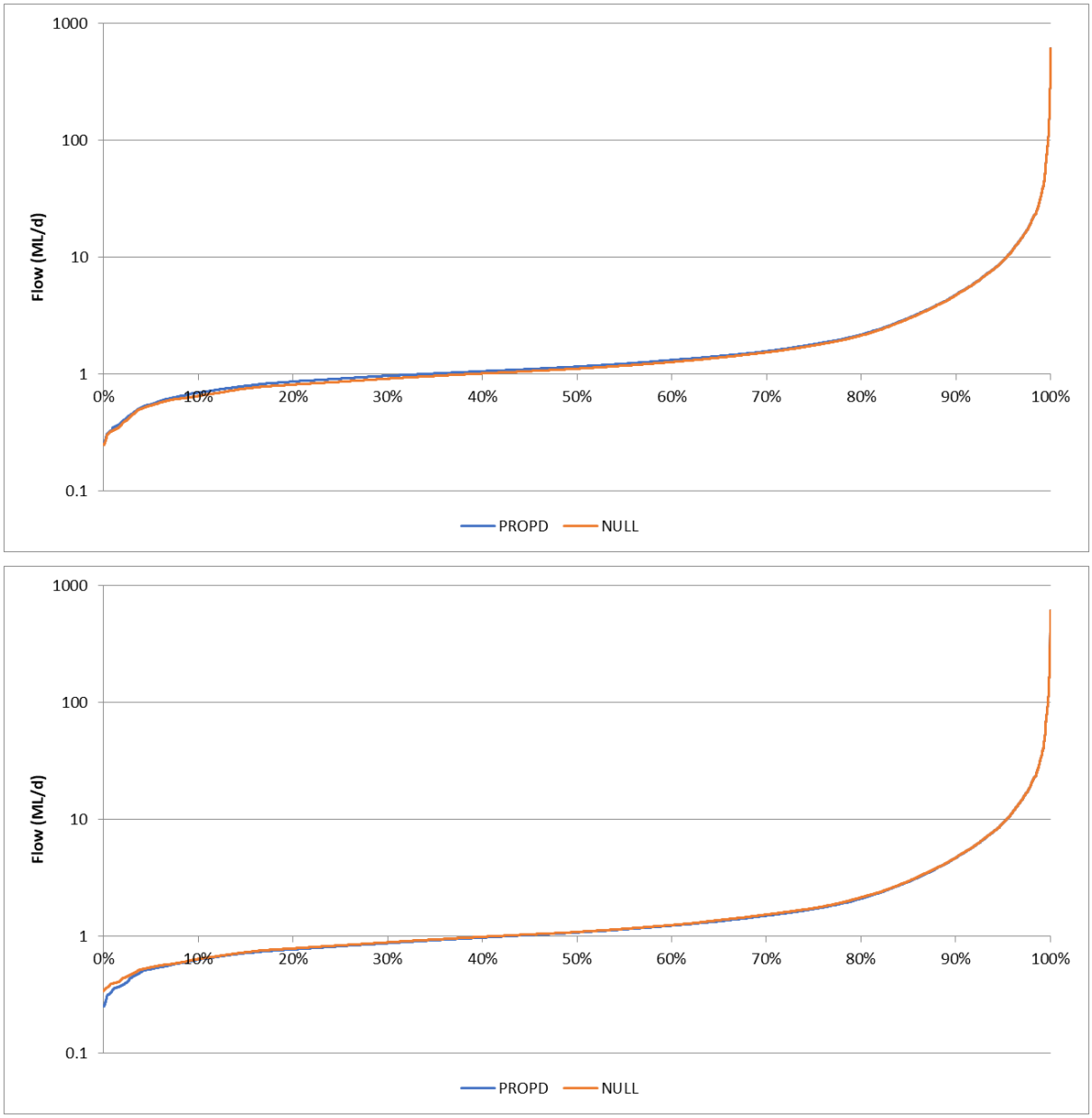


Figure 4.26: Statistical Distribution of Model Output – Wolgan River Swamp Upper Swamp (Node 325a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.6: Summary of Statistical Distribution of Model Output – Wolgan River Swamp Upper Swamp (Node 325a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.25	0.25	3	0.25	0.34	-26
5%	0.55	0.54	2	0.52	0.54	-3
10%	0.70	0.65	7	0.63	0.64	-1
20%	0.86	0.81	6	0.77	0.79	-2
50%	1.2	1.1	4	1.08	1.09	-1
80%	2.2	2.2	1	2.10	2.16	-3
90%	4.8	4.7	1	4.69	4.71	0
95%	9.4	9.3	1	9.2	9.3	0
Max	615	615	0	615	615	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

Tri-Star Swamp

Figure 4.27 presents time-series model output at Tri-Star Swamp (Node 324a) for the Proposed Case and Null Case in the period 2025 to 2061. Model output is presented in **Figure 4.27** with respect to the U10 and U90 percentile model results.

Figure 4.28 presents the statistical distribution of model output and **Table 4.7** presents a summary of that statistical distribution.

From **Figure 4.27**, there is a discernible difference between the Proposed Case and Null Case model output, with the Proposed Case being consistently lower than the Null Case in both the U10 and U90 model results. From **Table 4.7**, the modelled median flow is 0.51ML/d in the Null Case in the U10 model results and is 0.50ML/d in the Proposed Case. This represents a decrease of 2% and is considered to be a negligible change. It is noted that the definitions of magnitudes of change are presented in **Table NM-1**, which is located at the beginning of this report. From **Table 4.7**, the modelled median flow in the U90 model results is 0.55ML/d in the Null Case and is 0.44ML/d in the Proposed Case. This represents a decrease of 21% and is considered to be a large change.

Wolgan River Swamp

Figure 4.29 presents the time-series hydrographs from the SAPSWBM at Wolgan River Swamp and **Figure 4.30** presents the flow-duration curve associated with that time-series. **Table 4.8** presents a statistical summary of the flow-duration curve.

From **Figure 4.29**, the sharp reduction in flow in 2030, as identified in **Figure 4.20**, is discernible, however, is only a moderate, short-term, change compared to flow rate at that time.

From **Table 4.8**, the modelled change to median flow rate in the U10 results is an increase of 2% and is a 7% decrease in the U90 results. Whilst the magnitude of change is a moderate decrease, the median flow rate is 2.2ML/d.

From **Table 4.8**, the modelled change to 10th% flow rate ranges between a 3% increase in the U10 results and an 11% decrease in the U90 results. The modelled change to flow rate is a moderate decrease, however, the magnitude of flow at that level is 1.4ML/d, by way of comparison.

Twin Gully Swamp

Figure 4.31 presents time-series model output at Twin Gully Swamp (Node 322a).

Figure 4.32 presents the statistical distribution of model output at Twin Gully Swamp and **Table 4.9** presents a summary of that statistical distribution.

From **Figure 4.31**, for the U10 results, the Proposed Case is associated with higher flows than the Null Case, which is consistent with **Figure 4.21**. For the U90 results, the Proposed Case is associated with slightly lower flows than the Null Case. From **Table 4.9**, the modelled median flow in Twin Gully Swamp is 0.37ML/d in the Proposed Case and is 0.35ML/d in the Null Case for the U10 results. This represents an increase of 7% and is considered to be a moderate change. For the U90 results, the modelled median flow is 0.37ML/d in the Proposed Case and is 0.39ML/d in the Null Case. This represents a decrease of 4% and hence is considered to be a minor change.

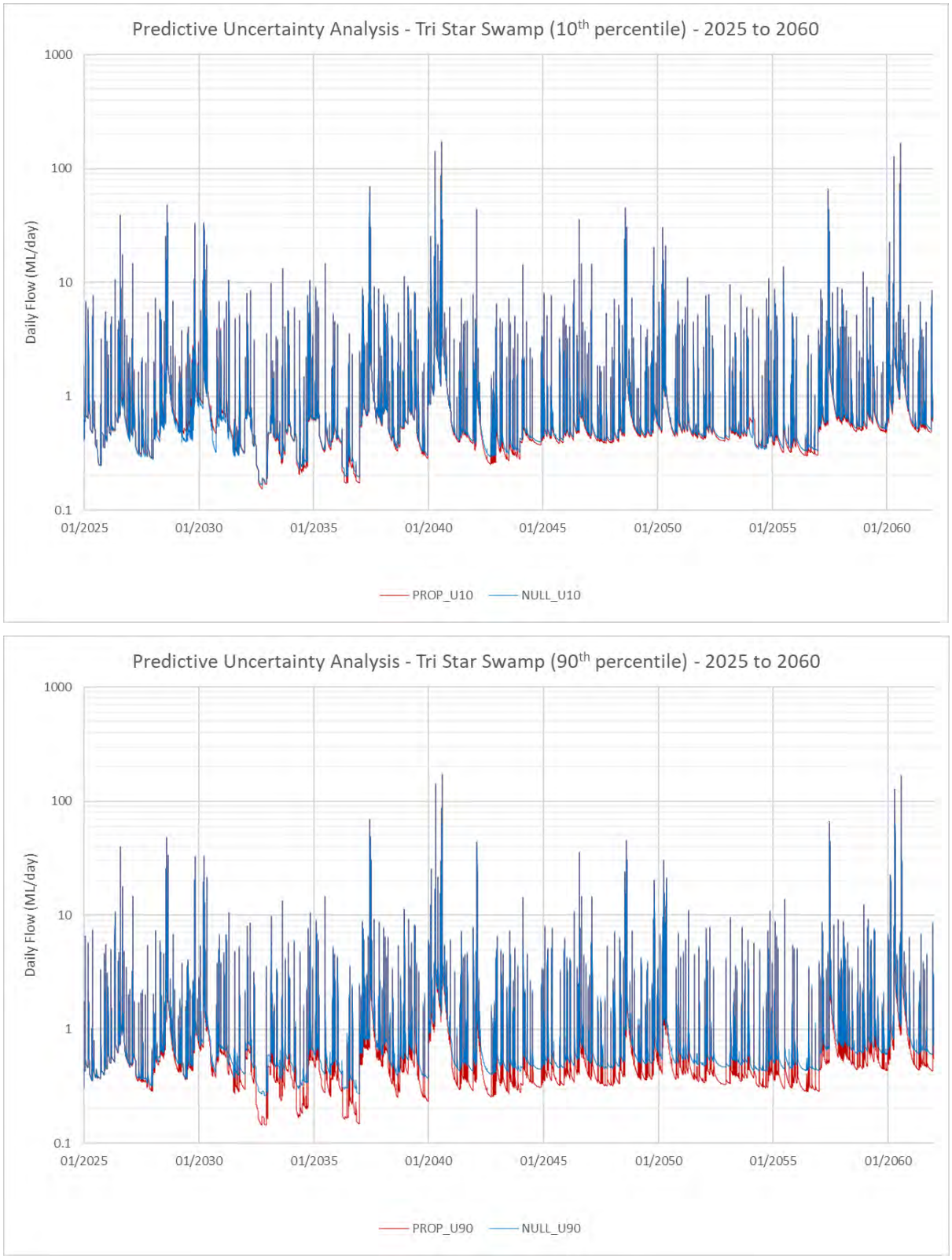


Figure 4.27: Time-Series Model Output – Tri-Star Swamp (Node 324a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

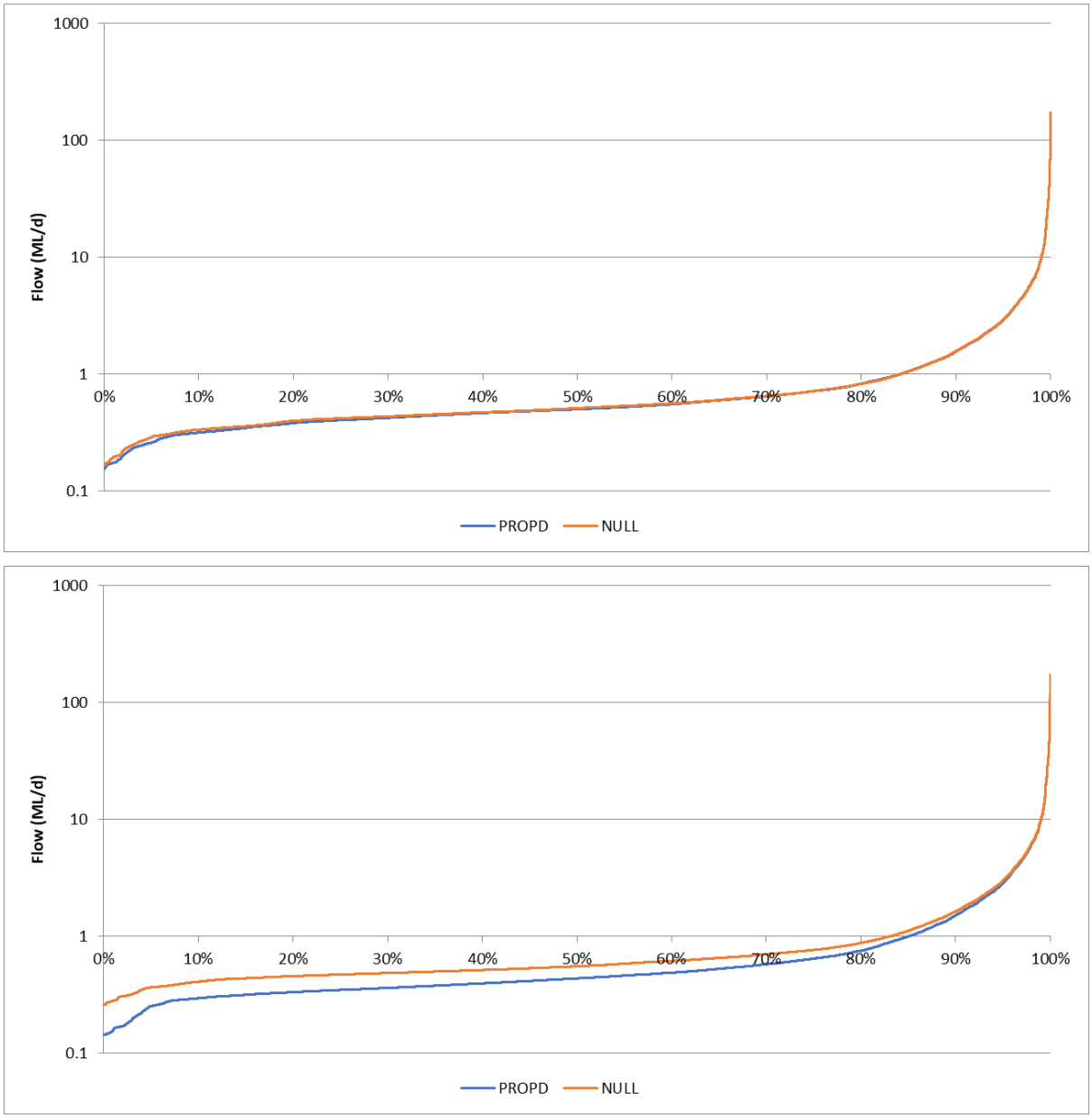


Figure 4.28: Statistical Distribution of Model Output – Tri-Star Swamp (Node 324a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.7: Summary of Statistical Distribution of Model Output – Tri-Star Swamp (Node 324a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.15	0.16	-6	0.14	0.26	-45
5%	0.26	0.29	-11	0.25	0.37	-31
10%	0.32	0.33	-5	0.30	0.41	-28
20%	0.38	0.40	-5	0.33	0.46	-27
50%	0.50	0.51	-2	0.44	0.55	-21
80%	0.83	0.83	0	0.75	0.88	-14
90%	1.6	1.6	-1	1.5	1.6	-7
95%	2.9	2.9	0	2.9	3.0	-4
Max	173	173	0	173	173	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

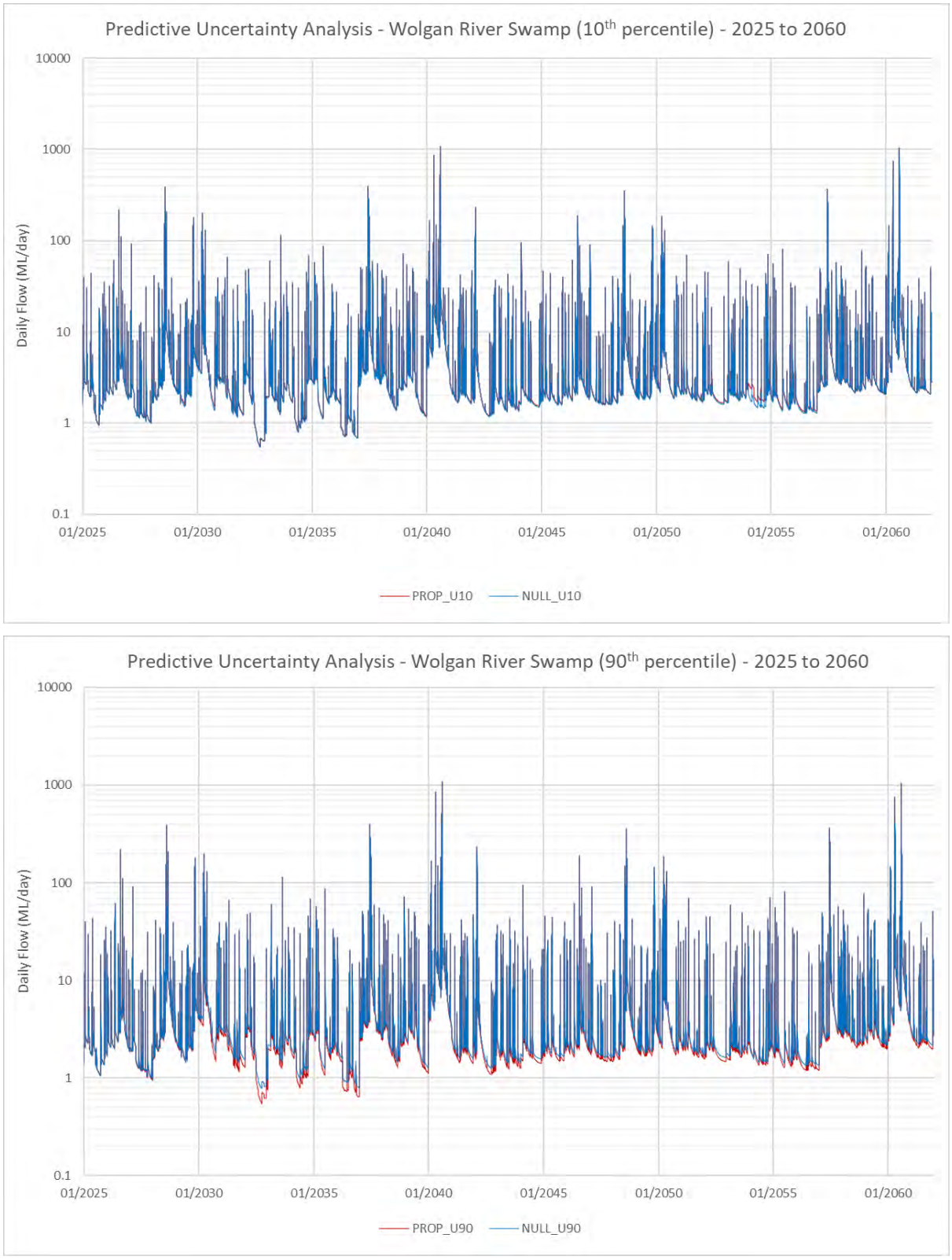


Figure 4.29: Time-Series Model Output – Wolgan River Swamp (Node 332a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

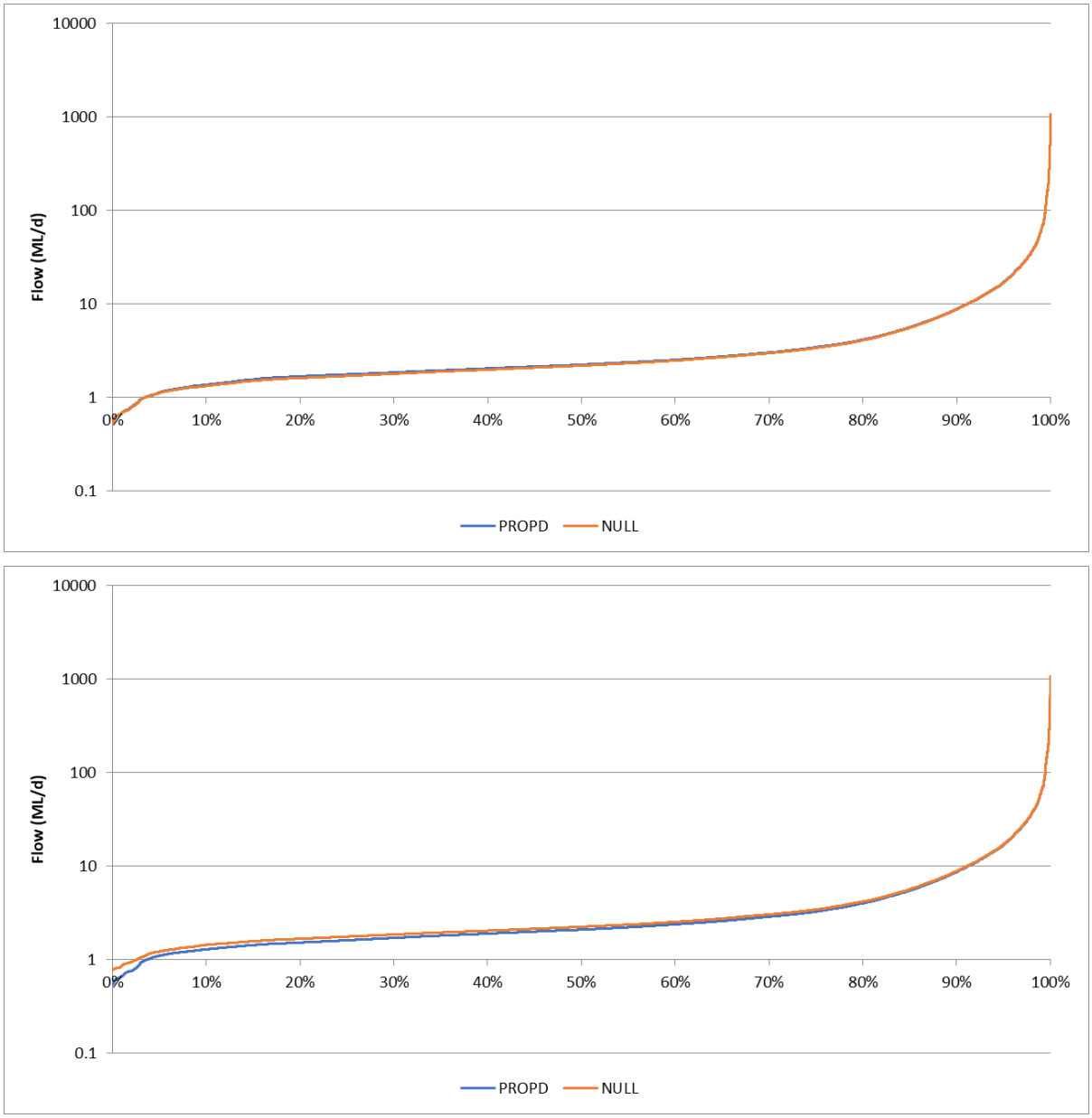


Figure 4.30: Statistical Distribution of Model Output – Wolgan River Swamp (Node 332a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.8: Summary of Statistical Distribution of Model Output – Wolgan River Swamp (Node 332a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.55	0.54	2	0.54	0.78	-30
5%	1.1	1.1	1	1.1	1.2	-10
10%	1.4	1.3	3	1.3	1.4	-11
20%	1.7	1.6	4	1.5	1.7	-9
50%	2.2	2.2	2	2.1	2.2	-7
80%	4.2	4.1	1	4.0	4.2	-4
90%	8.9	8.8	1	8.7	8.8	-2
95%	17	17	0	17	17	-1
Max	1081	1081	0	1080	1081	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

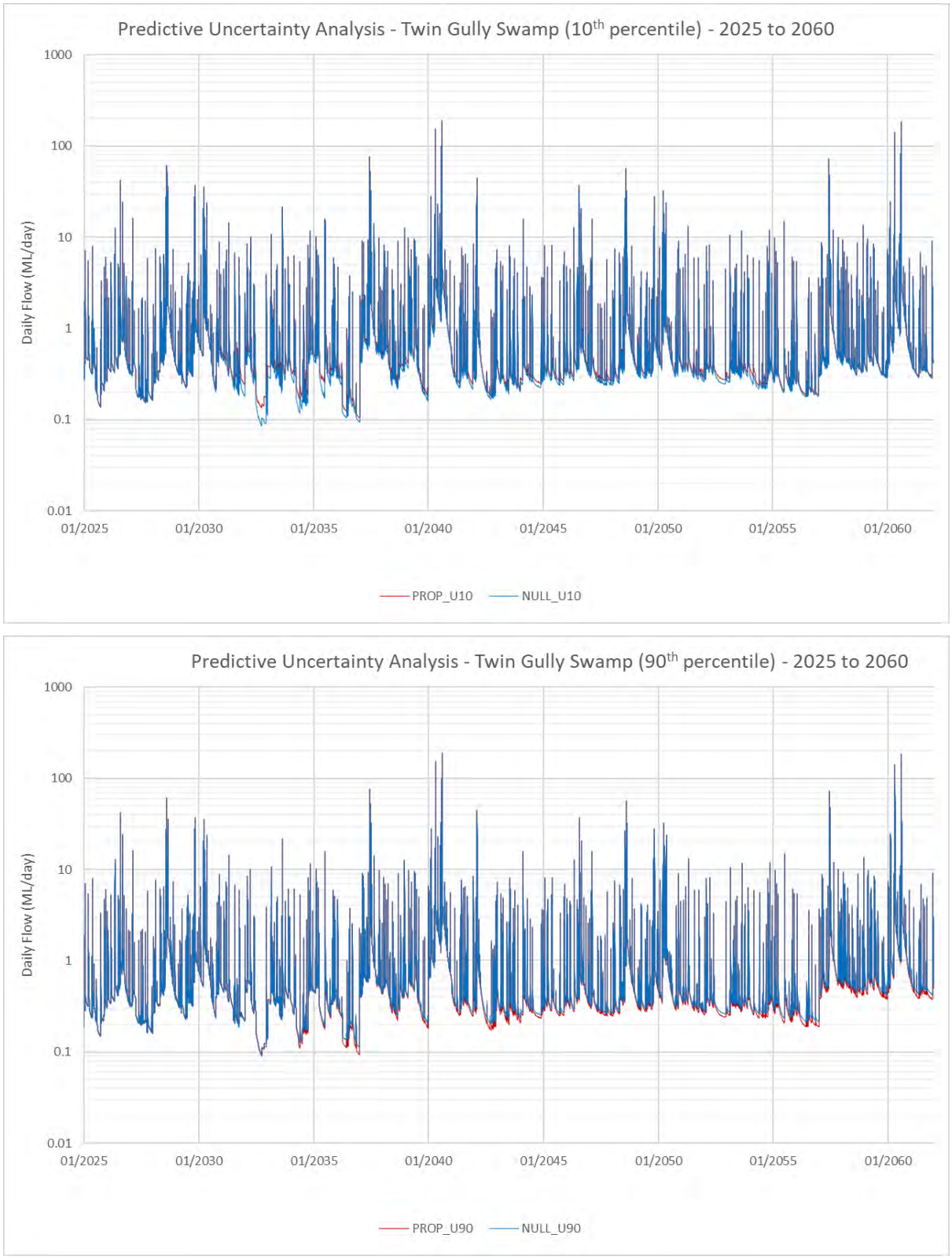


Figure 4.31: Time-Series Model Output – Twin Gully Swamp (Node 322a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

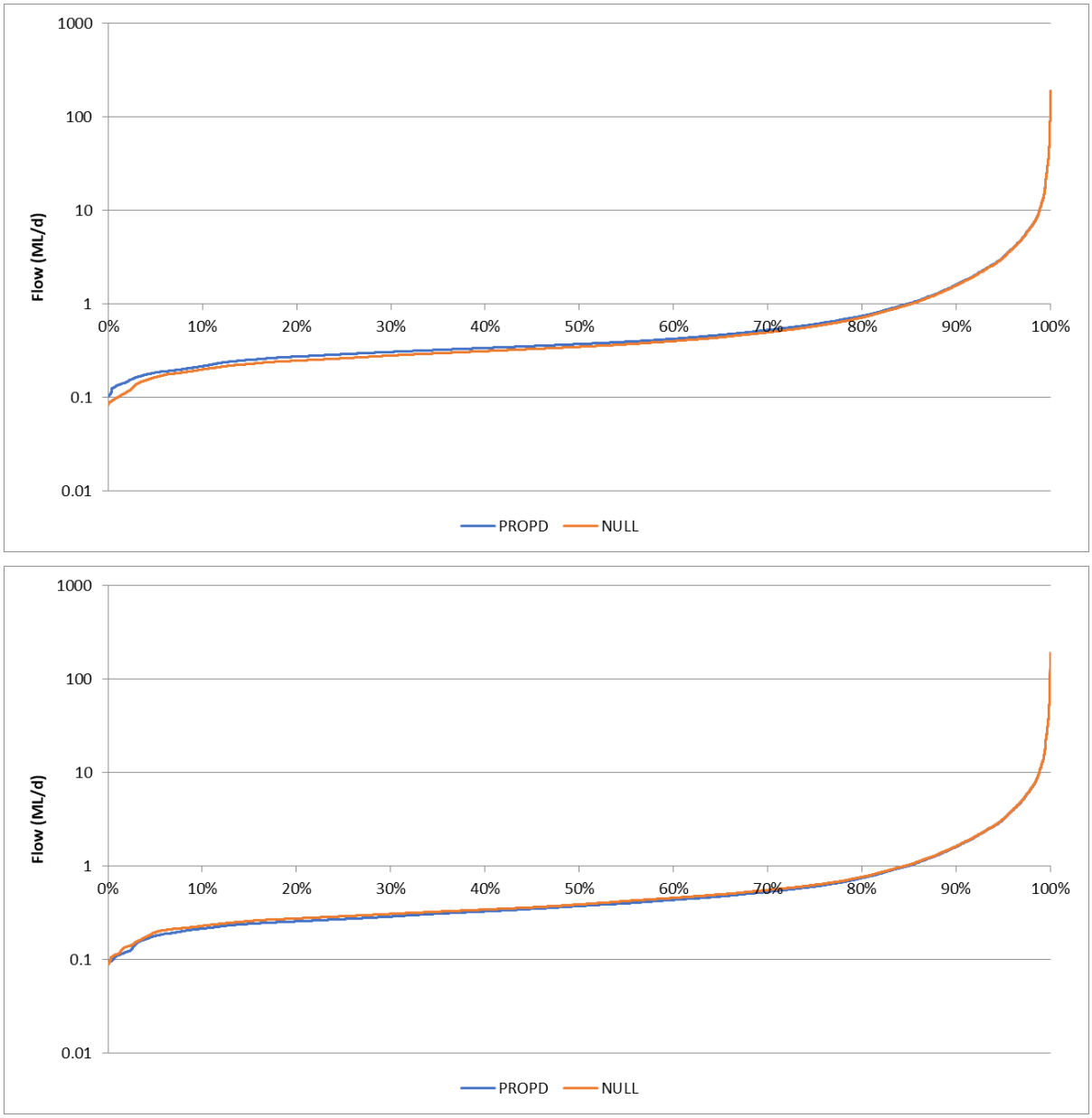


Figure 4.32: Statistical Distribution of Model Output – Twin Gully Swamp (Node 322a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.9: Summary of Statistical Distribution of Model Output – Twin Gully Swamp (Node 322a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.10	0.08	24	0.09	0.09	3
5%	0.18	0.17	12	0.18	0.20	-8
10%	0.22	0.20	8	0.21	0.23	-7
20%	0.27	0.25	11	0.26	0.28	-7
50%	0.37	0.35	7	0.37	0.39	-4
80%	0.75	0.72	4	0.75	0.77	-3
90%	1.6	1.6	2	1.6	1.6	-1
95%	3.2	3.1	1	3.2	3.2	-1
Max	191	191	0	191	191	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

Crocodile Swamp

Figure 4.33 presents time-series output from the SAPSWBM at Crocodile Swamp. **Figure 4.34** presents the statistical distribution of that model output, which is summarised in **Table 4.10**.

From **Table 4.10**, the change to modelled median flow rate ranges between a 5% increase in the U10 results to a 1% decrease in the U90 results. At the 10th% level, the change in flow rate ranges between a 5% increase in the U10 results to a 1% decrease in the U90 results. The results presented in **Table 4.10**, indicate a negligible change in flow rate due to the Amended Project.

Birds Rock Swamp

Figure 4.35 presents time-series hydrographs from the model at Birds Rock Swamp, with **Figure 4.36** presenting a statistical distribution of that time-series and **Table 4.11** presenting a summary of that statistical distribution.

From **Table 4.11**, the modelled change in median flow rate (50th% level) is a 0% decrease in U10 results and a 13% decrease in the U90 results. From **Table 4.11**, at the 10th% level, the modelled change to flow ranges between a 4% decrease and a 19% decrease in the U10 and U90 results respectively. From **Table 4.11**, the model outcome is a moderate to large change.

Trail Six Swamp

Figure 4.37 presents time-series model output for Trail Six Swamp. A statistical distribution of model output is presented in **Figure 4.38**, which is summarised in **Table 4.12**.

From **Figure 4.37**, for the U10 results, the Proposed Case is slightly higher flow than the Null Case. From **Figure 4.37**, for the U90 results, the Proposed Case is slightly lower flow than the Null Case. From **Table 4.12**, the modelled median flow is 0.21ML/d in the Proposed Case and is 0.20ML/d in the Null Case for the U10 results. This is considered to be a minor increase, being a 4% change. From **Table 4.12**, the modelled median flow is 0.24ML/d in the Proposed Case and is 0.26ML/d in the Null Case for the U90 results. This is considered to be a moderate decrease, being an 8% change.

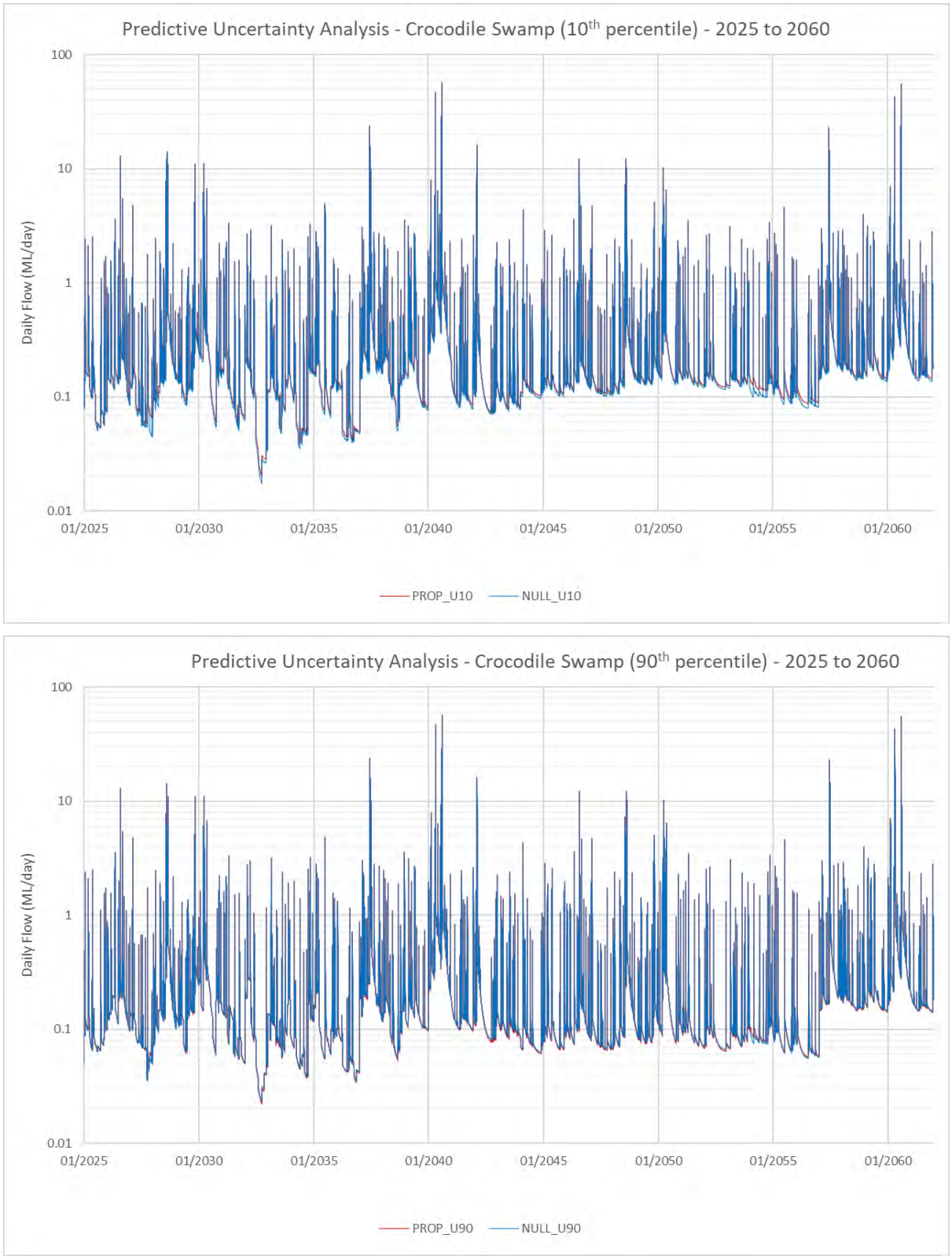


Figure 4.33: Time-Series Model Output – Crocodile Swamp (Node 562a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

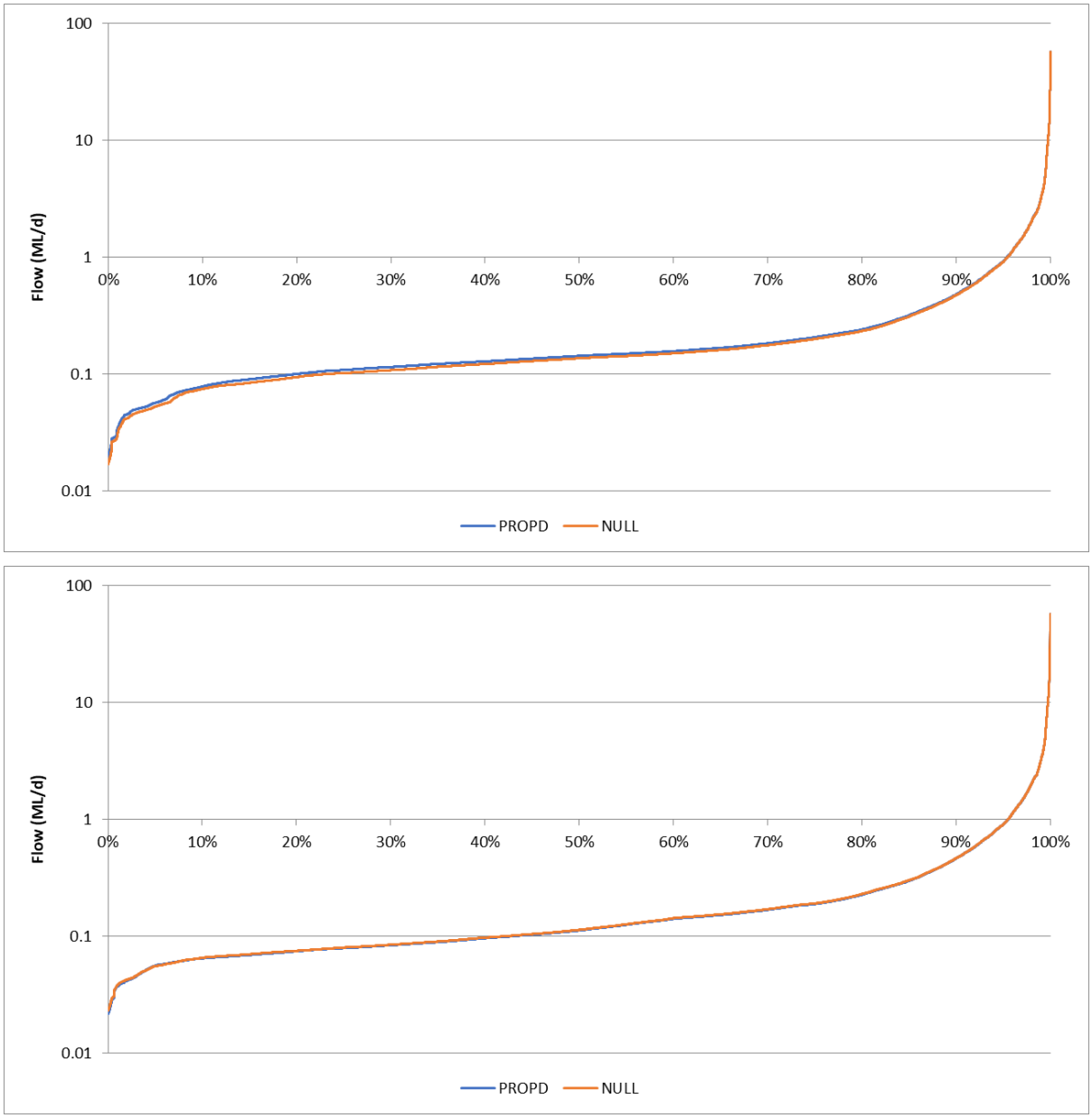


Figure 4.34: Statistical Distribution of Model Output – Crocodile Swamp (Node 562a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.10: Summary of Statistical Distribution of Model Output – Crocodile Swamp (Node 562a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.02	0.02	17	0.02	0.02	-6
5%	0.06	0.05	8	0.06	0.06	1
10%	0.08	0.07	5	0.06	0.07	-1
20%	0.10	0.09	7	0.07	0.08	-1
50%	0.14	0.14	5	0.11	0.11	-1
80%	0.24	0.23	3	0.23	0.23	-1
90%	0.48	0.47	2	0.46	0.47	-1
95%	0.92	0.91	1	0.91	0.91	0
Max	57	57	0	57	57	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

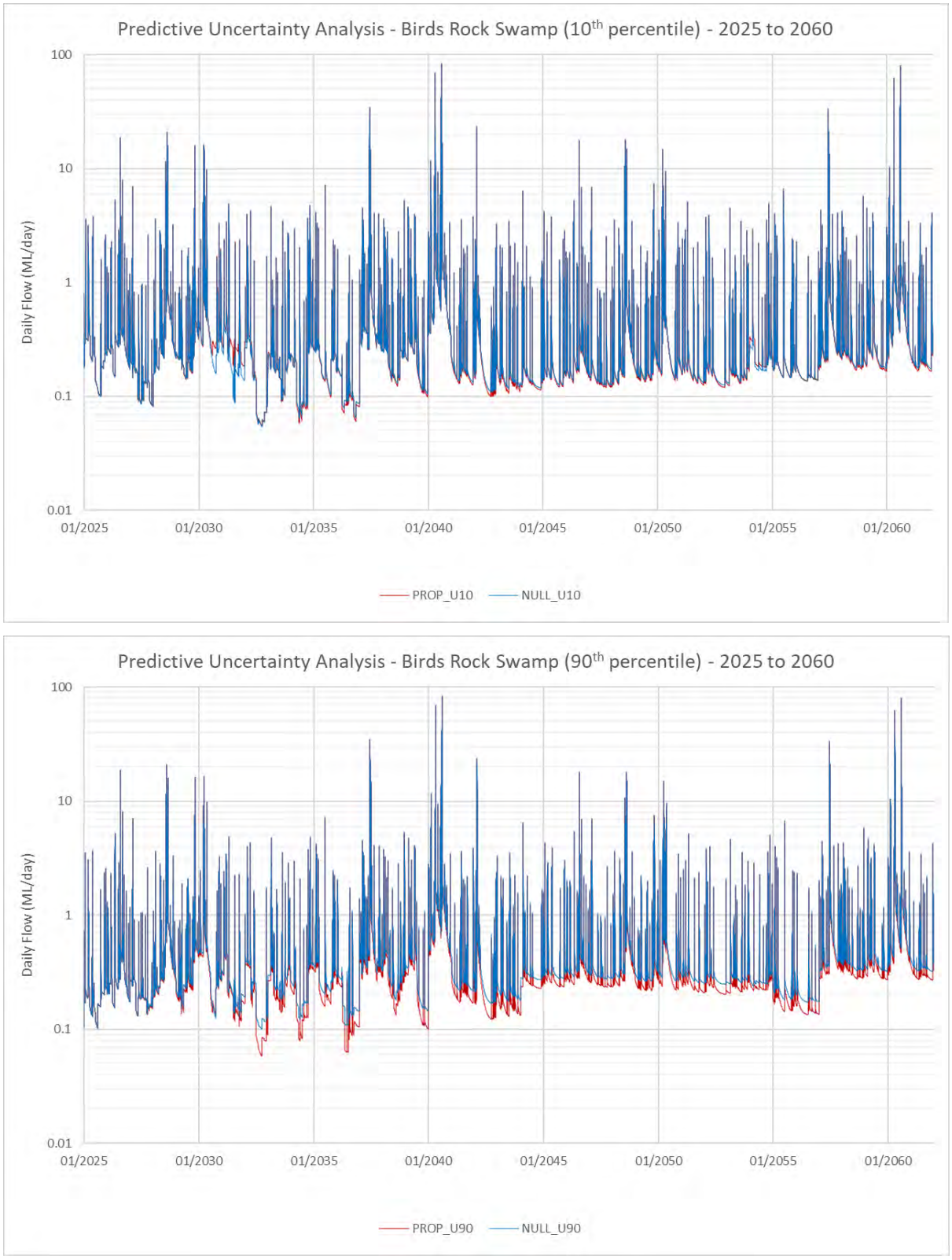


Figure 4.35: Time-Series Model Output – Birds Rock Swamp (Node 497a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

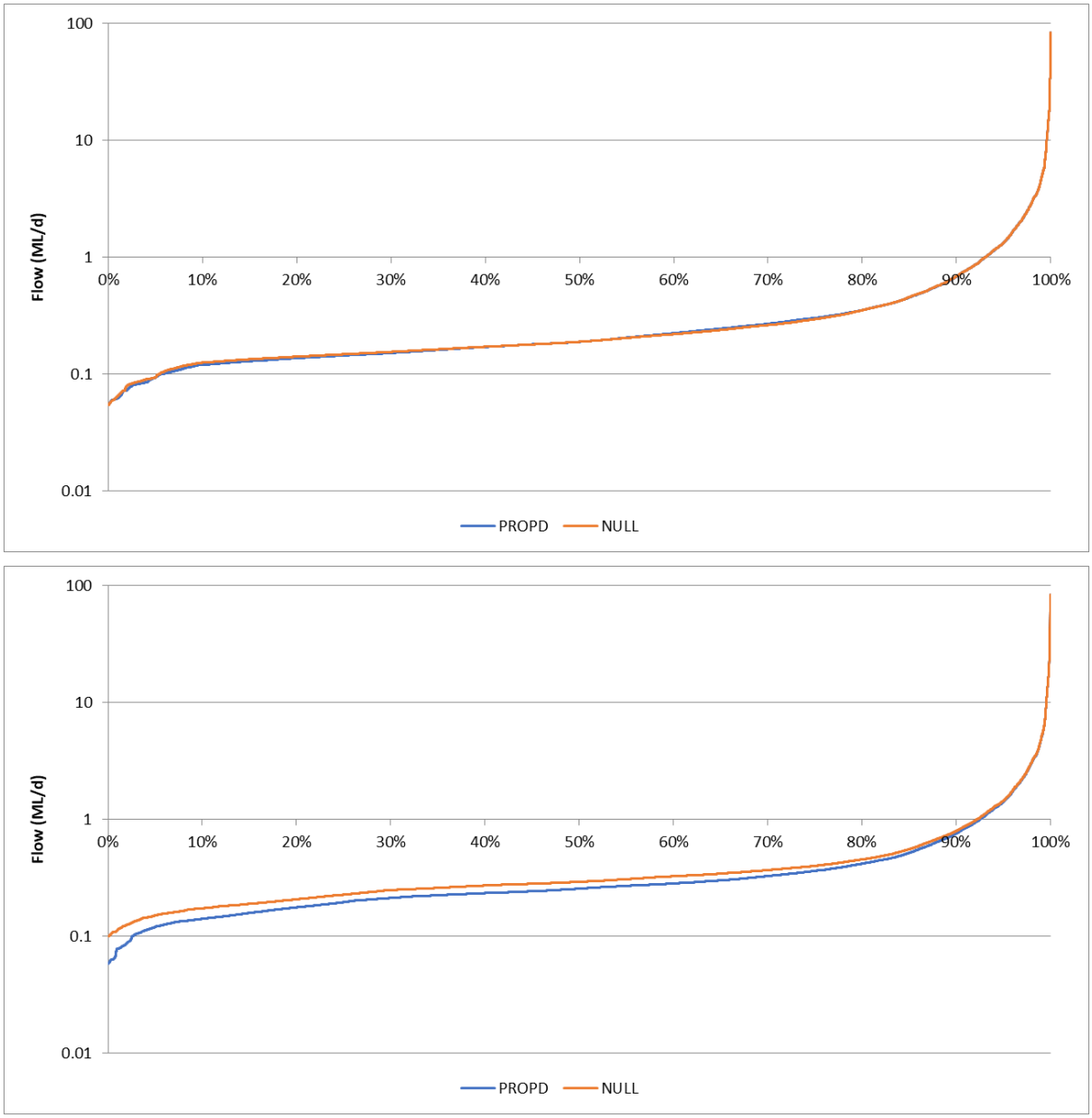


Figure 4.36: Statistical Distribution of Model Output – Birds Rock Swamp (Node 497a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.11: Summary of Statistical Distribution of Model Output – Birds Rock Swamp (Node 497a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.05	0.05	1	0.06	0.10	-42
5%	0.09	0.09	-1	0.12	0.15	-20
10%	0.12	0.13	-4	0.14	0.17	-19
20%	0.14	0.14	-3	0.18	0.21	-15
50%	0.19	0.19	0	0.26	0.29	-13
80%	0.35	0.35	0	0.42	0.46	-8
90%	0.69	0.69	-1	0.76	0.80	-5
95%	1.3	1.3	0	1.4	1.4	-3
Max	83	83	0	84	84	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

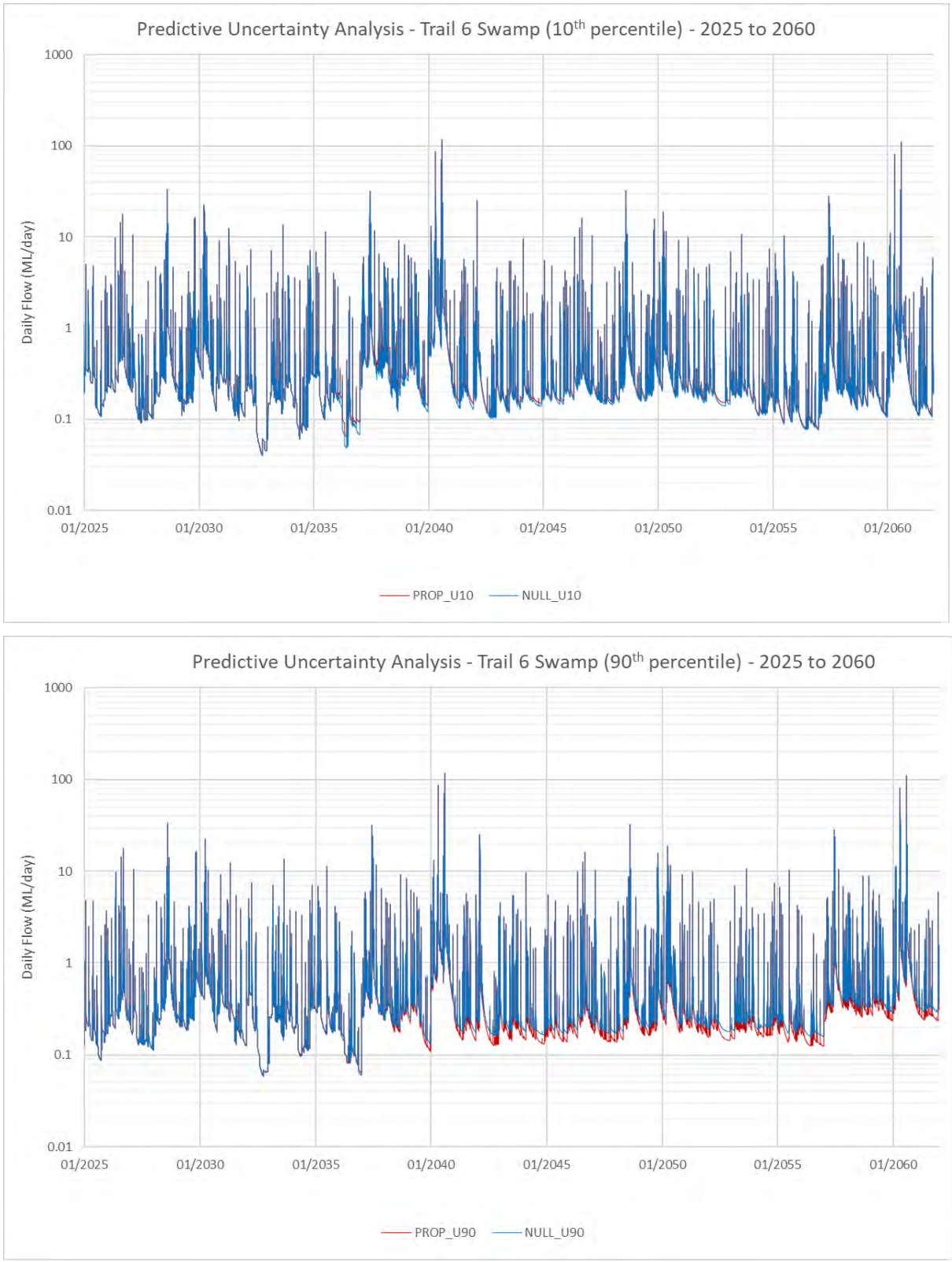


Figure 4.37: Time-Series Model Output – Trail Six Swamp (Node 342a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

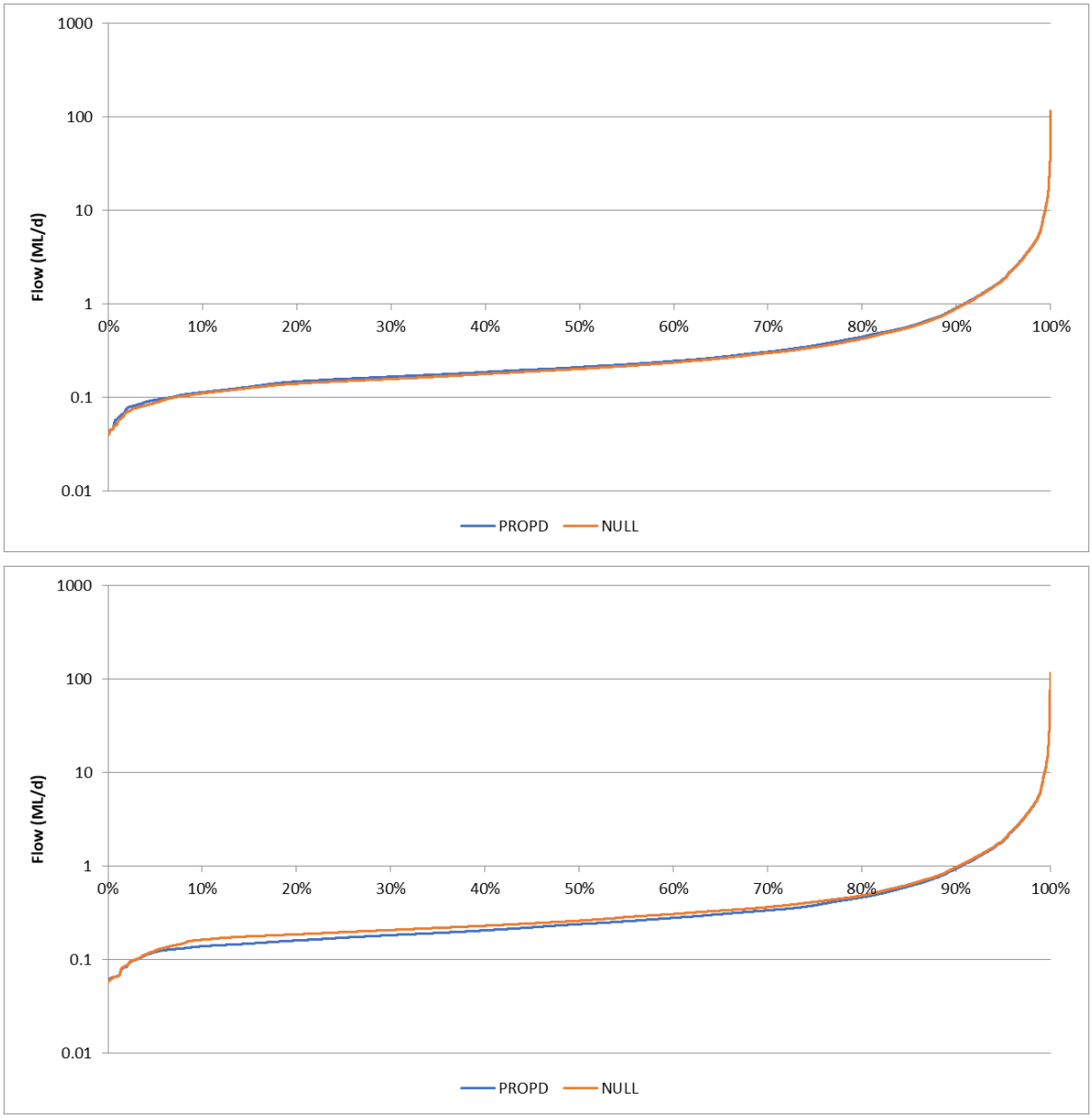


Figure 4.38: Statistical Distribution of Model Output – Trail Six Swamp (Node 342a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.12: Summary of Statistical Distribution of Model Output – Trail Six Swamp (Node 342a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.04	0.04	0	0.06	0.06	0
5%	0.09	0.09	7	0.12	0.12	-3
10%	0.11	0.11	2	0.14	0.16	-15
20%	0.15	0.14	6	0.16	0.19	-14
50%	0.21	0.20	4	0.24	0.26	-8
80%	0.45	0.43	5	0.47	0.49	-4
90%	0.91	0.90	1	0.95	0.98	-3
95%	1.9	1.8	1	1.9	1.9	-2
Max	117	117	0	117	117	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

4.9 Cumulative Impact Considerations

The approach adopted to Cumulative Impact Assessment in the SAPSWBM has been to:

- develop a Proposed Case based on extension of existing mining operations at Angus Place Colliery into the 1000 Panel Area.
    - the Proposed Case includes the extension of operation of Springvale Mine, with respect to maintaining Springvale Mine in a dewatered state through to 2053.
- develop a Null Case based on cessation of mining at Angus Place Colliery and the adjacent operation at Springvale at the end of 2029.
    - Both Angus Place Colliery and Springvale Mine are existing and approved operations.
- incorporate the potential influence from Clarence Colliery on proposed mining at Angus Place Colliery, although at sufficient distance from Angus Place Colliery to not be significant.

Whilst complicated, the adopted approach takes into account the potential changes to surface water flow due to surrounding existing and approved operations before assessing the proposed changes due to the extension of mining at Angus Place Colliery into the 1000 Panel Area.

It is highlighted that the adopted approach assumes all changes to surface water are due to the Amended Project, inclusive of changes associated with the extension of duration of dewatering at Springvale Mine.

4.10 Climate Change Scenarios

4.10.1 Approach to Uncertainty Analysis

The approach to predictive uncertainty for the Climate Change scenarios is consistent with the approach for the median rainfall/evapotranspiration presented in **Section 4.8.1**.

4.10.2 Model Setup

The Proposed and Null Case assumptions were the same as that presented in **Section 4.8.2**.

As presented in **Section 3.2**, outcomes from the NARCliM were used to identify a 'Highest Cumulative Rainfall, Lower Cumulative Evaporation' scenario (referred to as High Rainfall) and a 'Lowest Cumulative Rainfall, Higher Cumulative Evaporation' scenario (referred to as Low Rainfall).

The climate data in the SAPSWBM was updated to reflect the High Rainfall and Low Rainfall scenarios and groundwater model input was switched to the High Rainfall and Low Rainfall versions.

It is noted that the same multiplicative factor of 0.2 was applied to groundwater model input to the SAPSWBM.

4.10.3 Predictive Uncertainty Results

4.10.3.1 High Rainfall Scenario

<u>Wolgan River Swamp Upper Swamp</u>

Figure 4.39 presents the time-series hydrographs for Wolgan River Swamp Upper Swamp. **Figure 4.40** presents the flow-duration curve associated with that time-series and **Table 4.13** presents the summary of that flow-duration curve.

From **Table 4.13**, the modelled median flow rate is 1.3ML/d in the U10 results and is 1.2ML/d in the U90 results. The modelled change to median flow rate ranges between +4% and -1%.

From **Table 4.13**, the modelled change in median flow rate in the High Rainfall Scenario is essentially the same as that presented in **Table 4.6**, which considers median rainfall conditions.

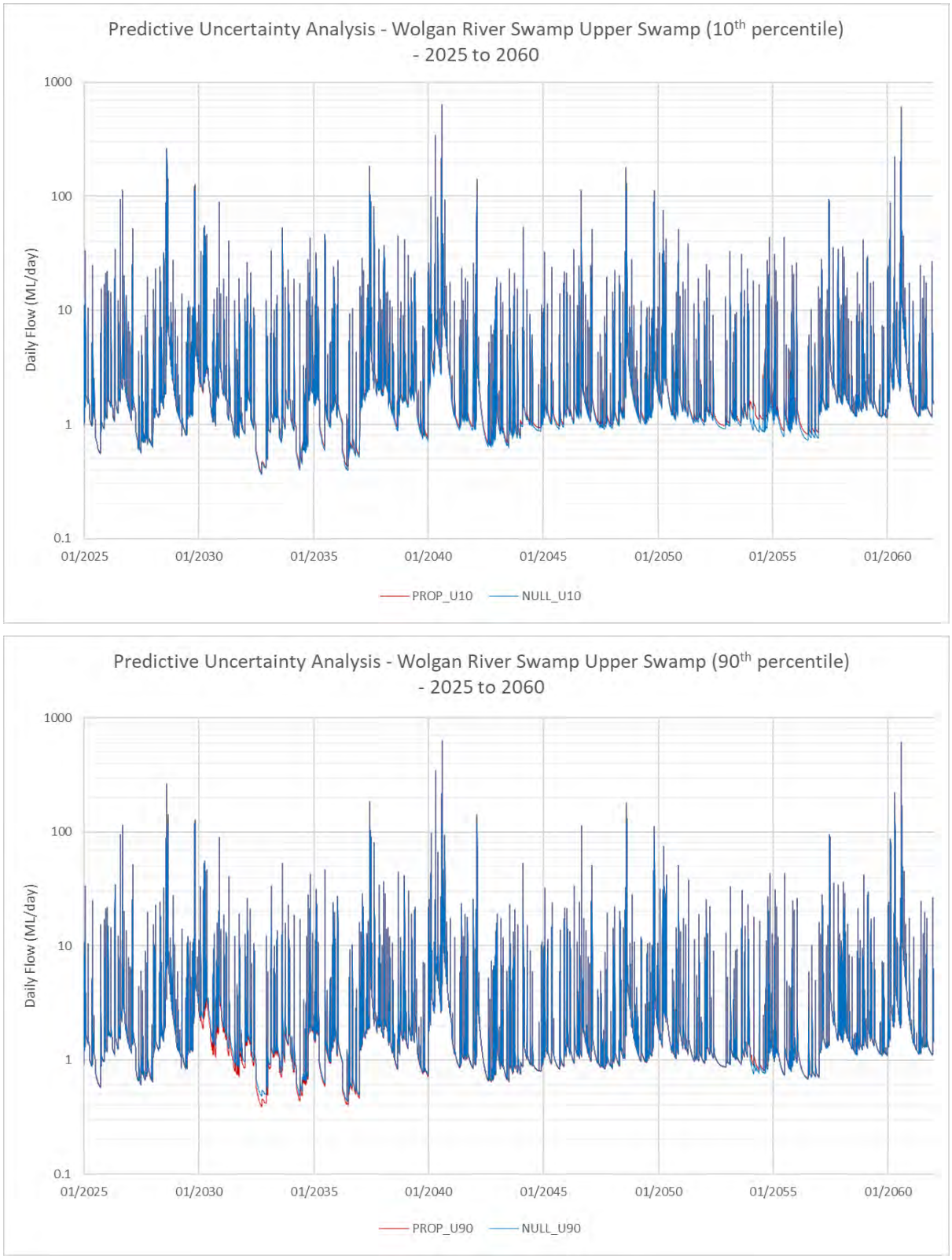


Figure 4.39: Time-Series Model Output (High Rainfall) – Wolgan River Swamp Upper Swamp (Node 325a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

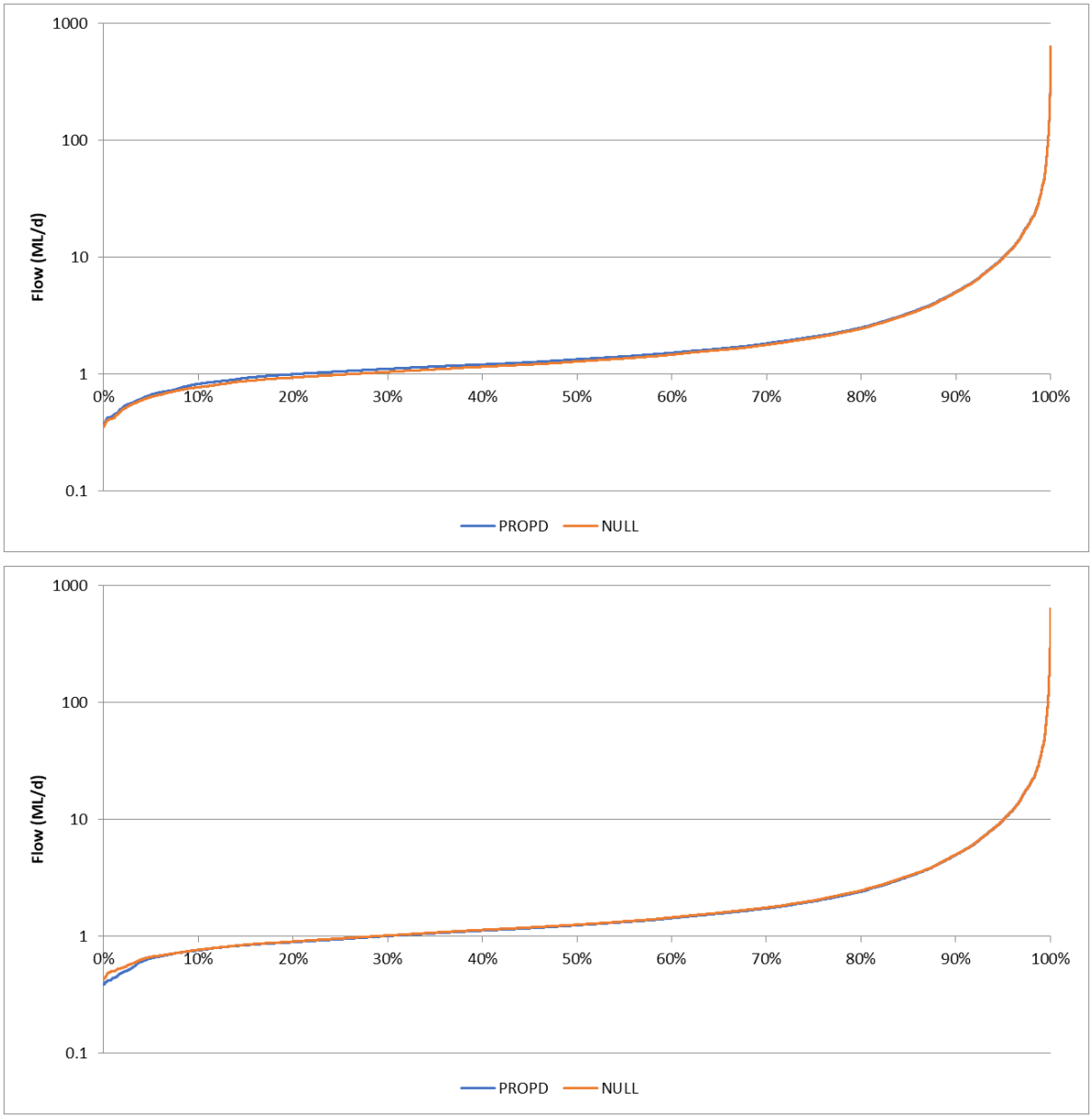


Figure 4.40: Statistical Distribution of Model Output (High Rainfall) – Wolgan River Swamp Upper Swamp (Node 325a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.13: Summary of Statistical Distribution of Model Output (High Rainfall) – Wolgan River Swamp Upper Swamp (Node 325a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.37	0.36	4	0.38	0.43	-11
5%	0.67	0.64	5	0.65	0.67	-3
10%	0.82	0.77	7	0.76	0.77	-1
20%	1.0	0.9	7	0.89	0.90	-1
50%	1.3	1.3	4	1.2	1.3	-1
80%	2.5	2.5	2	2.4	2.5	-2
90%	5.1	5.0	1	5.0	5.0	0
95%	10	10	1	10	10	0
Max	639	638	0	638	638	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

From **Table 4.13**, the modelled change to flow rate at the 10th% level ranges between a 7% increase in the U10 results to a 1% decrease in the U90 results. The modelled change in flow rate is a negligible decrease.

Tri-Star Swamp

Figure 4.41 presents time-series model output (U10 and U90) at Tri-Star Swamp considering a High Rainfall scenario. **Figure 4.42** presents a statistical distribution of the output presented in **Figure 4.41** and **Table 4.14** presents a summary of the statistical distribution presented in **Figure 4.42**.

From **Table 4.14**, for the U10 results, the modelled median flow is 0.44ML/d in the Proposed Case and is 0.45ML/d in the Null Case. This is considered to represent a negligible change, being a 2% decrease. For the U90 results, the modelled median flow is 0.48ML/d in the Proposed Case and is 0.62ML/d in the Null Case. The difference between the Proposed Case and Null Case is a decrease of 22%, which is assessed as a large change. The magnitude of the decrease is, however, consistent with that presented in **Table 4.7** with respect to median rainfall conditions.

Wolgan River Swamp

Figure 4.43 presents time-series output from the SAPSWBM for the High Rainfall Scenario at Wolgan River Swamp. **Figure 4.44** presents a statistical distribution of the model output, which is summarised in **Table 4.15**.

From **Table 4.15**, the modelled change to median flow rate ranges between a 3% increase and a 6% decrease. The flow rate at the 50th% level is approximately 2.5ML/d.

From **Table 4.15**, the modelled change to the 10th% level flow rate ranges between a 3% increase and an 8% decrease. The flow rate at the 10th% level is 1.6ML/d.

The results presented in **Table 4.15** are consistent with the results presented in **Table 4.8** with respect to median rainfall conditions. This indicates that modelled change is not particularly sensitive to the assumed rainfall condition.

Twin Gully Swamp

Figure 4.45 presents time-series model output at Twin Gully Swamp for the High Rainfall scenario.

Figure 4.46 presents a statistical distribution of model output and **Table 4.16** presents a summary of that statistical distribution.

From **Figure 4.45**, in the U10 results, the Proposed Case flow is slightly higher than the Null Case and in the U90 results, the Proposed Case flow is slightly lower than the Null Case flow. From **Table 4.16**, the modelled median flow in the Proposed Case, for the U10 results, is 0.42ML/d and is 0.39ML/d in the Null Case. This represents an increase of 7% and is considered to be a moderate change. From **Table 4.16**, the modelled median flow in the Proposed Case, for the U90 results, is 0.42ML/d and is 0.45ML/d in the Null Case. This presents a decrease of 7% and is considered to be a moderate change. Comparison of the outcomes in **Table 4.16** with **Table 4.9**, indicates that the U90 model results are a somewhat larger decrease in the High Rainfall scenario compared to Median Rainfall conditions.

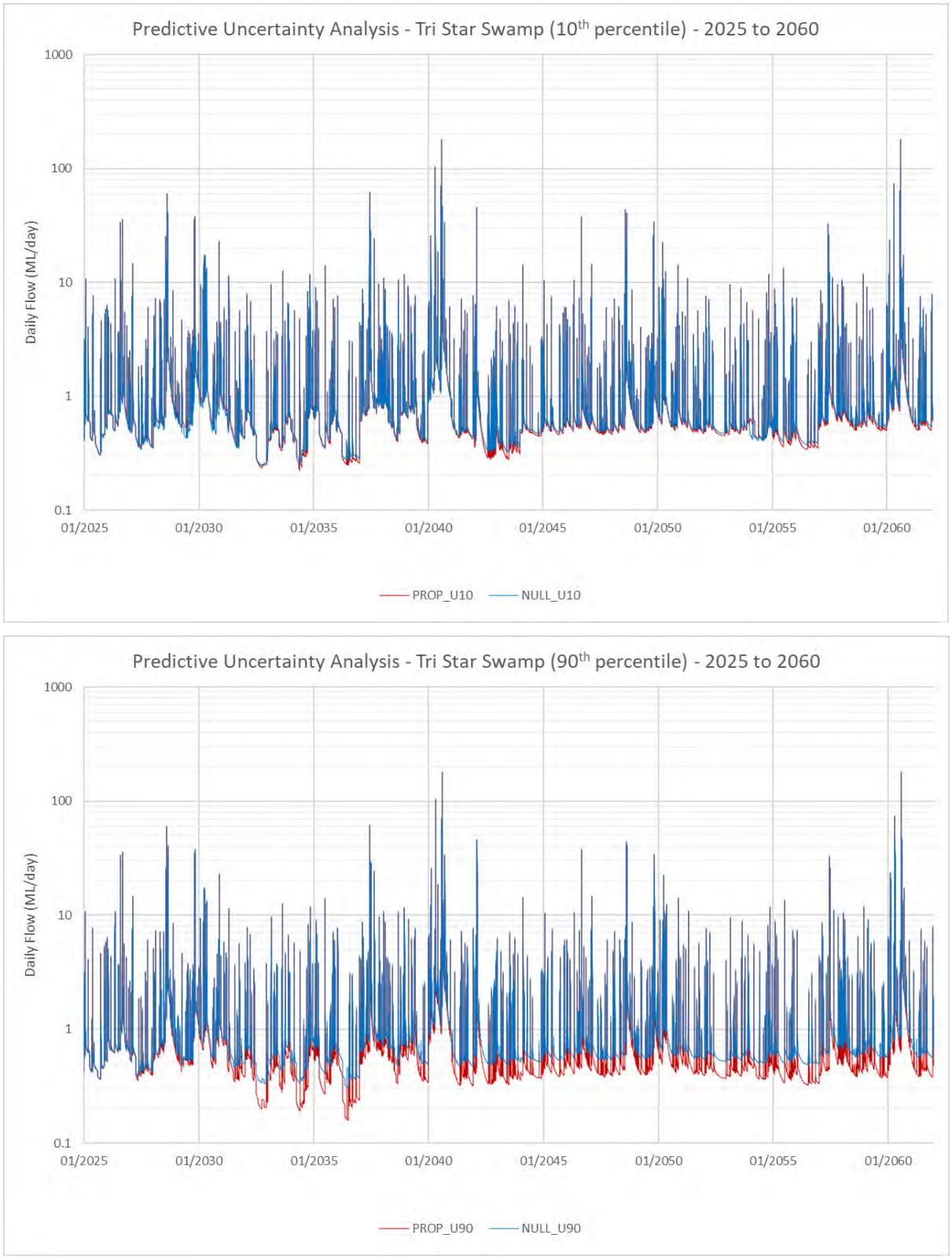


Figure 4.41: Time-Series Model Output (High Rainfall) – Tri-Star Swamp (Node 324a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

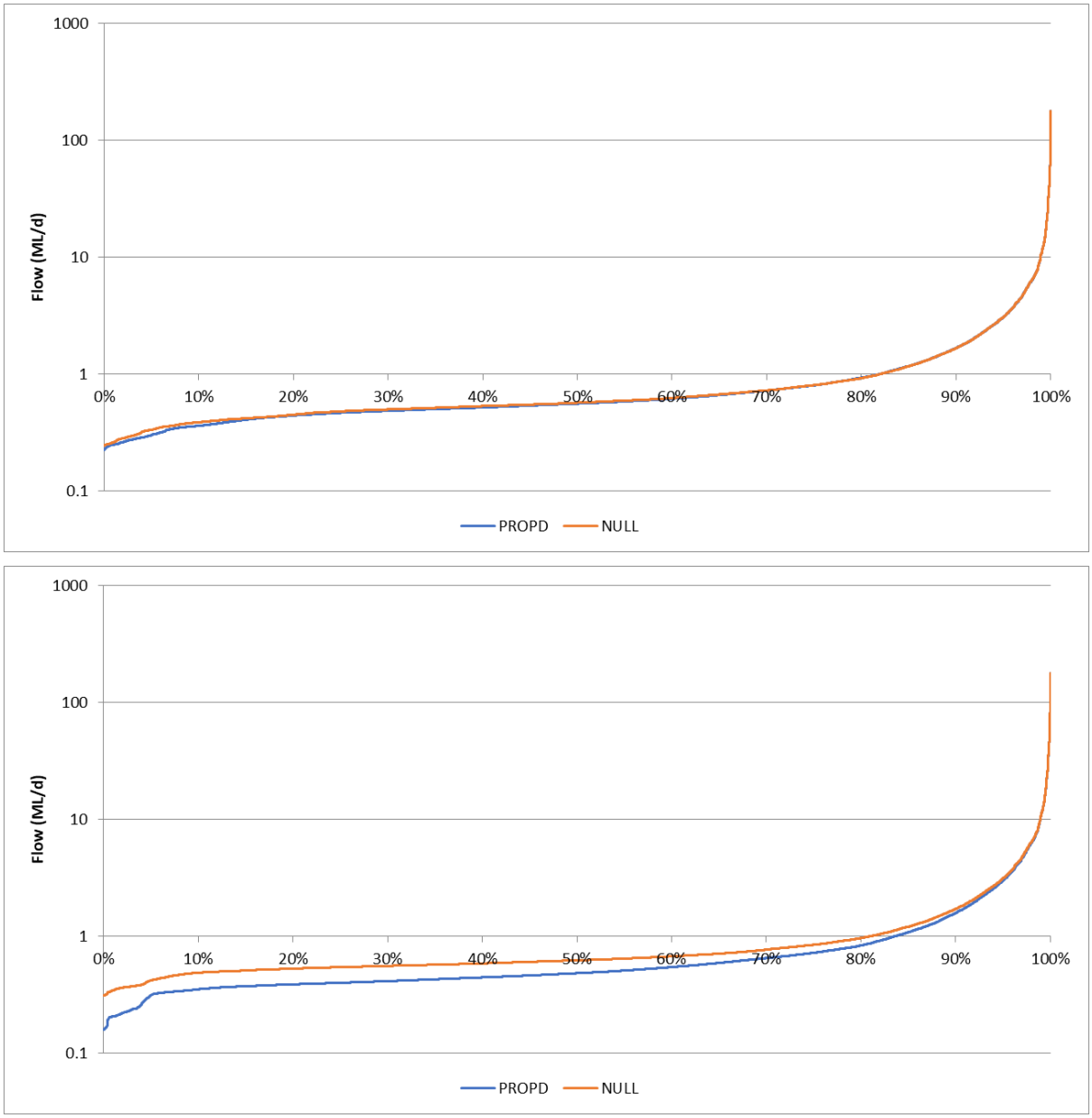


Figure 4.42: Statistical Distribution of Model Output (High Rainfall) – Tri-Star Swamp (Node 324a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.14: Summary of Statistical Distribution of Model Output (High Rainfall) – Tri-Star Swamp (Node 324a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.22	0.25	-9	0.16	0.31	-49
5%	0.30	0.33	-10	0.31	0.42	-26
10%	0.36	0.39	-7	0.35	0.49	-28
20%	0.44	0.45	-2	0.39	0.53	-27
50%	0.56	0.57	-2	0.48	0.62	-22
80%	0.93	0.93	1	0.84	0.97	-14
90%	1.7	1.7	0	1.6	1.7	-8
95%	3.1	3.1	0	3.0	3.1	-5
Max	180	180	0	179	180	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

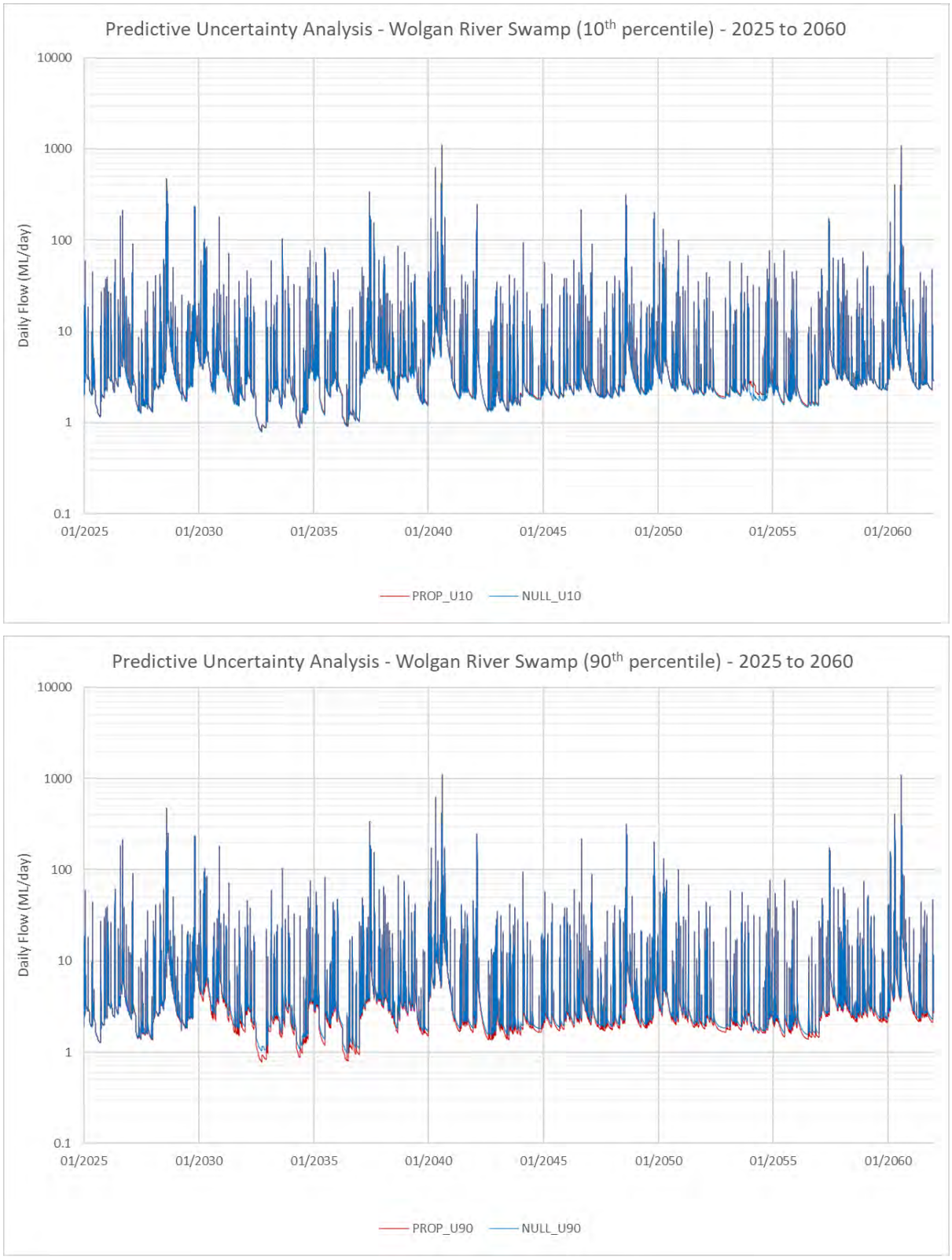


Figure 4.43: Time-Series Model Output (High Rainfall) – Wolgan River Swamp (Node 332a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

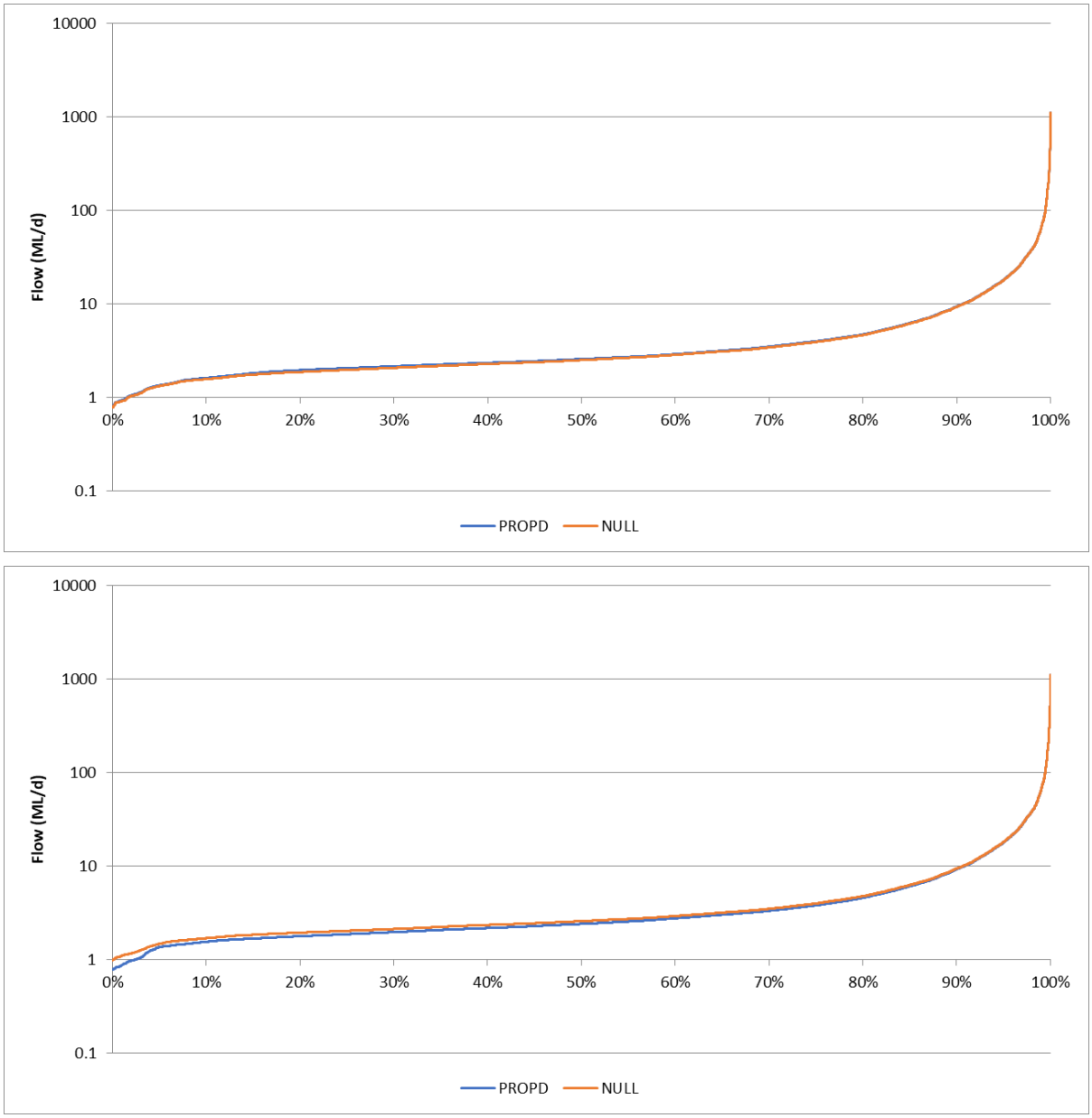


Figure 4.44: Statistical Distribution of Model Output (High Rainfall) – Wolgan River Swamp (Node 332a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.15: Summary of Statistical Distribution of Model Output (High Rainfall) – Wolgan River Swamp (Node 332a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.80	0.78	2	0.78	0.99	-21
5%	1.3	1.3	2	1.4	1.5	-7
10%	1.6	1.6	3	1.6	1.7	-8
20%	2.0	1.9	5	1.8	1.9	-8
50%	2.6	2.5	3	2.4	2.6	-6
80%	4.7	4.7	1	4.6	4.8	-4
90%	9.4	9.4	1	9.3	9.4	-2
95%	18	18	1	18	18	-1
Max	1,123	1,123	0	1,122	1,123	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

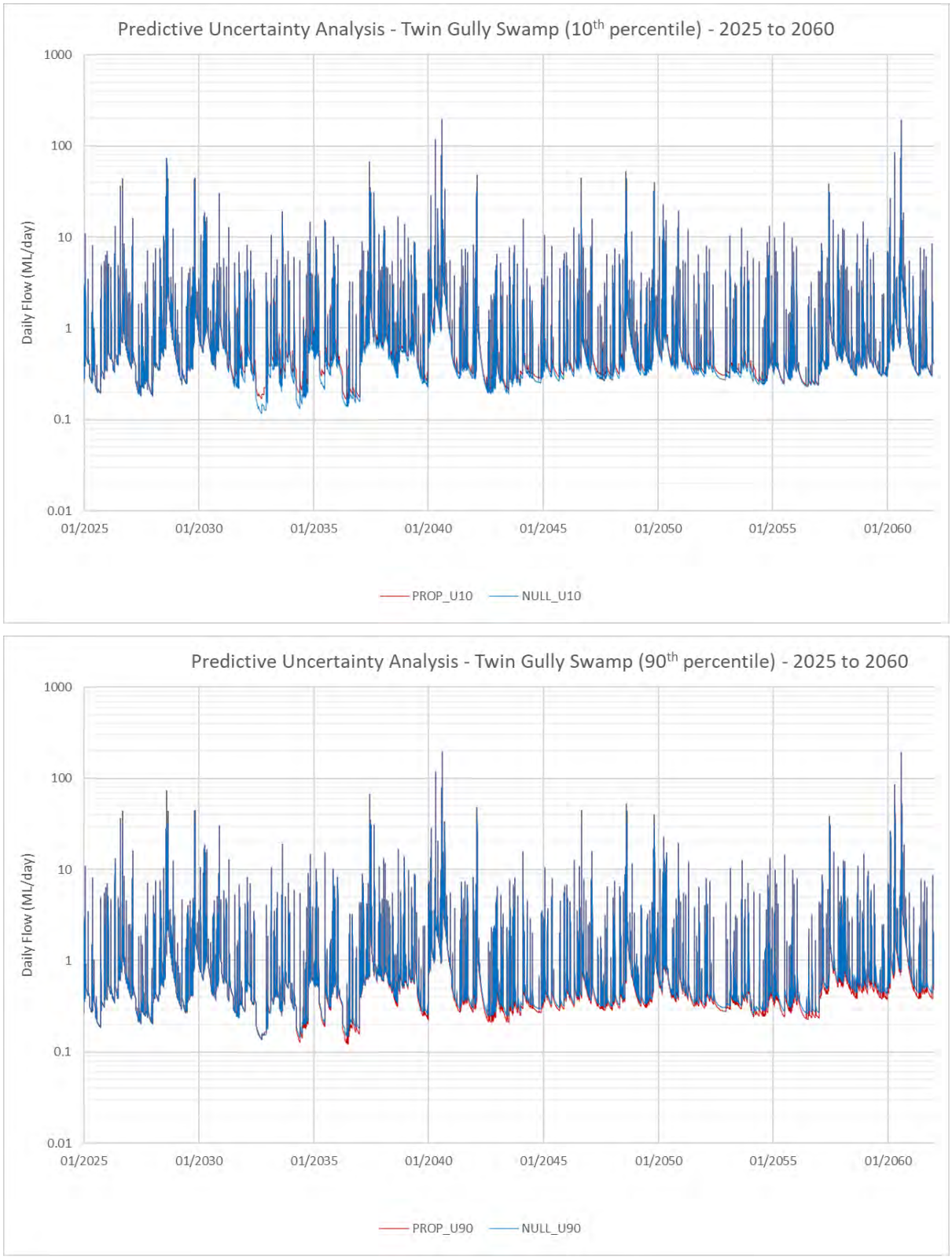


Figure 4.45: Time-Series Model Output (High Rainfall) – Twin Gully Swamp (Node 322a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

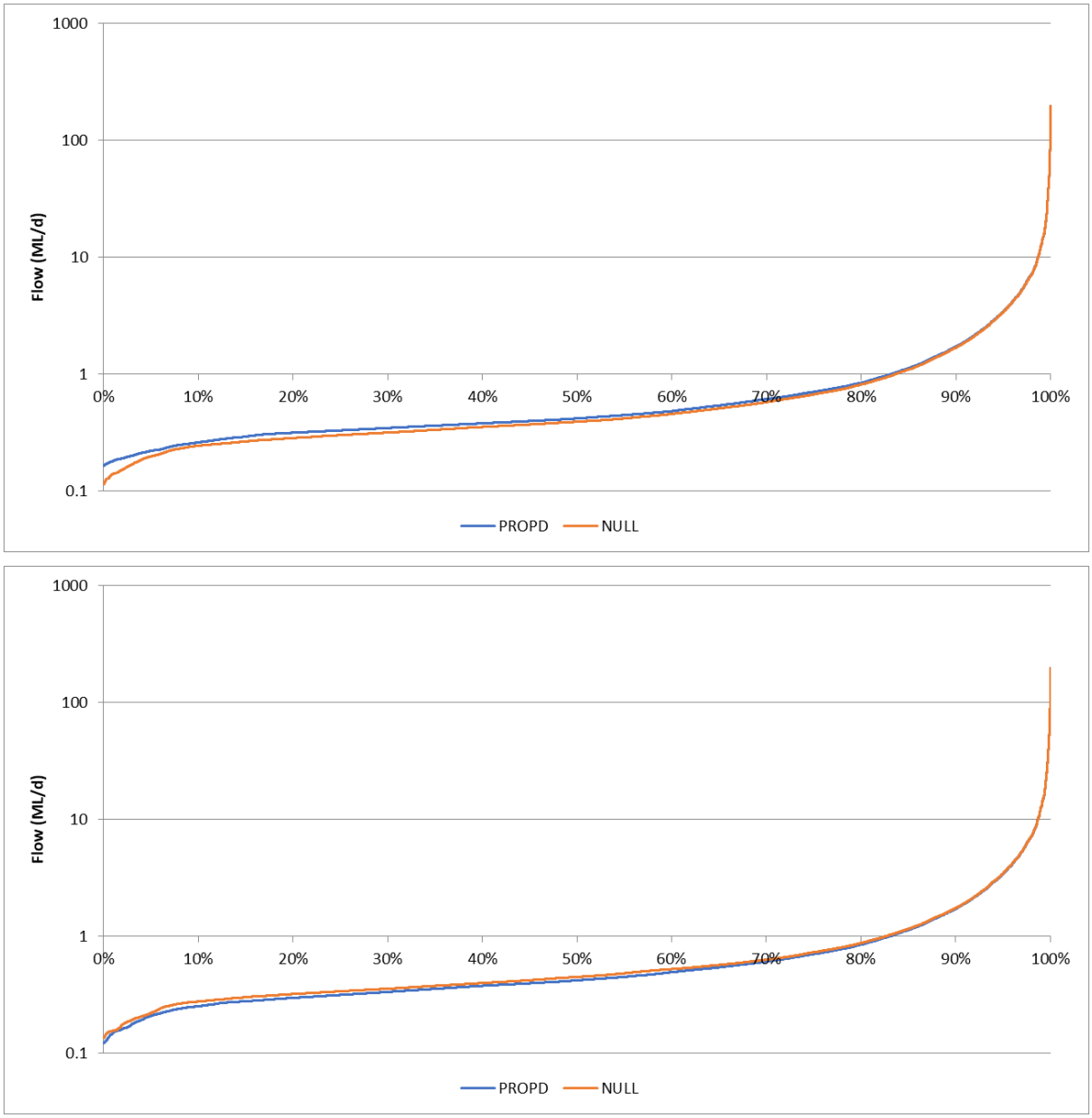


Figure 4.46: Statistical Distribution of Model Output (High Rainfall) – Twin Gully Swamp (Node 322a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.16: Summary of Statistical Distribution of Model Output (High Rainfall) – Twin Gully Swamp (Node 322a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.16	0.12	43	0.12	0.14	-10
5%	0.22	0.20	12	0.21	0.22	-5
10%	0.26	0.24	7	0.25	0.28	-9
20%	0.32	0.28	11	0.30	0.32	-7
50%	0.42	0.39	7	0.42	0.45	-7
80%	0.84	0.82	3	0.85	0.87	-3
90%	1.7	1.7	2	1.7	1.7	-1
95%	3.4	3.4	1	3.4	3.4	-1
Max	198	198	0	198	198	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

Crocodile Swamp

Figure 4.47 presents the time-series output from the model at Crocodile Swamp. **Figure 4.48** presents a statistical distribution of that model output and **Table 4.17** presents a summary of that distribution.

From **Table 4.17**, the modelled change to flow rate at the 50th% level ranges between a 5% increase and a -2% decrease. The modelled flow rate at that level is 0.15 to 0.17ML/d.

From **Table 4.17**, the modelled change to flow rate at the 10th% level is a 7% increase in the U10 results and is a 0% decrease in the U90 results.

From **Table 4.17**, the modelled change to flow rate is minor to negligible, and is consistent with the results presented in **Table 4.10**.

Birds Rock Swamp

Figure 4.49 presents time-series model output at Birds Rock Swamp for the High Rainfall Scenario. **Figure 4.50** presents the statistical distribution of that model output, which is summarised in **Table 4.18**.

From **Table 4.18**, the modelled change to median flow rate is a decrease of 0.01ML/d (1% decrease) in the U10 results and is a 0.04ML/d decrease in the U90 results (14% decrease).

From **Table 4.18**, the modelled change to flow rate at the 10th% flow level is a 0.01ML/d decrease (5% decrease) in the U10 results and is a 0.03ML/d decrease (18% decrease) in the U90 results.

From **Table 4.18**, the modelled change to flow rate at both the 50th% level and the 10th% level is moderate to large.

A comparison between the results presented in **Table 4.18**, which consider the High Rainfall Scenario, and the results presented in **Table 4.11**, which consider median rainfall conditions, indicates that they are consistent.

Trail Six Swamp

Figure 4.51 presents time-series output from the model for Trail Six Swamp. **Figure 4.52** presents the statistical distribution of the model output and **Table 4.19** presents a summary of that statistical distribution.

From **Table 4.19**, the modelled median flow rate is 0.24ML/d in the Proposed Case (U10 results) and is 0.23ML/d in the Null Case. This results an increase of 5% and is assessed as a minor change. From **Table 4.19**, the modelled median flow rate is 0.28ML/d in the Proposed Case (U90 results) and is 0.31ML/d in the Null Case. The difference between the Proposed Case and Null Case is therefore a decrease of 10% and is a moderate change.

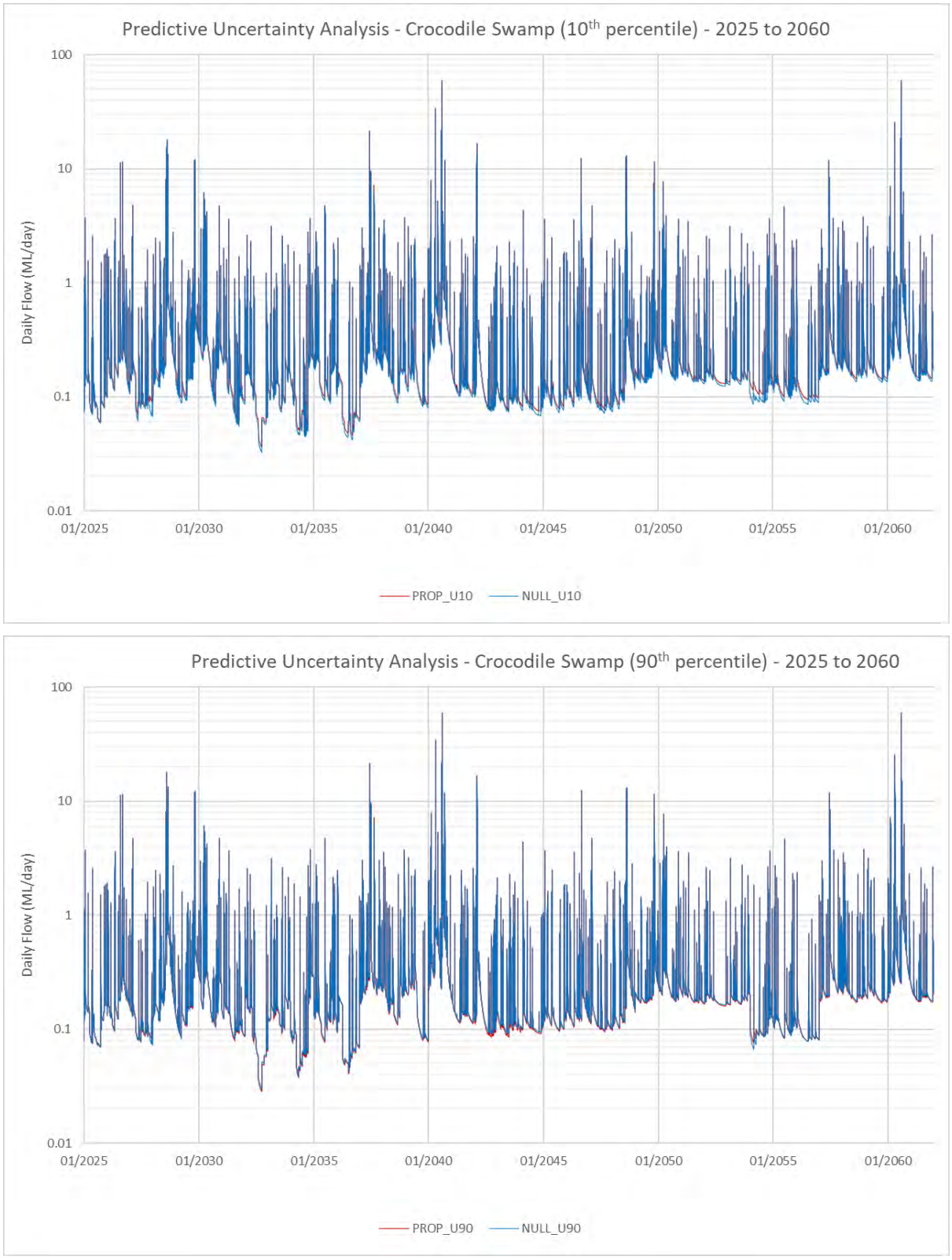


Figure 4.47: Time-Series Model Output (High Rainfall) – Crocodile Swamp (Node 562a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

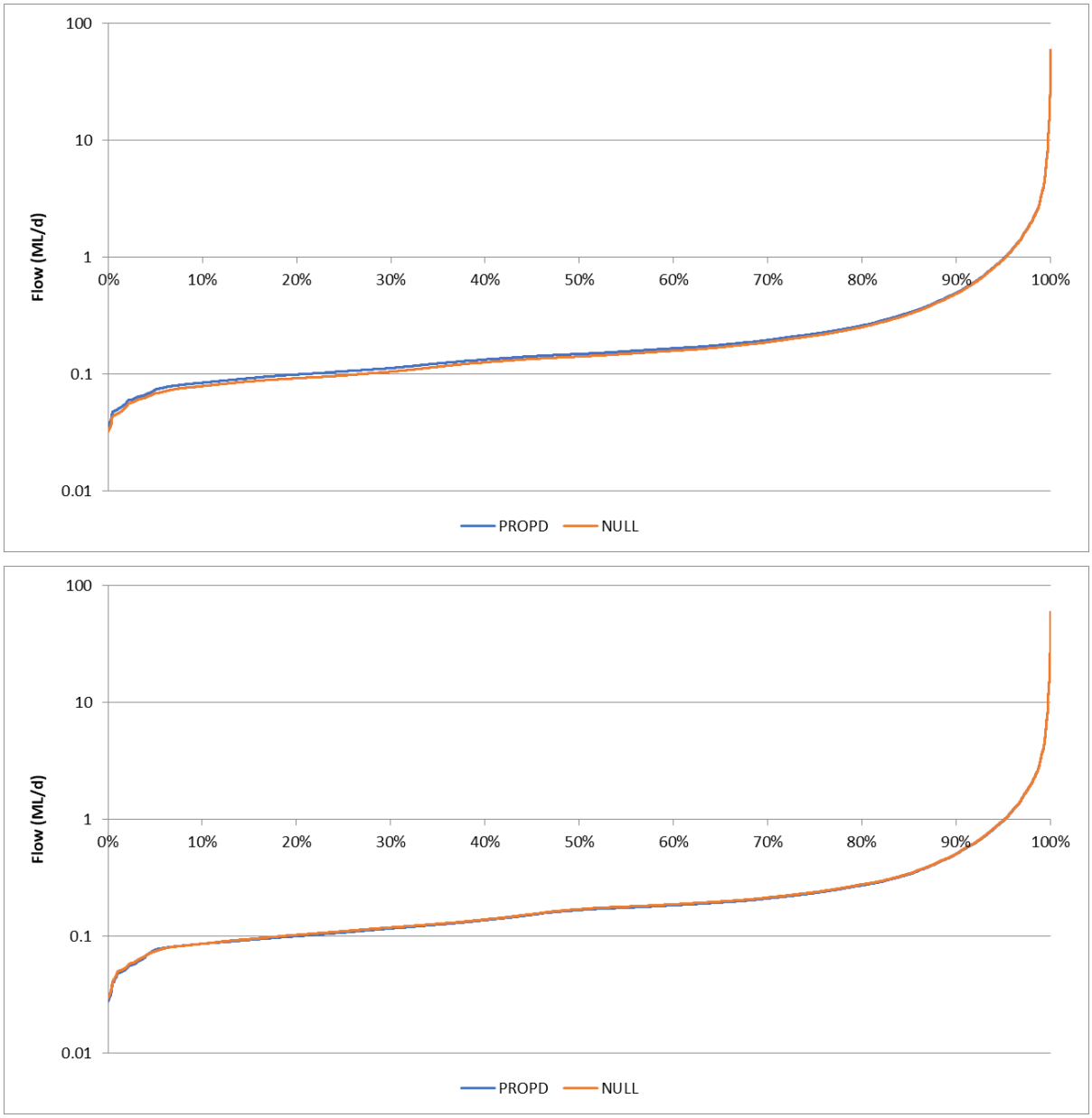


Figure 4.48: Statistical Distribution of Model Output (High Rainfall) – Crocodile Swamp (Node 562a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.17: Summary of Statistical Distribution of Model Output (High Rainfall) – Crocodile Swamp (Node 562a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.04	0.03	12	0.03	0.03	-6
5%	0.07	0.07	7	0.08	0.07	3
10%	0.08	0.08	7	0.09	0.09	0
20%	0.10	0.09	8	0.10	0.10	-3
50%	0.15	0.14	5	0.17	0.17	-2
80%	0.26	0.25	3	0.27	0.28	-2
90%	0.50	0.49	2	0.51	0.51	-1
95%	1.0	1.0	1	1.0	1.0	0
Max	59	59	0	60	60	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

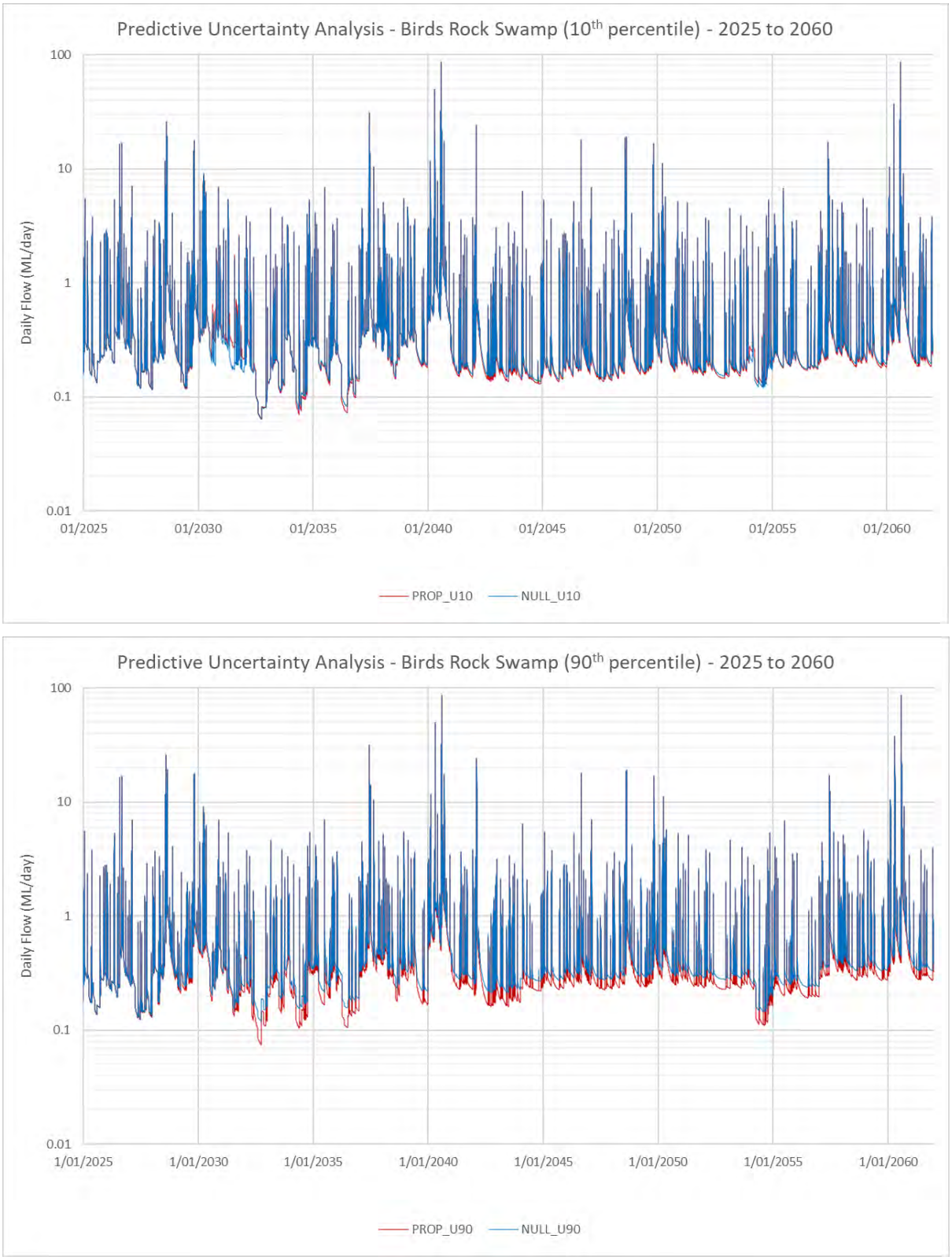


Figure 4.49: Time-Series Model Output (High Rainfall) – Birds Rock Swamp (Node 497a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

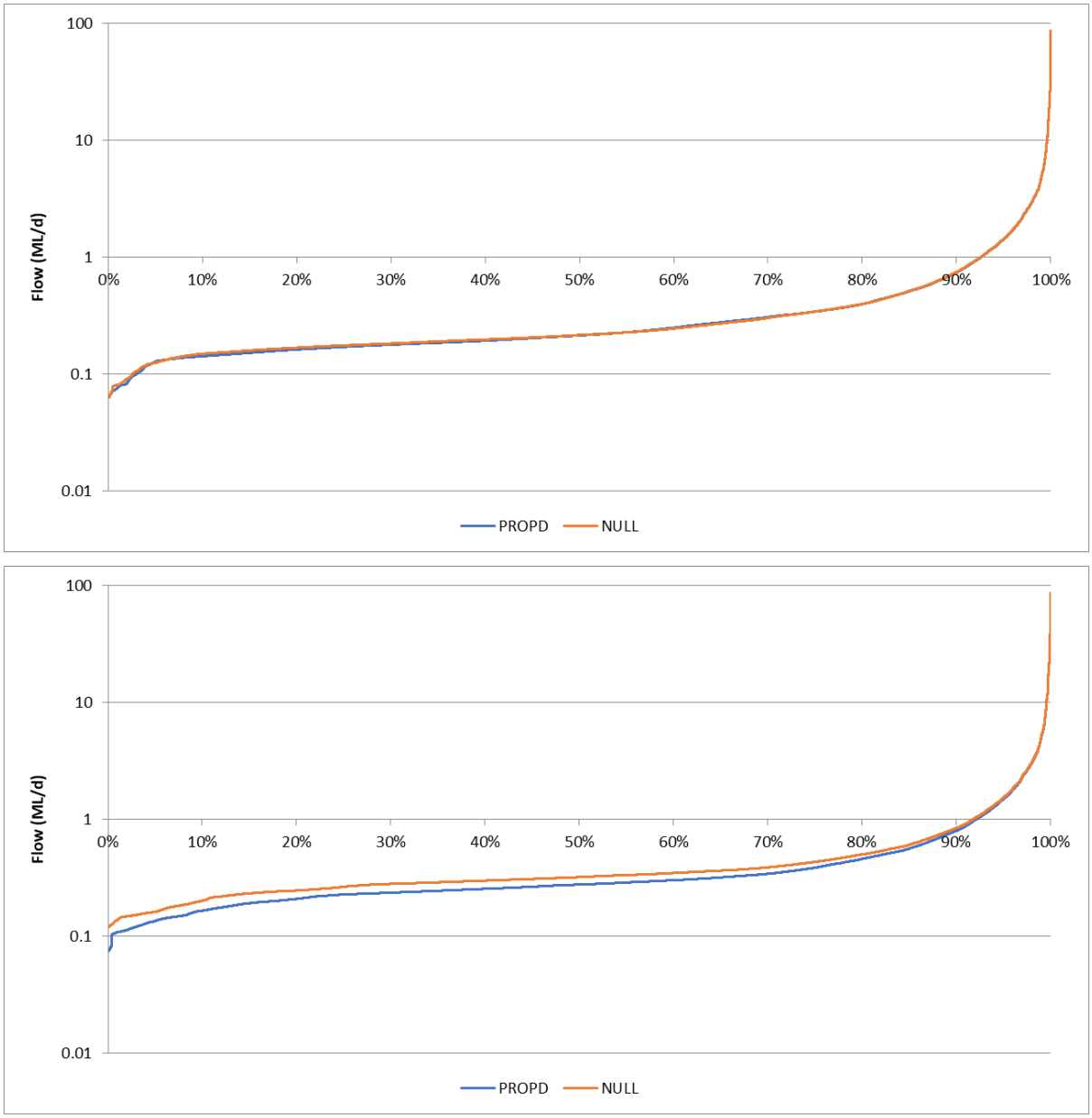


Figure 4.50: Statistical Distribution of Model Output (High Rainfall) – Birds Rock Swamp (Node 497a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.18: Summary of Statistical Distribution of Model Output (High Rainfall) – Birds Rock Swamp (Node 497a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.06	0.06	0	0.07	0.12	-38
5%	0.13	0.13	2	0.14	0.16	-17
10%	0.14	0.15	-5	0.17	0.20	-18
20%	0.16	0.17	-4	0.21	0.25	-15
50%	0.21	0.22	-1	0.28	0.32	-14
80%	0.40	0.40	0	0.46	0.50	-9
90%	0.74	0.75	-1	0.80	0.84	-5
95%	1.4	1.4	0	1.5	1.5	-2
Max	86	86	0	87	87	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

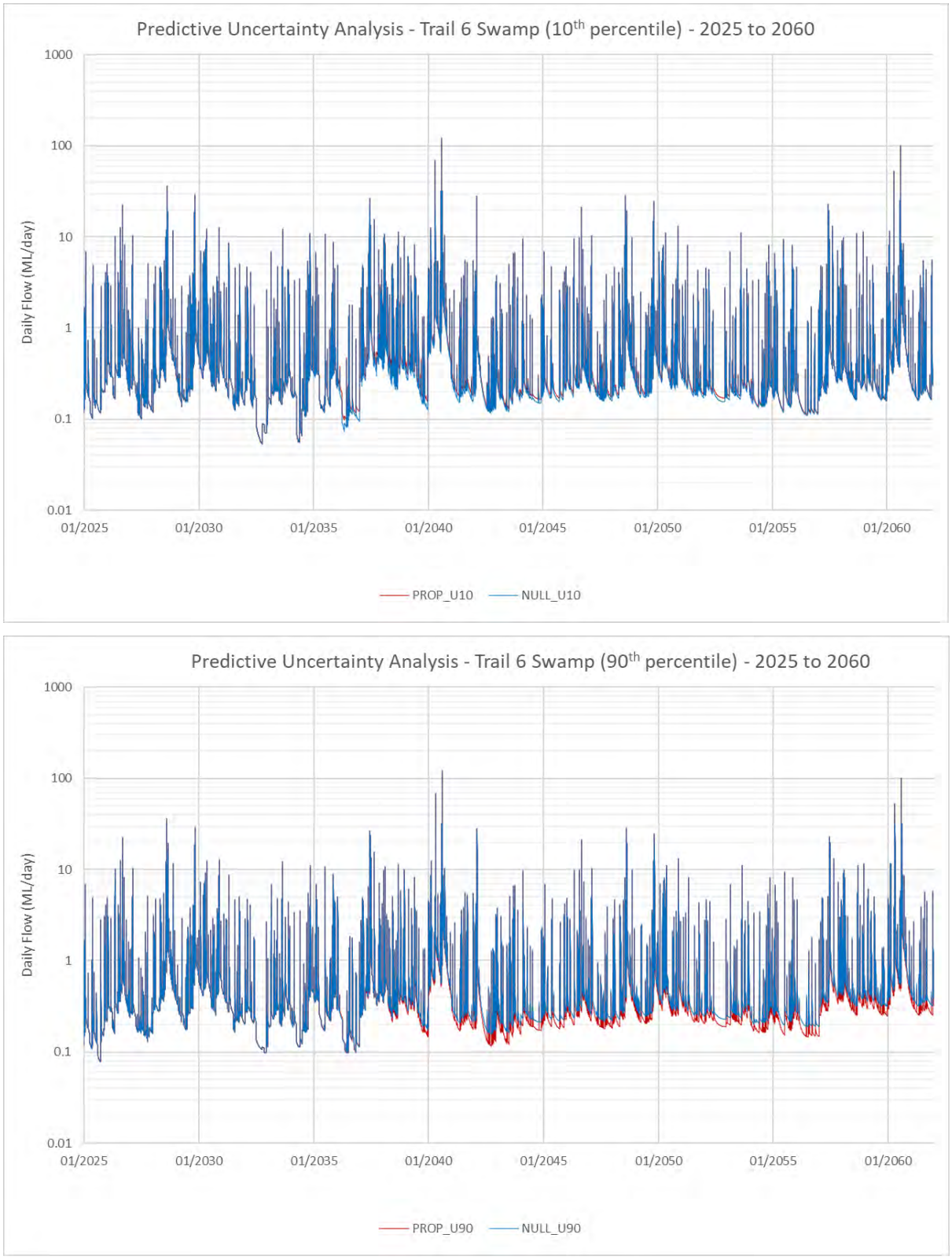


Figure 4.51: Time-Series Model Output (High Rainfall) – Trail Six Swamp (Node 342a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

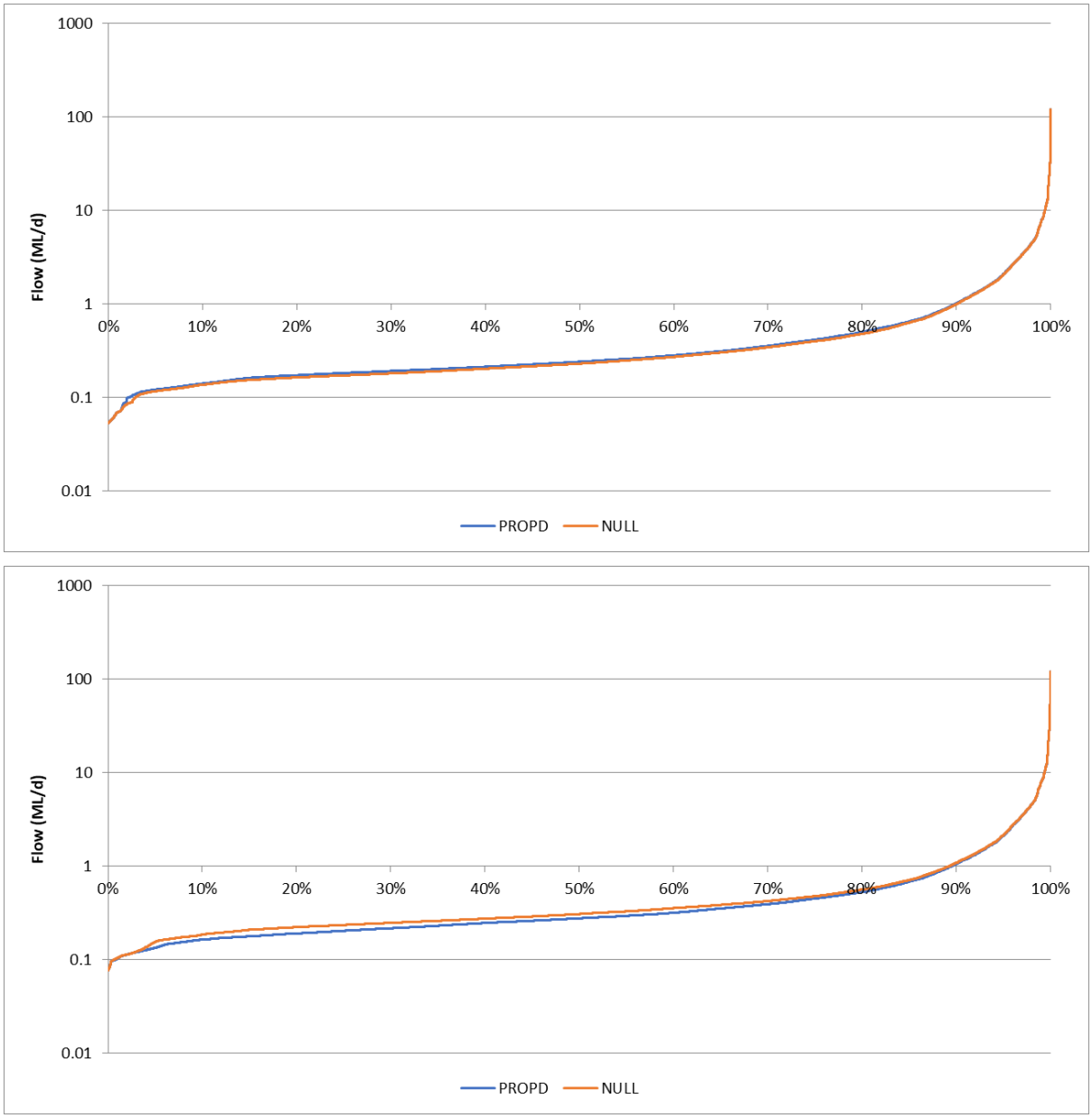


Figure 4.52: Statistical Distribution of Model Output (High Rainfall) – Trail Six Swamp (Node 342a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.19: Summary of Statistical Distribution of Model Output (High Rainfall) – Trail Six Swamp (Node 342a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.05	0.05	0	0.08	0.08	0
5%	0.12	0.12	4	0.13	0.15	-13
10%	0.14	0.14	3	0.16	0.19	-12
20%	0.17	0.16	6	0.19	0.22	-14
50%	0.24	0.23	5	0.28	0.31	-10
80%	0.50	0.48	5	0.53	0.56	-6
90%	1.0	1.0	2	1.1	1.1	-2
95%	2.1	2.1	1	2.1	2.2	-2
Max	121	121	0	121	121	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

4.10.3.2 Low Rainfall Scenario

Wolgan River Swamp Upper Swamp

Figure 4.53 presents time-series output from the SAPSWBM with respect to the Low Rainfall Scenario. **Figure 4.54** presents a statistical distribution of that model output and **Table 4.20** presents a summary of the distribution.

From **Table 4.20**, the modelled change to median flow rate ranges between a 4% increase in the U10 results to a 2% decrease in the U90 results. The results presented in **Table 4.20** are consistent with that presented in **Table 4.6**, which indicates that modelled change due to Amended Project is not particularly sensitive to the assumed rainfall condition.

From **Table 4.20**, the modelled median flow in the Low Rainfall Scenario is 0.82 to 0.88ML/d. This is compared to **Table 4.6**, where the modelled median flow, under median rainfall conditions, is 2.2ML/d. Accordingly, the sharp reduction in flow rate in 2030 identified in **Figure 4.18**, if it coincided with a low rainfall period, would be result in a large decrease, on a percentage basis.

From **Table 4.20**, the modelled change to flow at the 10th% level is a 4% increase in the U10 results and is a 3% decrease in the U90 results. From **Table 4.20**, the modelled flow rate at the 10th% level is 0.51 to 0.54ML/d.

Tri-Star Swamp

Figure 4.55 presents time-series output for Tri-Star Swamp for the Low Rainfall scenario. The U10 and U90 results are presented in **Figure 4.55**, with **Figure 4.56** presenting a statistical distribution of the model output presented in **Figure 4.55**. **Table 4.21** presents a summary of the statistical distribution presented in **Figure 4.56**.

From **Figure 4.55**, the U10 results indicate that the Proposed Case is slightly lower than the Null Case and, in the U90 results, the Proposed Case is also lower than the Null Case. From **Table 4.21**, the modelled median flow in the U10 results is 0.38ML/d in the Proposed Case and is 0.39ML/d in the Null Case. This represents a 2% decrease, which is considered negligible. From **Table 4.21**, modelled median flow in the U90 results is 0.35ML/d in the Proposed Case and is 0.45ML/d in the Null Case. The change between Proposed Case and Null Case is a large decrease, being 23%.

Wolgan River Swamp

Figure 4.57 presents the time-series output from the model for Wolgan River Swamp. **Figure 4.58** presents the statistical distribution of model output and **Table 4.22** presents a summary of that statistical distribution.

From **Table 4.22**, the modelled change to median flow is a 2% increase in the U10 results and is a 8% decrease in the U90 results. From **Table 4.22**, the modelled change to flow at the 10th% level is a 3% increase in the U10 results and is a 11% decrease in the U90 results.

From **Table 4.22**, the modelled flow rate at the 50th% level is 1.7ML/d in the Low Rainfall Scenario. The modelled flow rate at the 10th% level is 1.1ML/d.

Accordingly, the sharp reduction in groundwater contribution to flow in 2030, due to mining of the western end of LW1005 and LW1006 (refer **Figure 4.20**), if it coincided with a low rainfall period, would result in a large decrease, on a percentage basis.

Twin Gully Swamp

Figure 4.59 presents the time-series model output for Twin Gully Swamp for Low Rainfall conditions. **Figure 4.60** presents a statistical distribution of the model output and **Table 4.23** presents a summary of that statistical distribution.

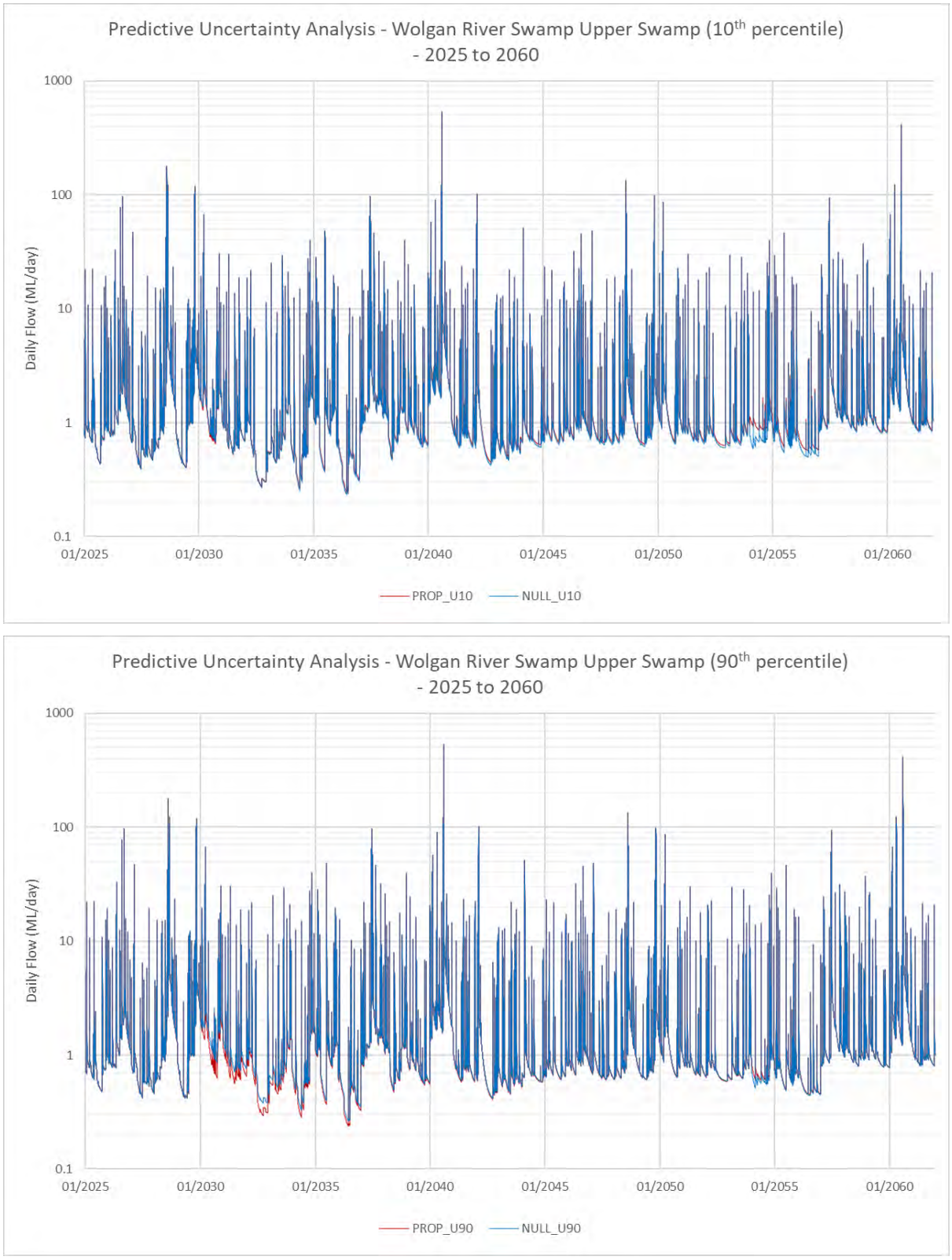


Figure 4.53: Time-Series Model Output (Low Rainfall) – Wolgan River Swamp Upper Swamp (Node 325a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

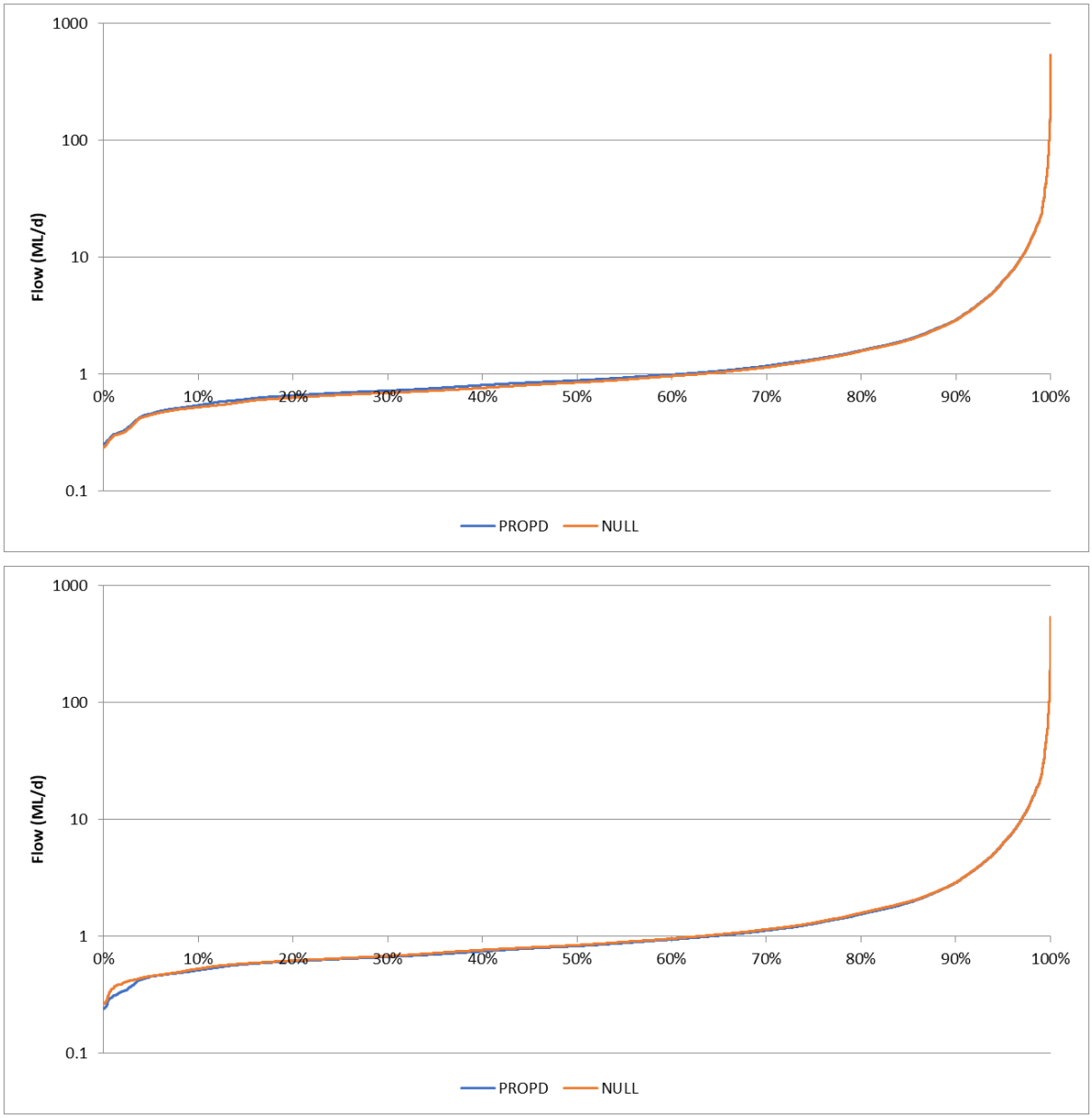


Figure 4.54: Statistical Distribution of Model Output (Low Rainfall) – Wolgan River Swamp Upper Swamp (Node 325a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.20: Summary of Statistical Distribution of Model Output (Low Rainfall) – Wolgan River Swamp Upper Swamp (Node 325a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.25	0.24	7	0.24	0.27	-10
5%	0.46	0.45	2	0.45	0.46	-1
10%	0.54	0.52	4	0.51	0.53	-3
20%	0.66	0.63	5	0.61	0.62	-1
50%	0.88	0.85	4	0.82	0.84	-2
80%	1.6	1.6	1	1.5	1.6	-2
90%	2.9	2.9	1	2.9	2.9	0
95%	6.3	6.3	1	6.3	6.3	0
Max	535	535	0	535	535	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

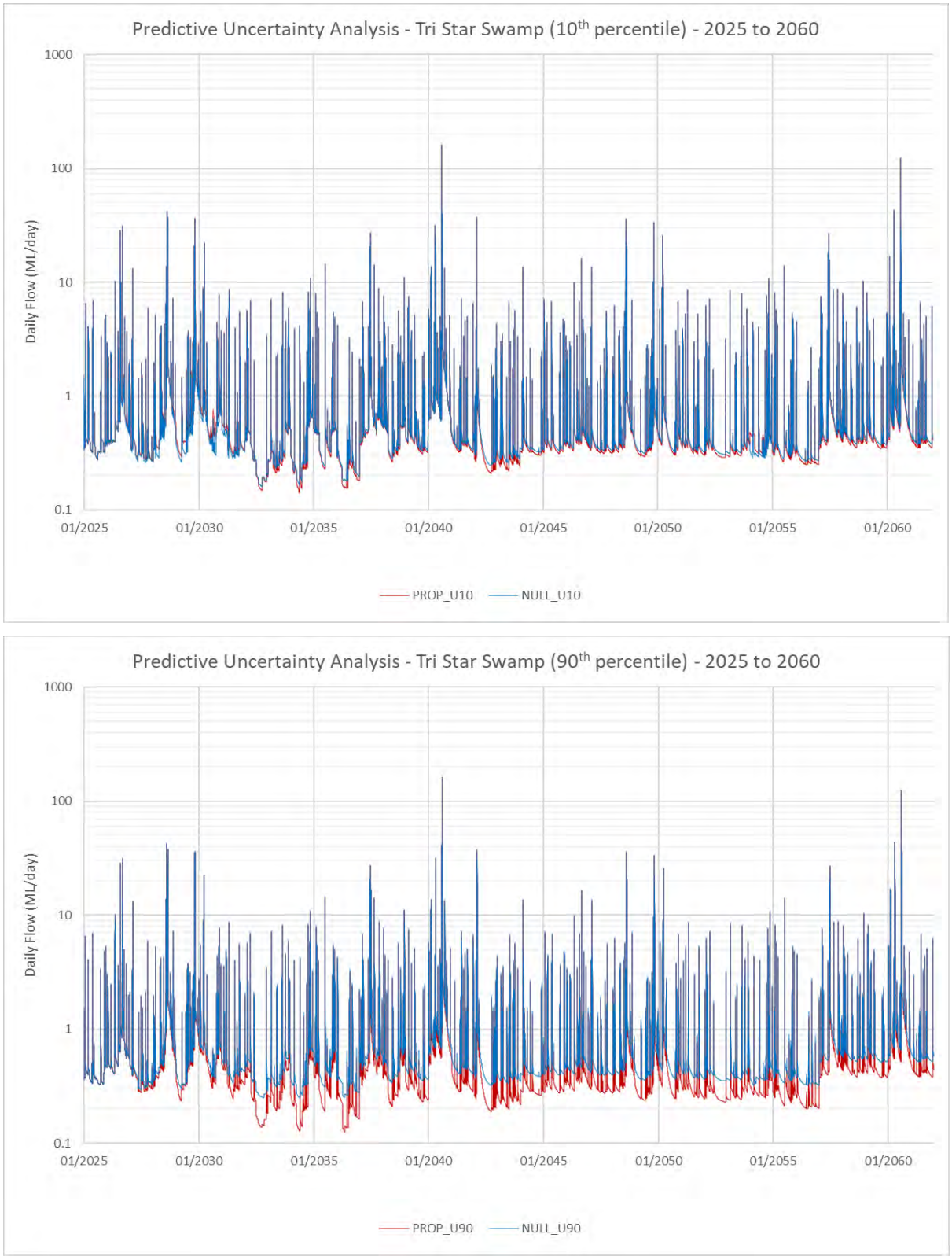


Figure 4.55: Time-Series Model Output (Low Rainfall) – Tri-Star Swamp (Node 324a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

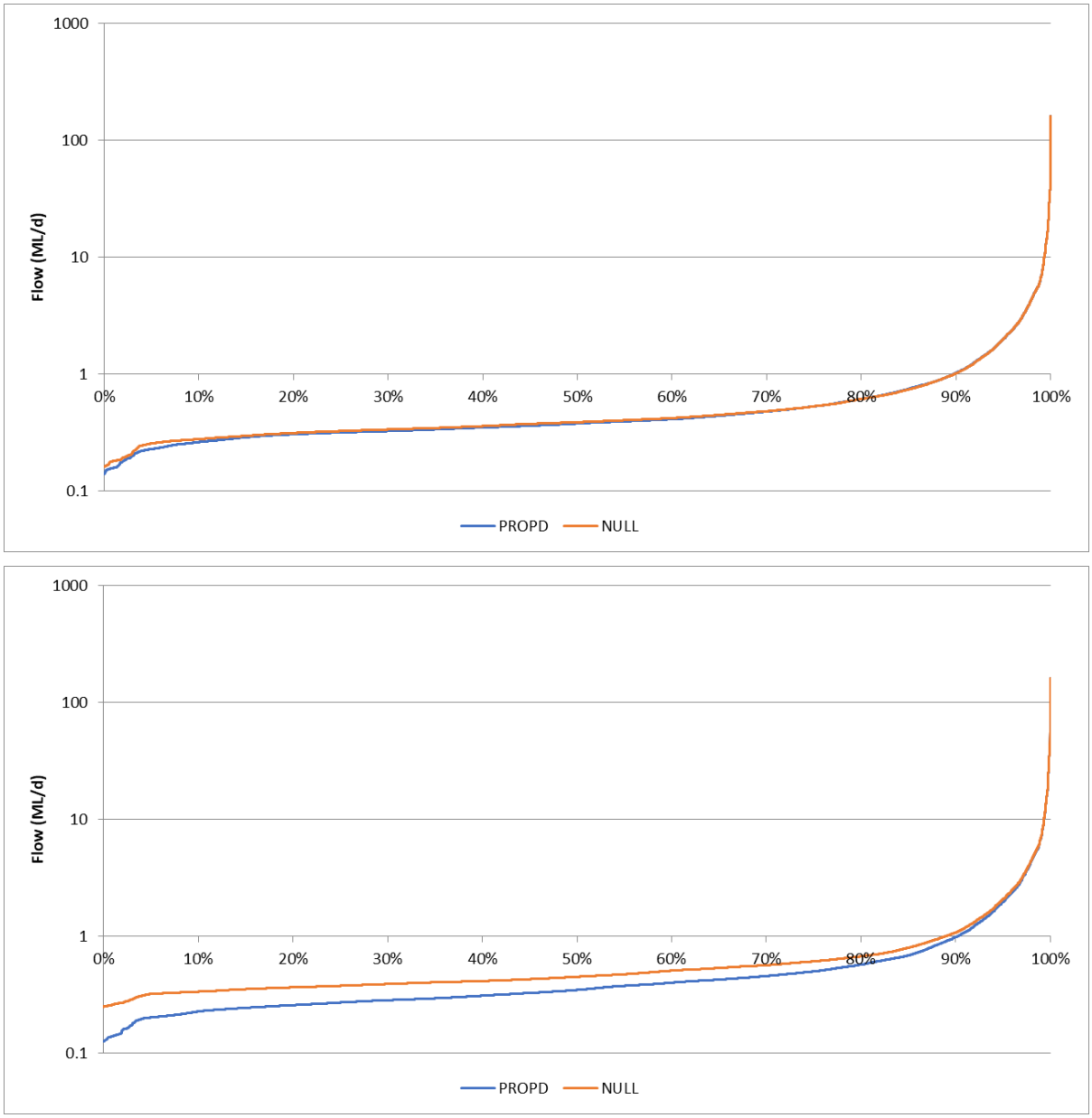


Figure 4.56: Statistical Distribution of Model Output (Low Rainfall) – Tri-Star Swamp (Node 324a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.21: Summary of Statistical Distribution of Model Output (Low Rainfall) – Tri-Star Swamp (Node 324a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.14	0.16	-13	0.13	0.25	-50
5%	0.23	0.26	-10	0.20	0.32	-37
10%	0.26	0.28	-6	0.23	0.34	-32
20%	0.31	0.31	-2	0.26	0.37	-30
50%	0.38	0.39	-2	0.35	0.45	-23
80%	0.61	0.61	0	0.57	0.67	-15
90%	1.0	1.0	1	0.99	1.1	-8
95%	2.0	2.0	-1	2.0	2.1	-5
Max	161	161	0	161	161	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

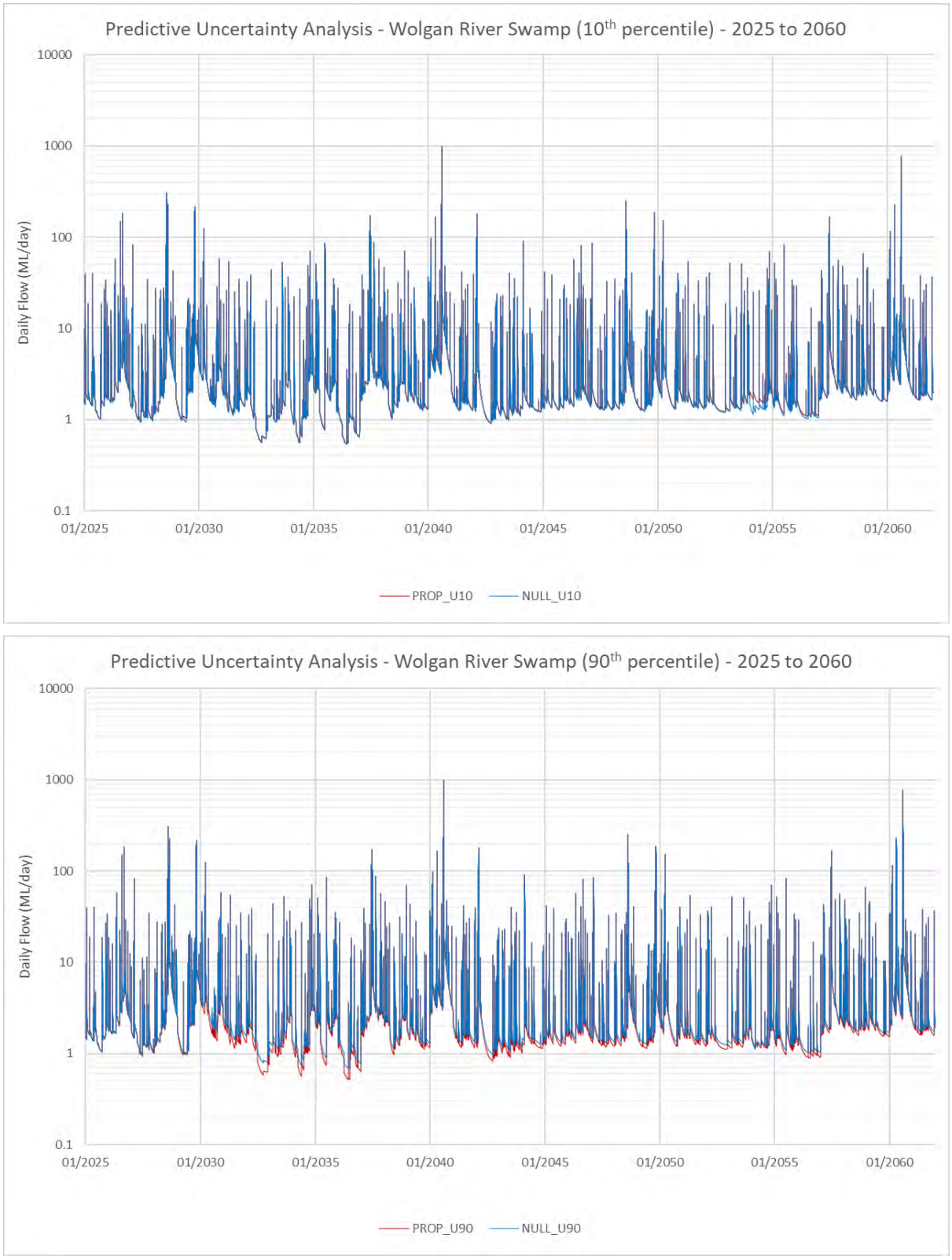


Figure 4.57: Time-Series Model Output (Low Rainfall) – Wolgan River Swamp (Node 332a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

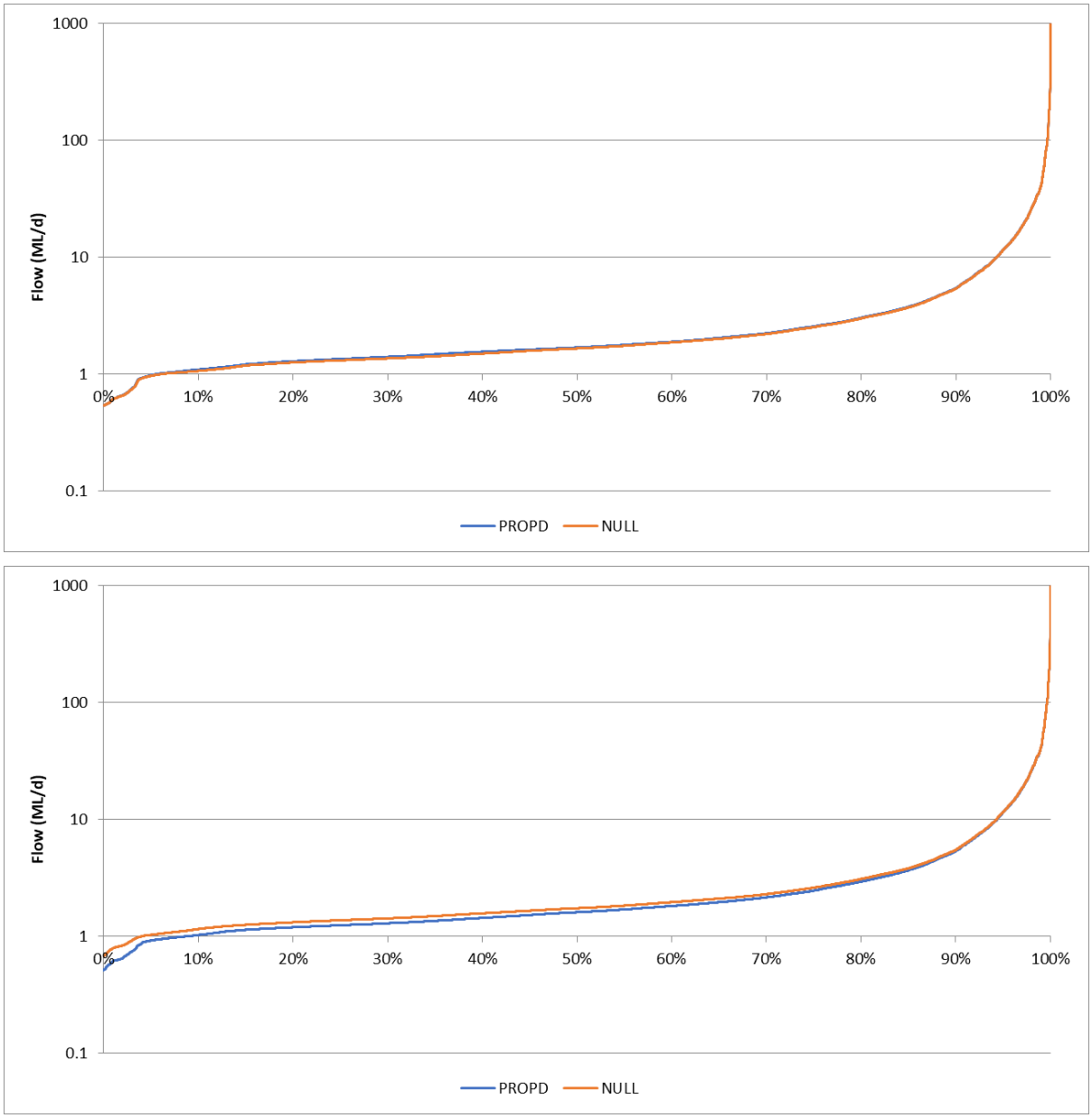


Figure 4.58: Statistical Distribution of Model Output (Low Rainfall) – Wolgan River Swamp (Node 332a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.22: Summary of Statistical Distribution of Model Output (Low Rainfall) – Wolgan River Swamp (Node 332a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.54	0.54	0	0.52	0.68	-24
5%	0.98	0.97	1	0.92	1.03	-11
10%	1.1	1.1	3	1.0	1.2	-11
20%	1.3	1.3	3	1.2	1.3	-9
50%	1.7	1.7	2	1.6	1.7	-8
80%	3.0	3.0	1	2.9	3.1	-5
90%	5.4	5.4	1	5.4	5.5	-2
95%	12	12	0	11	12	-1
Max	986	986	0	986	986	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

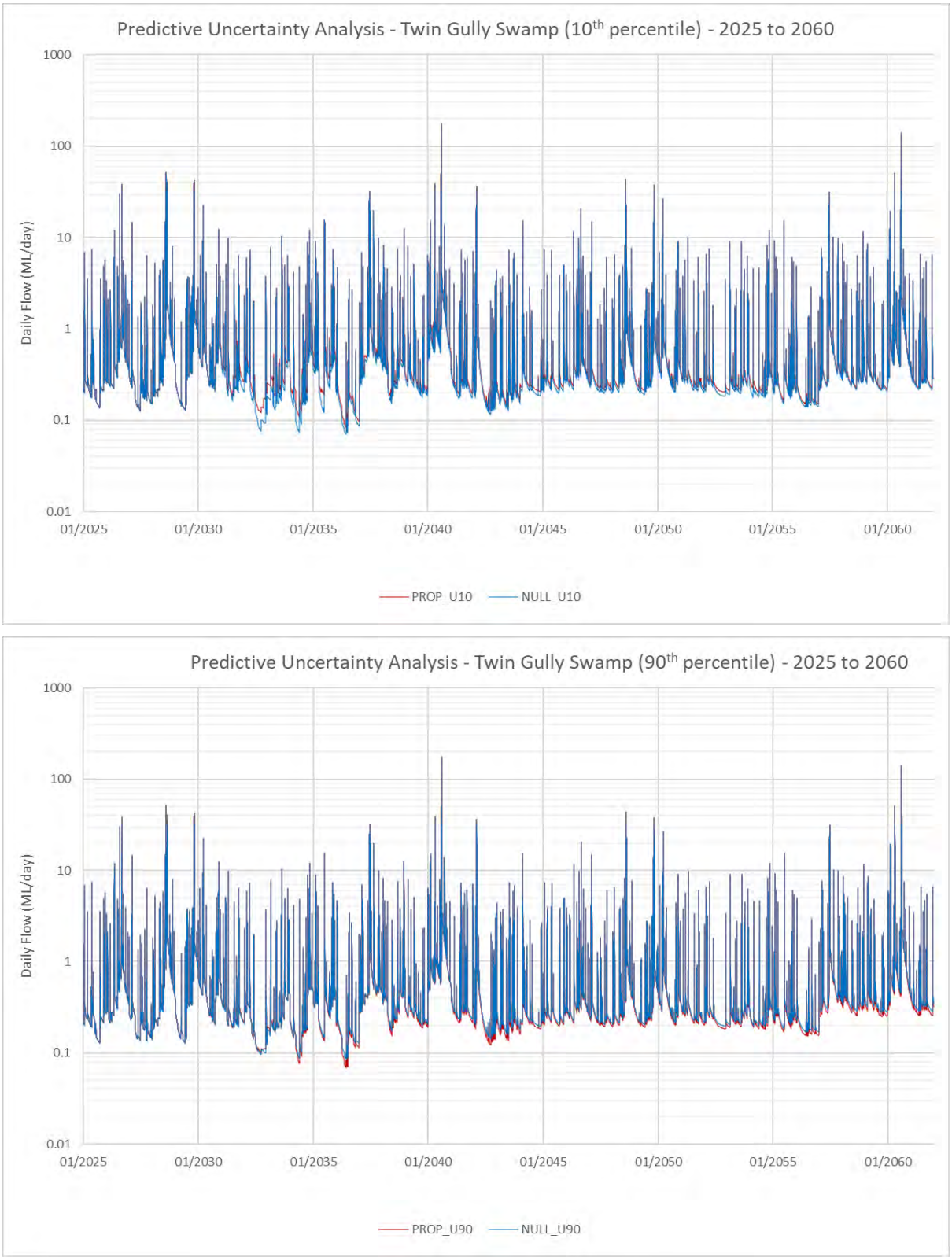


Figure 4.59: Time-Series Model Output (Low Rainfall) – Twin Gully Swamp (Node 322a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

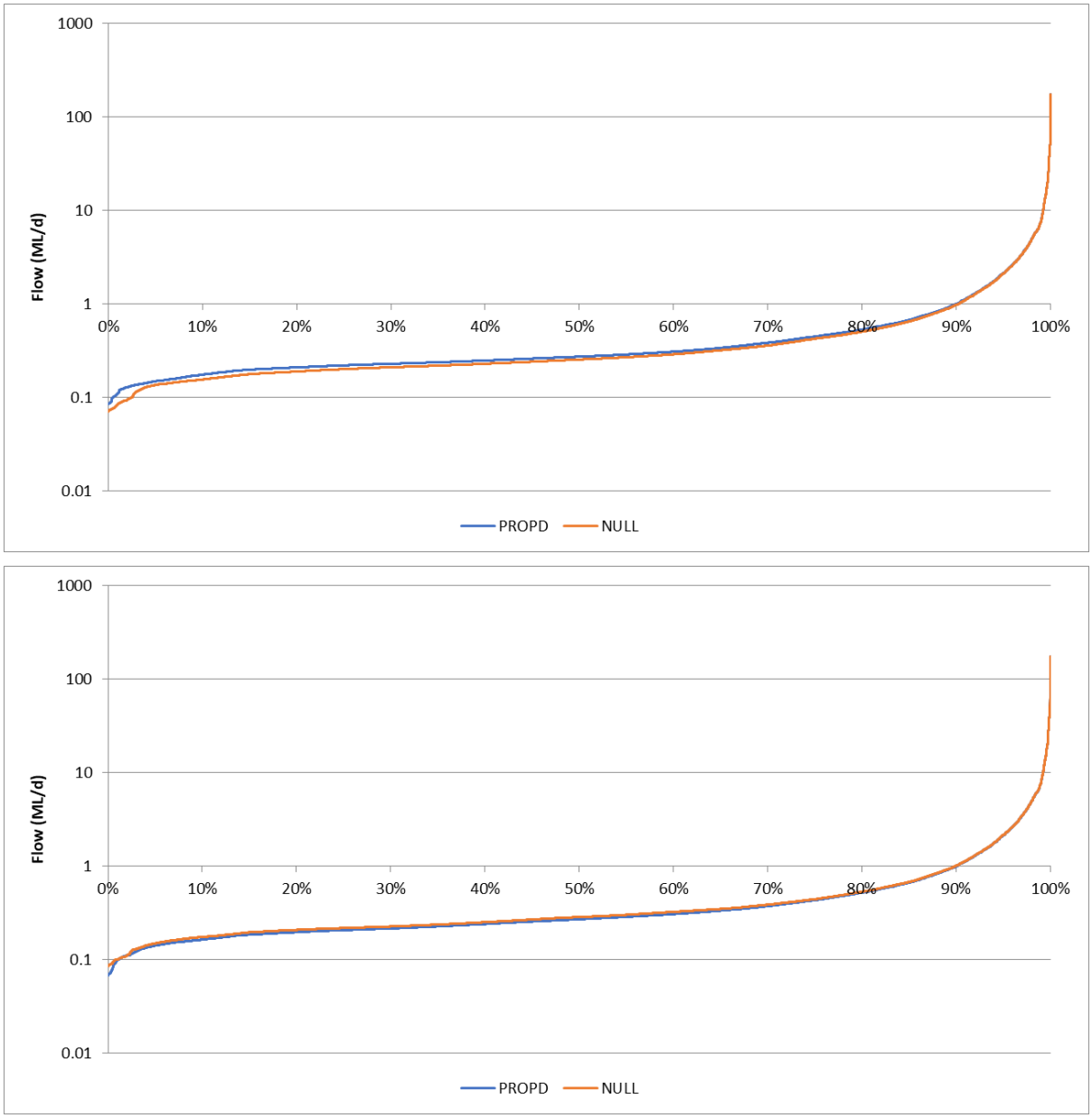


Figure 4.60: Statistical Distribution of Model Output (Low Rainfall) – Twin Gully Swamp (Node 322a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.23: Summary of Statistical Distribution of Model Output (Low Rainfall) – Twin Gully Swamp (Node 322a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.08	0.07	20	0.07	0.09	-20
5%	0.15	0.14	10	0.14	0.15	-5
10%	0.18	0.16	13	0.16	0.18	-6
20%	0.21	0.19	11	0.20	0.21	-6
50%	0.27	0.26	7	0.27	0.29	-5
80%	0.53	0.51	5	0.52	0.53	-2
90%	1.0	1.0	2	1.0	1.0	-2
95%	2.1	2.1	1	2.1	2.2	0
Max	177	177	0	177	177	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

From **Table 4.23**, the modelled median flow in the U10 results is 0.27ML/d in the Proposed Case and is 0.26ML/d in the Null Case. This represents a negligible change, being an increase of 2%. From **Table 4.23**, the modelled median flow in the U90 results is 0.27ML/d in the Proposed Case and is 0.29ML/d in the Null Case. This is a 5% decrease and is assessed to be a minor change. As per the findings for the High Rainfall scenario, the results presented in **Table 4.23** are essentially the same as that presented in **Table 4.9**, for median rainfall conditions.

Crocodile Swamp

Figure 4.61 presents time-series hydrographs for Crocodile Swamp in both the Proposed and Null Case. **Figure 4.62** presents a statistical distribution of model output at Crocodile Swamp for both the Proposed and Null Cases, with **Table 4.24** presenting a summary of the statistical distribution.

From **Table 4.24**, the modelled change in median flow is a 5% increase in the U10 results and is a 0% decrease in the U90 results. From **Table 4.24**, at the 10th% level, the modelled change in the U10 results is a 8% increase, and is a 1% increase in the U90 results.

From **Table 4.24**, the modelled changes are a negligible decrease in flow rate due to the Amended Project.

It is noted that the result presented in **Table 4.24** are consistent with that presented in **Table 4.10**.

Birds Rock Swamp

Figure 4.63 presents time-series output from the SAPSWBM at Birds Rock Swamp for the Low Rainfall Scenario. **Figure 4.64** presents a statistical distribution of the model output presented in **Figure 4.63**, with **Table 4.25** providing a summary of that distribution.

From **Table 4.25**, the modelled change in flow at the 50th% level is a 0% increase in the U10 results and is a 13% decrease in the U90 results. From **Table 4.25**, the modelled change in flow at the 10th% level is a 4% decrease in the U10 results and is a 19% decrease in the U90 results.

From **Table 4.25**, the magnitude of change to modelled flow is moderate to large.

The results presented in **Table 4.25** are, once again, consistent with that presented in **Table 4.11**, which indicates that the modelled change to flow is insensitive to the assumed rainfall condition.

Trail Six Swamp

Figure 4.65 presents the time-series model output at Trail Six Swamp for the Low Rainfall scenario. **Figure 4.66** presents the statistical distribution of model output and that distribution is summarised in **Table 4.26**.

From **Table 4.26**, the modelled median flow in the U10 results is 0.16ML/d in the Proposed Case and is 0.16ML/d in the Null Case. From **Table 4.26**, the calculated percentage change is a 4% increase, which is considered minor. As noted in **Table 4.26**, the percentage change is calculated prior to rounding. From **Table 4.26**, the modelled median flow in the U90 results is 0.18ML/d in the Proposed Case and is 0.20ML/d in the Null Case. This represents a decrease of 11%, and is assessed to be a moderate change.

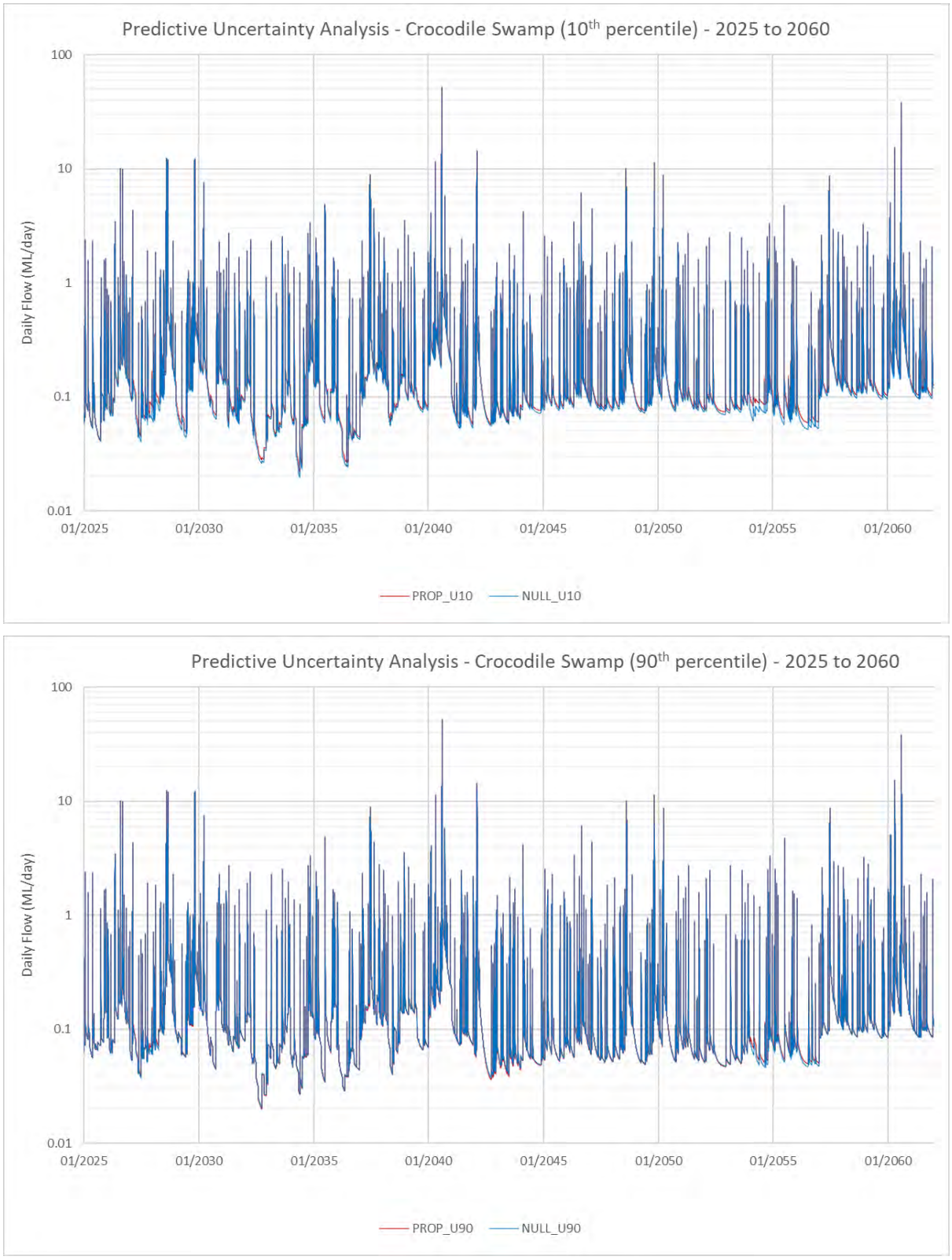


Figure 4.61: Time-Series Model Output (Low Rainfall) – Crocodile Swamp (Node 562a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

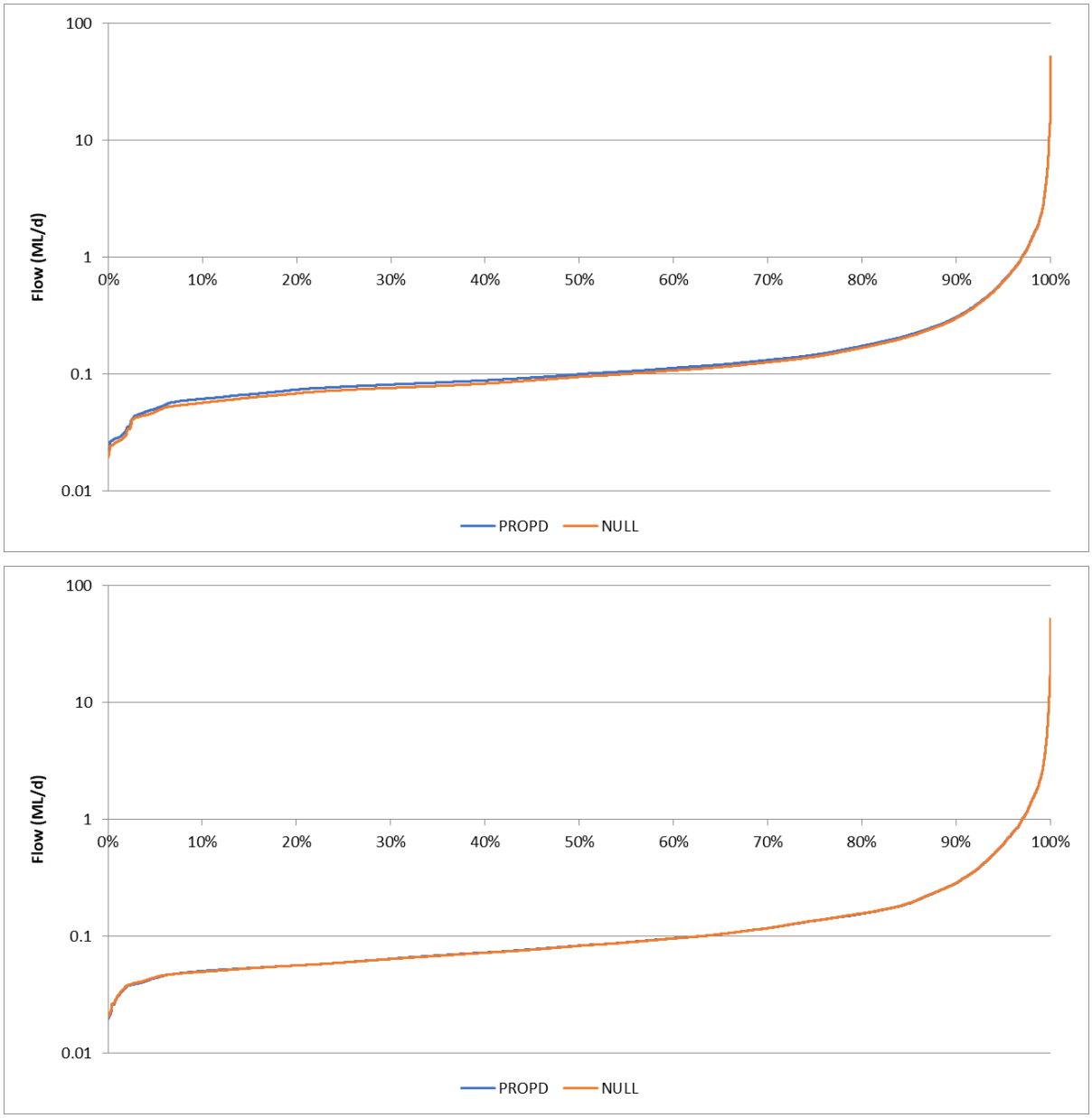


Figure 4.62: Statistical Distribution of Model Output (Low Rainfall) – Crocodile Swamp (Node 562a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.24: Summary of Statistical Distribution of Model Output (Low Rainfall) – Crocodile Swamp (Node 562a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.02	0.02	11	0.02	0.02	-4
5%	0.05	0.05	6	0.04	0.04	-1
10%	0.06	0.06	8	0.05	0.05	1
20%	0.07	0.07	8	0.06	0.06	0
50%	0.10	0.09	5	0.08	0.08	0
80%	0.17	0.17	4	0.16	0.16	-1
90%	0.31	0.30	2	0.29	0.29	0
95%	0.63	0.62	1	0.61	0.62	0
Max	52	52	0	52	52	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

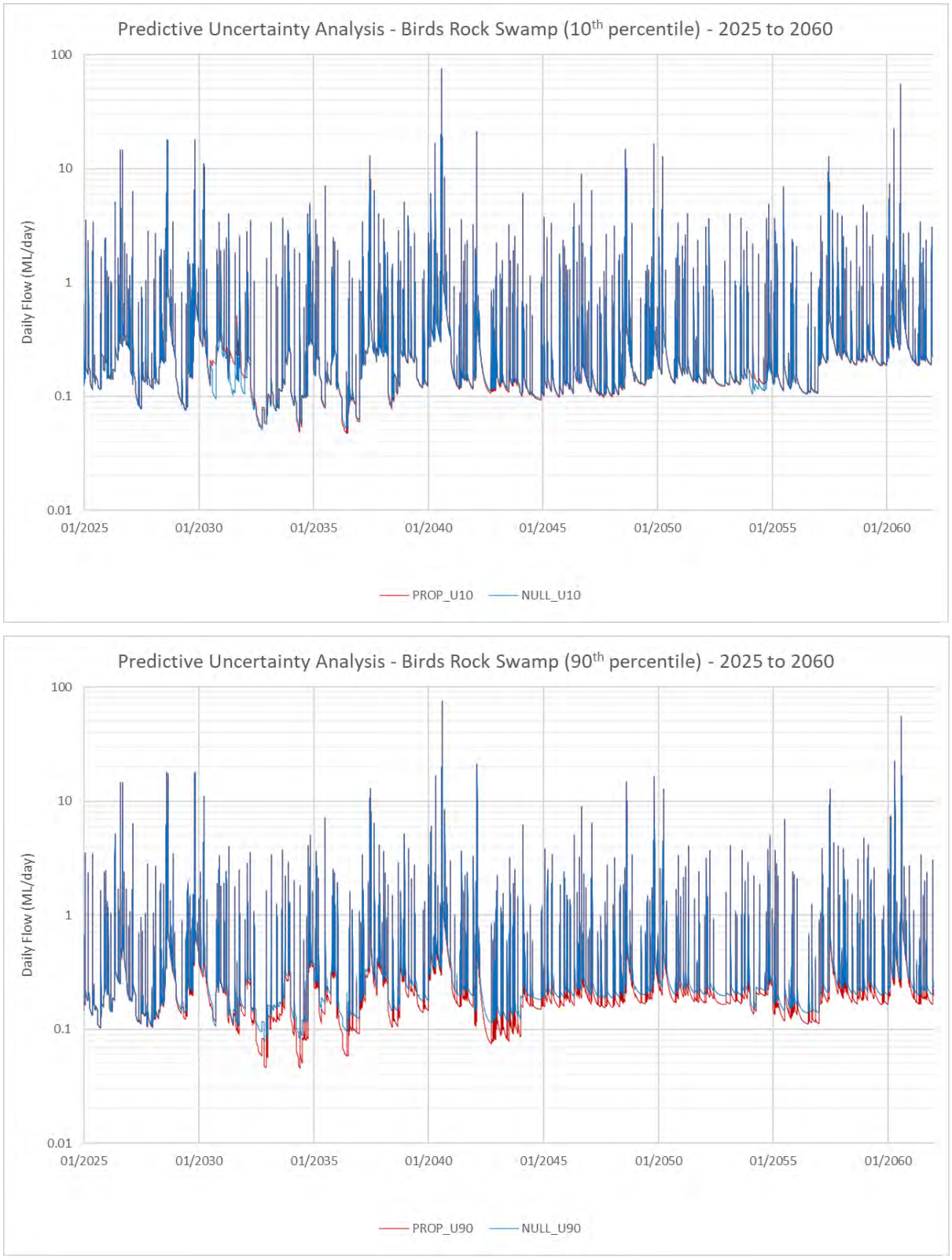


Figure 4.63: Time-Series Model Output (Low Rainfall) – Birds Rock Swamp (Node 497a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

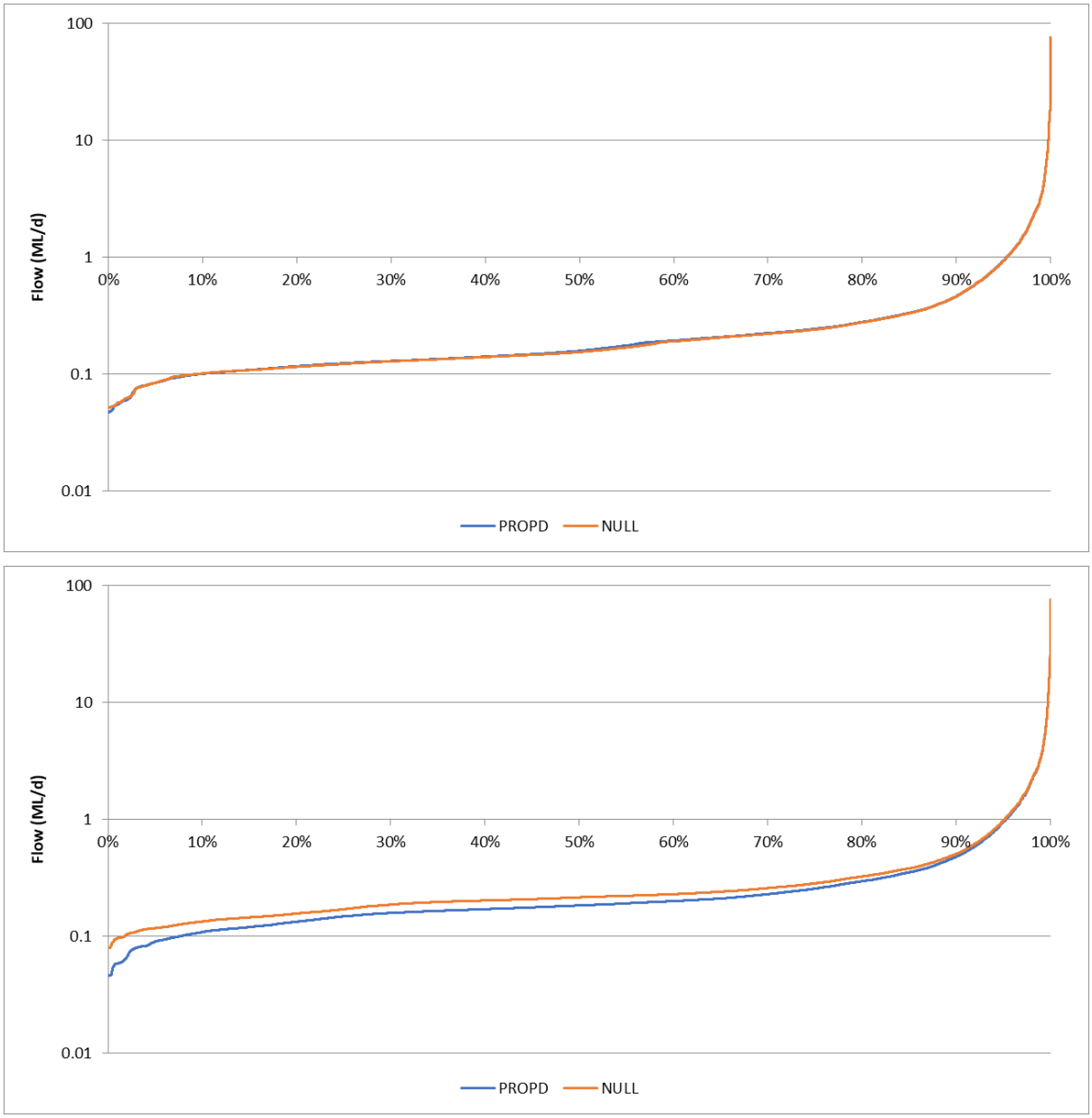


Figure 4.64: Statistical Distribution of Model Output (Low Rainfall) – Birds Rock Swamp (Node 497a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.25: Summary of Statistical Distribution of Model Output (Low Rainfall) – Birds Rock Swamp (Node 497a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.05	0.05	-8	0.05	0.08	-43
5%	0.08	0.08	0	0.09	0.12	-23
10%	0.10	0.10	-1	0.11	0.13	-19
20%	0.12	0.12	1	0.13	0.16	-15
50%	0.16	0.15	2	0.18	0.22	-15
80%	0.28	0.28	1	0.30	0.32	-9
90%	0.46	0.46	0	0.48	0.51	-5
95%	0.94	0.94	0	0.95	0.98	-3
Max	76	76	0	76	76	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

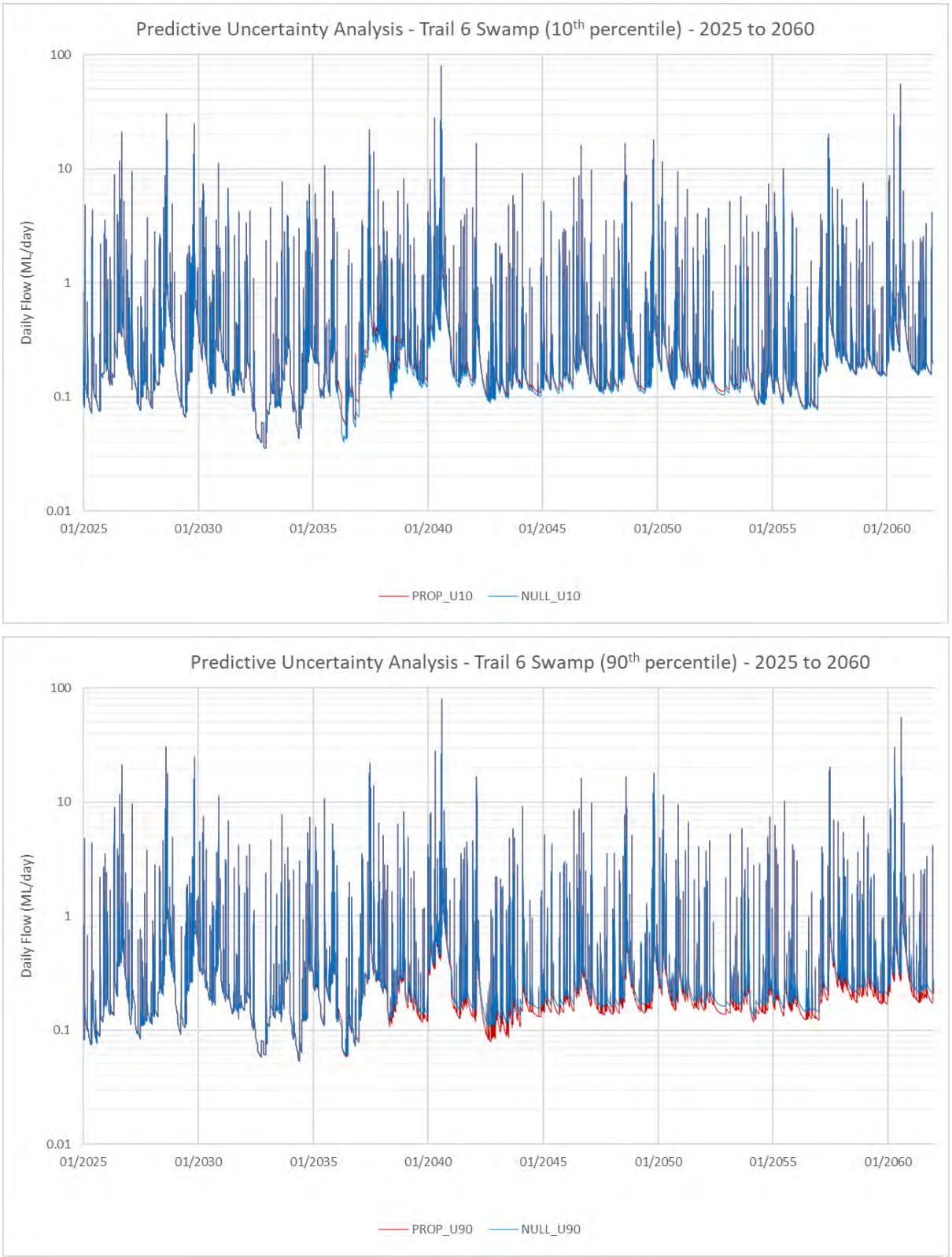


Figure 4.65: Time-Series Model Output (Low Rainfall) – Trail Six Swamp (Node 342a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

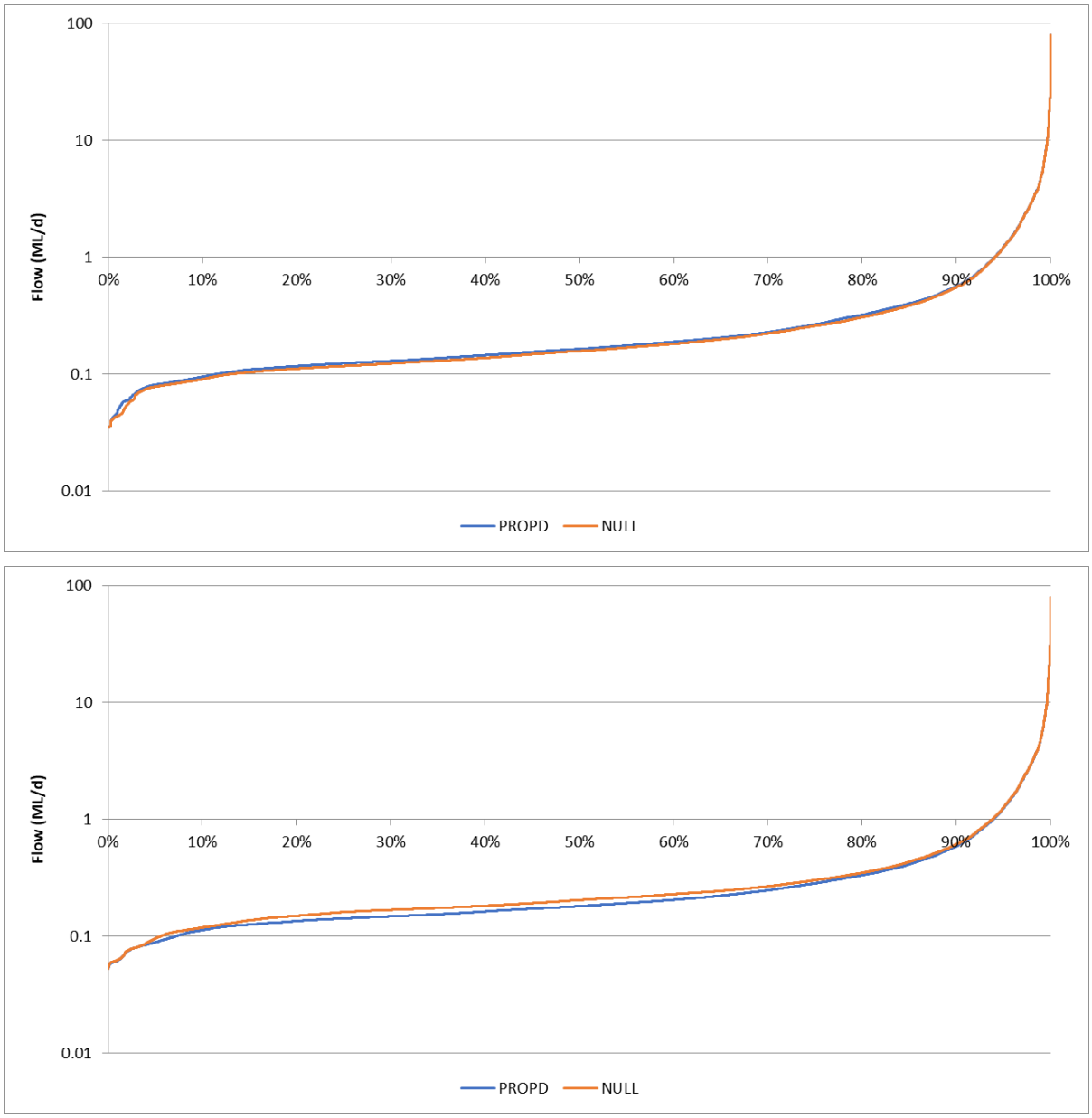


Figure 4.66: Statistical Distribution of Model Output (Low Rainfall) – Trail Six Swamp (Node 342a): Flow (ML/d) (Upper is U10 Results; Lower is U90 Results)

Table 4.26: Summary of Statistical Distribution of Model Output (Low Rainfall) – Trail Six Swamp (Node 342a): Flow (ML/d)

	U10 Results	Flow (ML/d)		U90 Results	Flow (ML/d)	
Percentile	PROPD	NULL	%Δ[1]	PROPD	NULL	%Δ[1]
Min	0.04	0.04	0	0.05	0.05	-1
5%	0.08	0.08	4	0.09	0.10	-7
10%	0.09	0.09	5	0.11	0.12	-5
20%	0.12	0.11	5	0.13	0.15	-10
50%	0.16	0.16	4	0.18	0.20	-11
80%	0.32	0.31	5	0.33	0.35	-5
90%	0.57	0.55	2	0.59	0.61	-4
95%	1.2	1.2	1	1.2	1.3	-1
Max	80	80	0	80	80	0

Notes. 1. %Δ is percent change between Proposed (PROPD) and Null Case (NULL) prior to rounding.

4.11 Summary of Model Results including Uncertainty Analysis

Modelling indicates that the predicted change to Wolgan River Swamp Upper Swamp due to the Amended Project ranges between a minor increase and a negligible decrease in median flow. Of note, however, is the moderate, short term, change to modelled flow rate in 2030 associated with mining of the western end of LW1005 and LW1006 in the vicinity of Tri-Star Swamp. As presented in JBS&G (2019), this is due to the smaller than average depth of cover at that location.

Modelling indicates the predicted change to Tri-Star Swamp ranges between a negligible/minor decrease to a large decrease in median flow due to the Amended Project. It is highlighted, however, that the magnitude of flow is low, therefore a percentage change for only a small change in numerical value can be high.

The modelled change to median flow rate in Wolgan River Swamp ranges between a negligible increase to a moderate decrease. As per the findings for Wolgan River Swamp Upper Swamp, the sharp, short term, reduction in 2030 is associated with mining of the western end of LW1005 and LW1006 and is due to the depth of cover being less than 350m at that location.

For Twin Gully Swamp, the predicted changes range between a moderate increase and a moderate decrease in median flow.

For Crocodile Swamp, the modelled change in median flow ranges between a moderate increase and a negligible decrease.

For Birds Rock Swamp, the modelled change in median flow ranges between a negligible increase and a large decrease. This is due to the location of Birds Rock Swamp in close proximity to LW1007 and the relatively small catchment contributing to Birds Rock Swamp.

For Trail Six Swamp, the predicted changes to median flow rate ranges between a minor increase and a moderate decrease.

Of note is that the change to flow in all THPSS continues after the cessation of dewatering activity in 2053.

Modelling outputs incorporating climate change scenarios indicate that results are generally consistent with median rainfall conditions. Modelled changes to median flow, under low and high rainfall conditions, are generally within 1 to 2% of the results from median rainfall conditions. This is due to the fact that groundwater model inputs for median rainfall conditions are generally consistent with groundwater model inputs for high rainfall and low rainfall conditions. i.e. climate conditions do not significantly change model outcomes, since the Proposed Case and Null Case both use the same climate dataset.

5. Conclusions

5.1 General Summary

The SAPSWBM was constructed to assess the changes to surface water flow due to mining-induced changes to groundwater contribution to surface water through alterations to direct groundwater/surface water interaction or through changes indirectly to outflow from groundwater seepage faces.

Modelling indicates that the Amended Project is likely to lead to a decrease in flow in Tri-Star, Twin Gully, Birds Rock and Trail Six Swamps.

In Tri-Star Swamp, the modelled change ranges between a 2% decrease (negligible change) up to a 23% decrease (large decrease). In Twin Gully Swamp, the modelled change ranges between a 7% increase (moderate increase) and a 7% decrease (moderate decrease). In Birds Rock Swamp, the modelled change ranges between 0% increase (negligible increase) and a 13% decrease (moderate decrease). In Crocodile Swamp, the modelled change ranges between a 5% increase (moderate increase) and a 1% decrease (negligible decrease). In Trail Six Swamp, the modelled change ranges between a 5% increase (minor increase) and a 11% decrease (moderate decrease).

Of note is that modelled changes continue beyond the end of mine life in 2053.

There is no proposed change to surface water quality associated with the Amended Project, therefore there is no change to modelled salinity presented from the SAPSWBM.

5.2 Response to IESC Comments

IESC01) Requirement to characterise existing surface water, groundwater and ecological conditions for the majority of Temperate Highland Peat Swamps on Sandstone (THPSS).

Since the time of Angus Place Mine Extension Project, significant additional investigation has been undertaken on the THPSS at both Angus Place Colliery and Springvale Mine.

Surface water flow data is presented in this report. Further data, such as water quality data is presented in the Surface Water Impact Assessment.

Groundwater monitoring data at Tri-Star, Twin Gully and Trail Six Swamp is presented in the Hydrogeological Model Report (JBS&G, 2019), together with model calibration. Further data, such as soil moisture data is presented in the Groundwater Impact Assessment.

Ecological assessment is presented in the Ecological Impact Assessment.

IESC02) Seasonal surface water flow and an assessment, or estimation, of the baseflow component of the Coxs River.

The groundwater model, both with respect to model calibration and model simulation, is based on quarterly stress periods in an attempt to incorporate seasonal variation.

The SAPSWBM was built using a daily timestep and receives input from the groundwater model. Accordingly, the modelled change to baseflow in the SAPSWBM, due to the Amended Project, can be assessed in the context of seasonal variation.

Furthermore, the NARCliM climatic datasets, which are future forecasts of climate based on a NSW and ACT Government instigated research project, were used for the prediction period. From that data, a high rainfall and a low rainfall scenario was extracted and evaluated.

IESC03) Inclusion of all swamps in the groundwater model.

As presented in Hydrogeological Model Report (JBS&G, 2019), all THPSS swamps have been included in the groundwater model. In addition, should analysis be required of other surface watercourses,

these are also included in the groundwater model. As presented in **Section 4.6.1**, output from the groundwater model is used as input to the SAPSWBM.

IESC04) Finer scaled, site specific models, informed by a conceptualisation of the hydrology and hydrogeology, would be needed to have confidence in the predictions of groundwater impacts to individual swamps.

As presented in this report, 998 sub-catchments were delineated in the SAPSWBM to provide the spatial resolution necessary to achieve the abovementioned aim of finer scaled models.

Local scale groundwater models were investigated during the development of the SAPSWBM, however, it was found that a regional groundwater model was necessary due to the scale of changes due to mining. Accordingly, the SAPSWBM was developed to receive input from the regional groundwater model and provide the means to assess the modelled change due to the Amended Project in the context of daily variation in rainfall/runoff.

IESC05) Water quality impact estimations for the Coxs River need to consider the increased discharge volumes to Coxs River resulting from reduced demand from the Wallerawang Power Station.

This aspect was addressed at the time through the Regional Water Quality Impact Assessment Model (RWQIAM). In any regard, in accordance with Angus Place Colliery Modification 5 (JBS&G, 2018), Angus Place Mine Extension Project: Amended Project mine water discharge will cease from 1 January 2020. Accordingly, the issue is considered to be resolved.

IESC06) Confidence in groundwater model predictions is limited by a lack of site-specific hydrogeological data and lineament groundwater flow behaviour.

As presented in the Hydrogeological Model Report (JBS&G, 2019), site-specific hydrogeological data from Springvale Mine and Angus Place Colliery is available and comprises hydraulic testing (packer tests) at multiple locations. That data is presented in the Groundwater Impact Assessment.

The updated groundwater model considers the role of lineaments through adopting a heterogeneous approach to the distribution of hydraulic properties. Further detail of this approach is presented in the Hydrogeological Model Report (JBS&G, 2019).

To address the potential uncertainty in model predictions, the IESC recently issued an Explanatory Note on the approach to undertaking uncertainty analysis in groundwater modelling (IESC, 2018). As presented in the Hydrogeological Model Report (JBS&G, 2019), a stochastic approach was used, which was the most sophisticated of the potential methods suggested. The stochastic approach generated multiple realisations of the parameterisation of the groundwater model, whilst simultaneously honouring a reasonable match to observed groundwater level and mine dewatering rates.

Output from predictive uncertainty analysis, in the form of the groundwater contribution associated with the 10th and 90th percentile difference between Proposed and Null case (referred to as the U10 and U90 results in this report), was input to the SAPSWBM. The use of predictive uncertainty analysis provides greater confidence in the assessment of potential change due to the Amended Project.

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Appendix A Mine Schedule

A1. Mine Schedule

Figure A.1 presents the mine schedule implemented in the numerical groundwater model. The schedule includes mining of Longwall 910N, on retreat, in 2038.

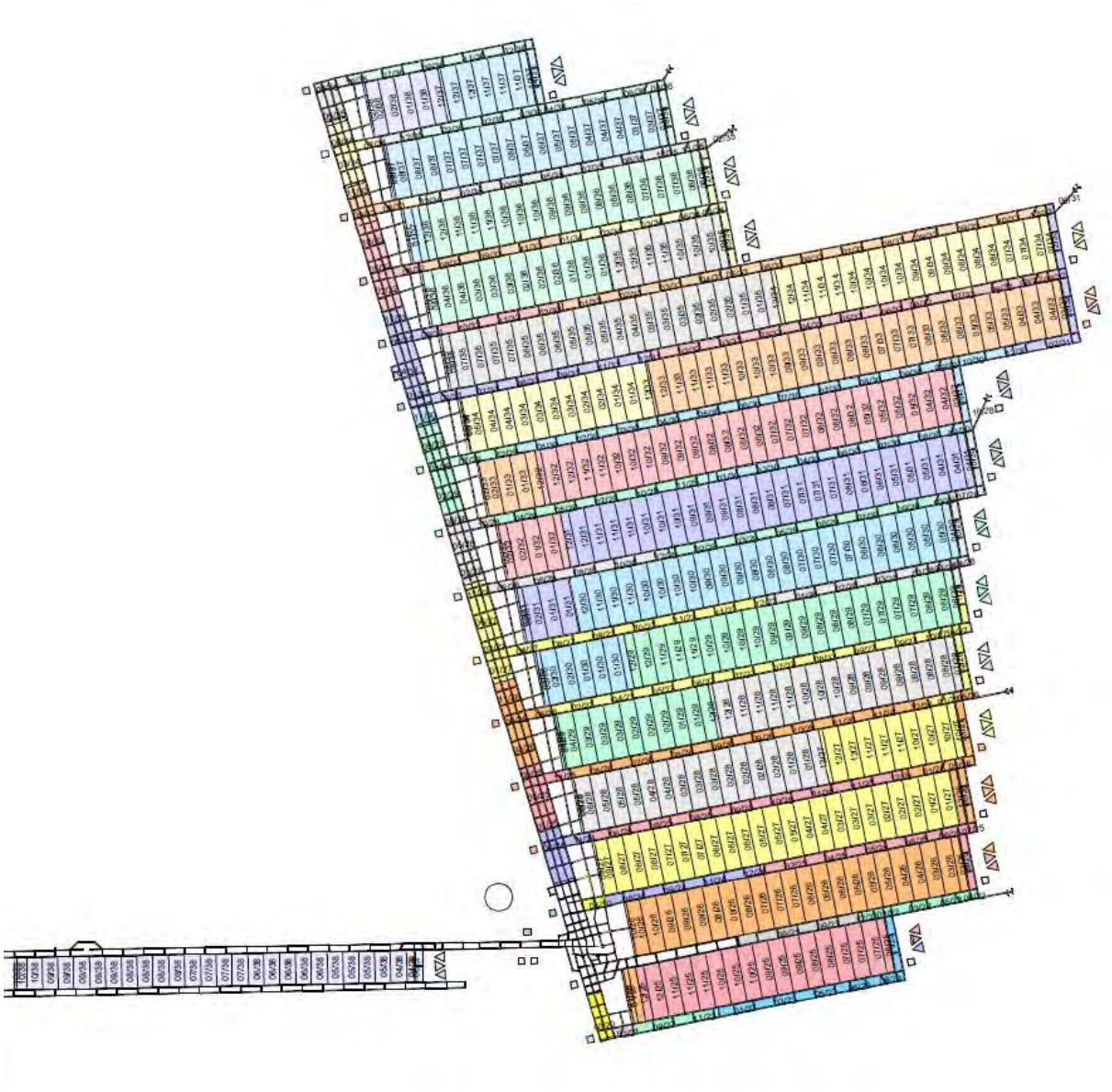

Figure A.1: Mine Schedule implemented in the Model

Table A.1 tabulates the information presented in **Figure A.1**.

Table A.1: Mine Scheduled implemented in the Model

Longwall	Start Month	End Month
LW1002	July 2025	January 2026
LW1001	March 2026	September 2026
LW1003	January 2027	September 2027
LW1004	October 2027	June 2028
LW1005	August 2028	April 2029
LW1006	June 2029	February 2030
LW1007	May 2030	February 2031
LW1008	April 2031	February 2032
LW1009	April 2032	February 2033
LW1010	April 2033	May 2034
LW1011	July 2034	July 2035
LW1012	October 2035	April 2036
LW1013	June 2036	January 2037
LW1014	March 2037	August 2037
LW1015	October 2037	February 2038
LW910N	April 2038	October 2038

Appendix B Calibration Parameters

B1. Calibration Parameters

The following figures present the calibrated parameter values for the Western, Northeastern and Southeastern region components of the SAPSWBM.

The zones used for SILO climatic data (refer **Figure 3.2**) were also used for groundwater salinity. In the following figures, a value of '999' indicates that a particular zone was not present in the respective SAPSWBM. It is noted that numerical value, rather than "n/a" was needed for import into GoldSIM.

In some cases a SILO grid cell encompassed two regions. In that circumstance, the value assigned to groundwater salinity in a particular cell may be different between regions.

	Channel	Disturbed	Natural	Pasture	Urban
Cave	27	79	168	192	27
BFI	0.25	0.25	0.25	0.25	0.25
Kb	0.98	0.98	0.98	0.98	0.98
BaseflowInitial	5.4	4.2	11.3	1.1	5.4
RunoffInitial	0.4	0.18	5.6	0.1	0.4
Ks	0.6	0.3	0.3	0.3	0.6
BVI	0.98	0.95	0.98	0.98	0.95
RunoffSalinity	999	999	999	999	999
SurfaceInitial1	2	6	12	11	2
SurfaceInitial2	20	30	128	134	20
SurfaceInitial3	20	90	253	134	20
SalinityModel					
InitialSalinity	190	300	170	210	400
ROThreshold	0.001	0.001	0.001	0.001	0.001
Multipler	1.04	1.027	1.027	1.04	1.027
Divider	0.8	0.9	0.8	0.8	0.9
MaximumSalinit	500	700	550	600	700
Groundwater Salinity					
C8	999	999	999	250	999
C9	999	999	999	999	999
D7	999	999	999	250	999
D8	999	999	999	250	999
D9	999	999	999	250	999
E7	999	1300	400	500	999
E8	999	1300	400	500	900
E9	999	999	400	500	999
E10	999	999	400	500	999
E11	999	999	999	500	999
F5	999	999	999	999	999
F6	999	999	400	999	999
F7	999	1300	400	500	900
F8	600	1300	400	500	900
F9	999	999	400	500	999
F10	999	999	400	500	900
F11	999	999	999	500	999
G5	999	999	999	999	999
G6	999	999	999	999	999
G7	999	999	400	999	999
G8	999	999	400	999	999
G9	999	1300	400	999	999
G10	999	999	999	999	900
H4	999	999	999	999	999
H5	999	999	999	999	999
H6	999	999	999	999	999
H7	999	999	999	999	999
H8	999	999	20	999	999
H9	999	999	90	999	900
H10	999	999	400	999	900
I4	999	999	999	999	999
I5	999	999	999	999	999
I6	999	999	999	999	999
I7	999	999	999	999	999
I8	999	999	999	999	999
I9	999	999	50	999	999
I10	999	999	999	999	999
J4	999	999	999	999	999
J5	999	999	999	999	999
J6	999	999	999	999	999
J7	999	999	999	999	999
J8	999	999	999	999	999
J9	999	999	999	999	999
J10	999	999	999	999	999
K5	999	999	999	999	999
K6	999	999	999	999	999
K7	999	999	999	999	999
K8	999	999	999	999	999
K9	999	999	999	999	999
K10	999	999	999	999	999
L6	999	999	999	999	999
L7	999	999	999	999	999
L8	999	999	999	999	999
L9	999	999	999	999	999
L10	999	999	999	999	999
M7	999	999	999	999	999
M8	999	999	999	999	999
M9	999	999	999	999	999
Climate Input					
Start time	1/01/1994				
End time	31/12/2061				

Figure B.1: SAPSWBM Western Region parameters

	Channel	Disturbed	Natural	Pasture	Urban
Cave	27	79	168	192	27
BFI	0.25	0.25	0.25	0.25	0.25
Kb	0.98	0.98	0.98	0.98	0.98
BaseflowInitial	5.4	4.2	11.3	1.1	5.4
RunoffInitial	0.4	0.18	5.6	0.1	0.4
Ks	0.6	0.3	0.3	0.3	0.6
BVI	0.98	0.95	0.98	0.98	0.95
RunoffSalinity	999	999	999	999	999
SurfaceInitial1	2	6	12	11	2
SurfaceInitial2	20	30	128	134	20
SurfaceInitial3	20	90	253	134	20
SalinityModel					
InitialSalinity	40	80	10	40	90
ROThreshold	0.001	0.001	0.001	0.001	0.001
Multipler	1.04	1.027	1.027	1.04	1.027
Divider	0.8	0.9	0.8	0.8	0.9
MaximumSalinit	150	400	110	150	325
Groundwater Salinity					
C8	999	999	999	999	999
C9	999	999	999	999	999
D7	999	999	999	999	999
D8	999	999	999	999	999
D9	999	999	999	999	999
E7	999	999	999	999	999
E8	999	999	999	999	999
E9	999	999	999	999	999
E10	999	999	999	999	999
E11	999	999	999	999	999
F5	999	999	999	160	999
F6	999	999	999	160	999
F7	999	999	999	999	999
F8	999	999	999	999	999
F9	999	999	999	999	999
F10	999	999	999	999	999
F11	999	999	999	999	999
G5	999	999	70	160	999
G6	999	999	10	160	999
G7	999	999	10	999	999
G8	999	999	10	999	999
G9	999	999	999	999	999
G10	999	999	999	999	999
H4	999	999	70	999	999
H5	999	999	70	160	999
H6	999	999	10	160	999
H7	999	999	10	999	999
H8	999	999	35	999	999
H9	999	999	999	999	999
H10	999	999	999	999	999
I4	999	999	70	160	999
I5	999	999	35	999	999
I6	999	999	10	999	999
I7	999	999	35	90	999
I8	999	999	35	90	999
I9	999	999	999	999	999
I10	999	999	999	999	999
J4	999	999	35	999	999
J5	999	999	10	999	999
J6	999	999	10	999	999
J7	999	999	10	999	999
J8	999	999	999	999	999
J9	999	999	999	999	999
J10	999	999	999	999	999
K5	999	999	35	999	999
K6	999	999	10	999	999
K7	999	999	10	999	999
K8	999	999	999	999	999
K9	999	999	999	999	999
K10	999	999	999	999	999
L6	999	999	35	999	999
L7	999	999	35	999	999
L8	999	999	999	999	999
L9	999	999	999	999	999
L10	999	999	999	999	999
M7	999	999	70	999	999
M8	999	999	999	999	999
M9	999	999	999	999	999
Climate Input					
Start time	1/01/1994				
End time	31/12/2061				

Figure B.2: SAPSWBM Northeast Region parameters

	Channel	Disturbed	Natural	Pasture	Urban
Cave	27	79	168	192	27
BFI	0.25	0.25	0.25	0.25	0.25
Kb	0.98	0.98	0.98	0.98	0.98
BaseflowInitial	5.4	4.2	11.3	1.1	5.4
RunoffInitial	0.4	0.18	5.6	0.1	0.4
Ks	0.6	0.3	0.3	0.3	0.6
BVI	0.98	0.95	0.98	0.98	0.95
RunoffSalinity	999	999	999	999	999
SurfaceInitial1	2	6	12	11	2
SurfaceInitial2	20	30	128	134	20
SurfaceInitial3	20	90	253	134	20
SalinityModel					
InitialSalinity	40	80	10	40	90
ROThreshold	0.001	0.001	0.001	0.001	0.001
Multipler	1.04	1.027	1.027	1.04	1.027
Divider	0.8	0.9	0.8	0.8	0.9
MaximumSalinit	150	400	110	150	325
Groundwater Salinity					
C8	999	999	999	999	999
C9	999	999	999	999	999
D7	999	999	999	999	999
D8	999	999	999	999	999
D9	999	999	999	999	999
E7	999	999	999	999	999
E8	999	999	999	999	999
E9	999	999	999	999	999
E10	999	999	999	999	999
E11	999	999	999	999	999
F5	999	999	999	999	999
F6	999	999	999	999	999
F7	999	999	999	999	999
F8	999	999	999	999	999
F9	999	999	999	999	999
F10	999	999	999	999	999
F11	999	999	999	999	999
G5	999	999	999	999	999
G6	999	999	999	999	999
G7	999	999	999	999	999
G8	999	999	999	999	999
G9	999	999	999	999	999
G10	999	999	999	999	999
H4	999	999	999	999	999
H5	999	999	999	999	999
H6	999	999	999	999	999
H7	999	999	999	999	999
H8	999	999	35	90	999
H9	999	400	70	999	999
H10	999	999	999	999	999
I4	999	999	999	999	999
I5	999	999	999	999	999
I6	999	999	999	999	999
I7	999	999	999	90	999
I8	999	999	35	90	999
I9	999	400	35	999	500
I10	999	999	35	999	999
J4	999	999	999	999	999
J5	999	999	999	999	999
J6	999	999	999	999	999
J7	999	999	10	999	999
J8	999	999	10	90	999
J9	999	999	10	999	999
J10	999	999	10	999	999
K5	999	999	999	999	999
K6	999	999	999	999	999
K7	999	999	10	999	999
K8	999	999	10	999	999
K9	999	999	10	999	999
K10	999	999	999	999	999
L6	999	999	999	999	999
L7	999	999	999	999	999
L8	999	999	35	999	999
L9	999	999	999	999	999
L10	999	999	35	999	999
M7	999	999	999	999	999
M8	999	999	999	999	999
M9	999	999	70	999	999
Climate Input					
Start time	1/01/1994				
End time	31/12/2061				

Figure B.3: SAPSWBM Southeast Region parameters

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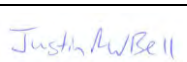
1	Dr Justin Bell	Dr Lyndon Bell	Dr Justin Bell		18 October 2019



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Appendix F. Stream Geomorphology Assessment

Angus Place Mine Extension Project

Centennial Coal Angus Place Colliery Pty Ltd

Surface Water Impact Assessment - Fluvial Geomorphology Assessment

IA161511-RPT-0001-GEOMORPH | FINAL

25/10/2019

-

Angus Place Mine Extension Project

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Appendix A. Hydraulic Modelling

Executive Summary

Background

Centennial Angus Place Pty Limited (Centennial) operates the Angus Place Colliery and propose to recommence longwall mining operations with the proposed LW1001 to LW1015 longwalls.

In April 2014 a State significant development application and the supporting Environmental Impact Statement for the Angus Place Mine Extension Project was submitted to the then NSW Department of Planning and Infrastructure. In response to a prolonged downturn in international coal markets, Centennial made the decision in March 2015 to move Angus Place Colliery to care and maintenance following the completion of secondary extraction within Longwall 900W. At this time, the assessment of the Angus Place Mine Extension Project was placed on hold.

Centennial now propose to recommence longwall mining operations at Angus Place. Mining operations are planned to be undertaken in six stages over a 13-year mine life. Since the submission of the Angus Place Mine Extension Project EIS, and subsequent Response to Submission documents, a review of the Angus Place Mine Extension Project has been completed to take into consideration up to date information obtained from the adjacent Springvale Mine as well as recent changes in operational requirements. This review has resulted in proposed changes to the Angus Place Mine Extension Project to what was presented in the original EIS.

To enable Centennial to progress the Angus Place Mine Extension Project, Centennial sought written agreement from DPIE to modify the SSD 5602 development application, pursuant to Clause 55 of the EP&A Regulation, to incorporate the proposed project changes as the overall concept of the project as proposed will essentially remain the same as the project presented in the original application.

The scope of this fluvial geomorphology assessment has been partly informed by comments made by the NSW Office of Environment and Heritage (OEH, 2014) in response to review of the Springvale Mine Extension Project (SSD 5594), Angus Place Mine Extension Project (SSD 5602) and Angus Place Development Continuity Project (PA_0021 Modification 4). Specifically, OEH recommended (3.1) that 3rd order (Strahler) streams be monitored to determine whether post-mining impacts occur.

Methodology

The assessment has been completed though use of:

- Desktop review of available information and data as well as processing of various spatial data;
- Fieldwork – fluvial geomorphological inspection of 13 sites;
- Hydraulic modelling – 2-dimensional modelling for watercourses across the AMEP application area; and
- Impact assessment

Existing Condition

Table 1.1 below summarises the characterisation of fluvial geomorphological diversity across the Study Area. All sites visited within the Study Area were considered to be in good condition and showing a behaviour and character appropriate to the river style. Two sites outside the Study Area that had previously been under mined showed signs of impact resulting from loss of baseflow due to lowering of the standing water level in the swamps located immediately upstream.

Potential Impacts

Post-mining tilt is not expected to present significant impact as the predicted maximum tilt within the Study Area is 25mm/m (2.5%). This is contrasted to the average natural gradients of drainage lines which typically vary between 25 mm/m and 300 mm/m (i.e. 30 %) directly above the proposed longwalls. The predicted maximum tilt is therefore less than the existing streambed gradients and it is therefore considered unlikely that this will have an impact on surface flows as they will continue to remain free draining.

Changes to the surface profile of the catchment areas reporting to each drainage line may result in minor changes to the volume and timing of runoff entering the channel. This might occur through ponding, changes to watersheds or reductions in the time for flow concentration to occur. These changes are considered to be minor however and unlikely to have a material impact.

Loss of flow via development of fracture networks beneath watercourses may significantly reduce or in some cases effectively eliminate baseflow as well as shortening flow recession after flow events. This loss of flow can lead to the progressive drying of downstream swamps which can result in impacts including loss of wetland plant species, drying and desiccation of the swamp peat, increased potential for incision and erosion of the swamp surface during high flow events. During high flow events however, the increased surface flow will likely exceed the capacity of any subsurface fracture network surface and hence ensure continuation of surface flow.

Swamps also provide significant attenuation of flows and afford affective regulation of downstream stream flow and supply of sediment. This attenuation serves to sustain flows downstream during prolonged dry periods whilst moderating the impacts of larger flows as well as limiting the supply of sediment throughput.

Hydraulic modelling indicated the potential for small changes to the estimated peak discharge. Relative changes in discharge were typically in the order of +/- 1% and are not considered of material impact. Larger changes in the order of +2 to +4% were noted in relation to a channel immediately downstream of Site 10 however the value of the absolute change was no greater than 0.27 m^3/s which is considered negligible.

Modelling also indicated the potential for both increases and decreases in stream power. At a total of ten locations the magnitude of stream power increase ranged from 50 to 100% during the 5% AEP storm event. It is noted however that at a number of these locations the increase was of a very low initial value with the increased stream power not considered to present an additional erosional risk. For some sites, existing stream power is already in excess of 1,000 W/m^2 and the post-subsidence case is therefore not expected to present a significant additional erosional risk above that already experienced. For the remaining locations it is recommended that site specific investigations be conducted following significant flood events in order to assess existing resilience and to develop a baseline level of understanding of the potential for erosion at these locations.

Monitoring and Management

It is recommended that a site monitoring program be developed as a means with which to monitor existing baseline conditions and to assess potential geomorphological impacts resulting from the APMEP. The program should include sites that are:

- Representative of each of the river styles found in the Study Area;
- Include existing higher risk sites e.g. that overly areas of maximum predicted tilt or exhibit existing erosional concerns (e.g. Site 10); and
- Are outside of the proposed subsidence area for reference.

Establishing an understanding of the existing balance of erosion and sediment movement is critical to understanding whether observed impacts are part of naturally-occurring process or have been enhanced or induced by post-mining subsidence. Of key importance is understanding existing patterns of erosion and

sedimentation resulting from bankfull discharges (typically 1-2-year AEP) events as these relatively frequent events and are significant drivers of geomorphological change.

Table 1.1: Fluvial Geomorphology Assessment Summary

River Style	Description	Condition Assessment
Intact Valley Infill (Swamp)	Low gradient, intact, concave valley infill that covers the valley floor. Flow is typically subsurface with occasional surface expressions occurring at low points. Drainage channels are typically absent.	With the exception of Carne West and Gang Gang Swamps (which were selected as previously impacted reference sites), all sites were found to be in good condition and no concerns were noted. Each site appeared to be in good condition showing an appropriate behaviour and character for the river style.
Channelised Fill	Typically found on the inflow tributaries to swamps. Low sinuosity, discontinuous channels located within an infilled, confined valley setting. Alternate phases of channel entrenchment (gullying) and filling occur. Where present channels are typically small and trench-like. Elsewhere, the valley floor is effectively the channel with shallow swale-like channels tending to poorly defined, discontinuous drainage lines.	All sites visited typically appeared to be in good condition with no adverse concerns; processes of channel development and infilling appeared to be in balance and riparian vegetation was found to be intact and undisturbed. One site (Site 10) was noted to have some relatively large-scale, historical erosion and scour features however these generally appeared to be stable and well vegetated.
Steep Headwater	Steep-graded, bedrock confined channels located in narrow, confined valley settings that typically lead into downstream gorges. Bedrock steps (waterfalls) and runs and cascades are prevalent.	Sites visited within the Study area appeared to be in good condition showing an appropriate behaviour and character for the river style. Two sites outside of the Study area that were visited (sites 12 and 13) were found to be moderately impacted from loss of baseflow as well as sedimentation from material eroded from adjacent access tracks
Gorge	Confined valley setting with a single, continuous channel; no floodplain present. Valley sides are steep to vertical (cliffs), sometimes deeply dissected by inflow tributaries leading to bedrock spurs which force the main channel to adopt a relatively sinuous planform. Lower gradient sites within a wider valley setting also comprise some alluvial infilling of the valley floor into which the channel is incised.	All sites visited were found to be in good condition showing a behaviour and character appropriate to the river style. It is noted that, similar to Sites 12 and 13 (Steep Headwater), Site 7 also exhibited some minor, localised impact from the vehicle access track which resulted in some minor sedimentation in the watercourse adjacent to where water crossings were present or where track runoff entered the watercourse.

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- *an exclusion of any warranty/guarantee (expressed or implied) to the data, observations and findings in the report to the extent permitted by law*
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1. Introduction

1.1 Project Description

1.1.1 Overview

Angus Place Colliery is an existing underground coal mine producing high quality thermal coal for domestic markets, predominantly the Mount Piper Power Station. It is located 15 kilometres to the northwest of the regional city of Lithgow and 120 kilometres west northwest of Sydney in New South Wales.

The mine's current project approval (Project Application 06_0021) was granted in September 2006 under Part 3A of the Environmental Planning and Assessment Act 1979. The current project approval has since been declared a State Significant Development (SSD) under clause 6 of Schedule 2 to the Environmental Planning and Assessment (Savings, Transitional and Other Provisions) Regulation 2017, for the purposes of the EP&A Act. Accordingly, Angus Place Colliery now operates as a SSD approval. The Angus Place Colliery project approval and its subsequent modifications remain current and authorises the extraction of up to 4 million tonnes of run of mine (ROM) coal per annum. The current project approval will expire in August 2024 and a new development consent is required to ensure Angus Place Colliery is operational beyond this date.

1.1.2 Proponent Details

Angus Place Colliery is owned by Centennial Coal as a joint venture with SK Kores Australia Pty Ltd (50-50% joint venture). The Angus Place Colliery has been operated by Centennial Angus Place Pty Limited (Centennial Angus Place), on behalf of the joint venture participants since 2002.

Centennial Angus Place Pty Limited is the proponent for the Project.

1.1.3 Project Background

A new SSD application (SSD 5602) and supporting Environmental Impact Statement (EIS) was submitted to NSW Department of Planning, Infrastructure and Environment (DPIE) in April 2014 (2014 EIS) for the Angus Place Mine Extension Project. The Angus Place Mine Extension Project sought to extend the life of the Angus Place Colliery and continue the ability to extract up to 4 million tonnes per annum (Mtpa) of run of mine (ROM) coal using longwall mining techniques. The project also sought to continue the utilisation of existing infrastructure, as well as construct and operate additional infrastructure to support the underground mining operations.

The exhibition period for the EIS commenced on 12 April 2014 and ended on 26 May 2014. A Response to Submissions (RTS) report was lodged with the DPIE on 1 October 2014 to respond to submissions received during the public exhibition period. A supplementary RTS was lodged with the DPIE in December 2014.

In response to a prolonged downturn in international coal markets, a decision was made by Centennial Coal to place the Angus Place Colliery into care and maintenance following the completion of secondary extraction within longwall panel 900W. Secondary extraction of longwall panel 900W was completed on 15 February 2015 and the mine was placed in care and maintenance on 28 March 2015. At this stage, the assessment of the Angus Place Mine Extension Project (AMEP) was placed on hold.

1.1.4 Project Update

Since the submission of the Angus Place Mine Extension Project EIS, and subsequent Response to Submission documents, a review of the Angus Place Mine Extension Project has been completed to take into consideration up to date information obtained from the adjacent Springvale Mine as well as recent changes in operational

requirements. This review has resulted in proposed changes to the Angus Place Mine Extension Project to what was presented in the original EIS.

To enable Centennial to progress the Angus Place Mine Extension Project, Centennial sought written agreement from DPIE to modify the SSD 5602 development application, pursuant to Clause 55 of the EP&A Regulation, to incorporate the proposed project changes as the overall concept of the project as proposed will essentially remain the same as the project presented in the original application.

1.1.5 Purpose of the Fluvial Geomorphology Assessment

In order to facilitate the amendment to the SSD 5602 development application, an Amended Project Report has been developed to detail the revisions to the Angus Place Mine Extension Project and include updated assessments that take into consideration contemporary standards/guidelines and the latest information available to inform the assessment process. This fluvial geomorphology assessment partly comprises the Water Impact Assessment (Appendix G) of the Amended Project Report as shown below:

- Subsidence Assessment (Appendix A)
- Biodiversity Impact Assessment (Appendix B)
- Water Impact Assessment (Appendix C):
  - Geomorphology assessment ('the study' - this document)
  - Site water and salt balance
  - Regional water and salt balance
  - Groundwater model and groundwater impact assessment
- Air Quality Impact Assessment (Appendix D)
- Noise Impact Assessment (Appendix E)
- Greenhouse Gas Assessment (Appendix F)
- Traffic Impact Assessment (Appendix G)

1.2 Methodology and Data Sources

1.2.1 Methodology

This study has been completed using a combination of desktop, fieldwork and modeling as indicated below:

- Desktop review of available information and data as well as processing of various spatial data;
- Fieldwork – fluvial geomorphological inspection of 13 sites;
- Hydraulic modelling – 2-dimensional modelling for watercourses across the AMEP application area; and
- Impact assessment

1.2.2 Data Sources

Data utilised in this study was obtained from a number of different sources as shown below in Table 1.1.

Table 1.1: Data Sources

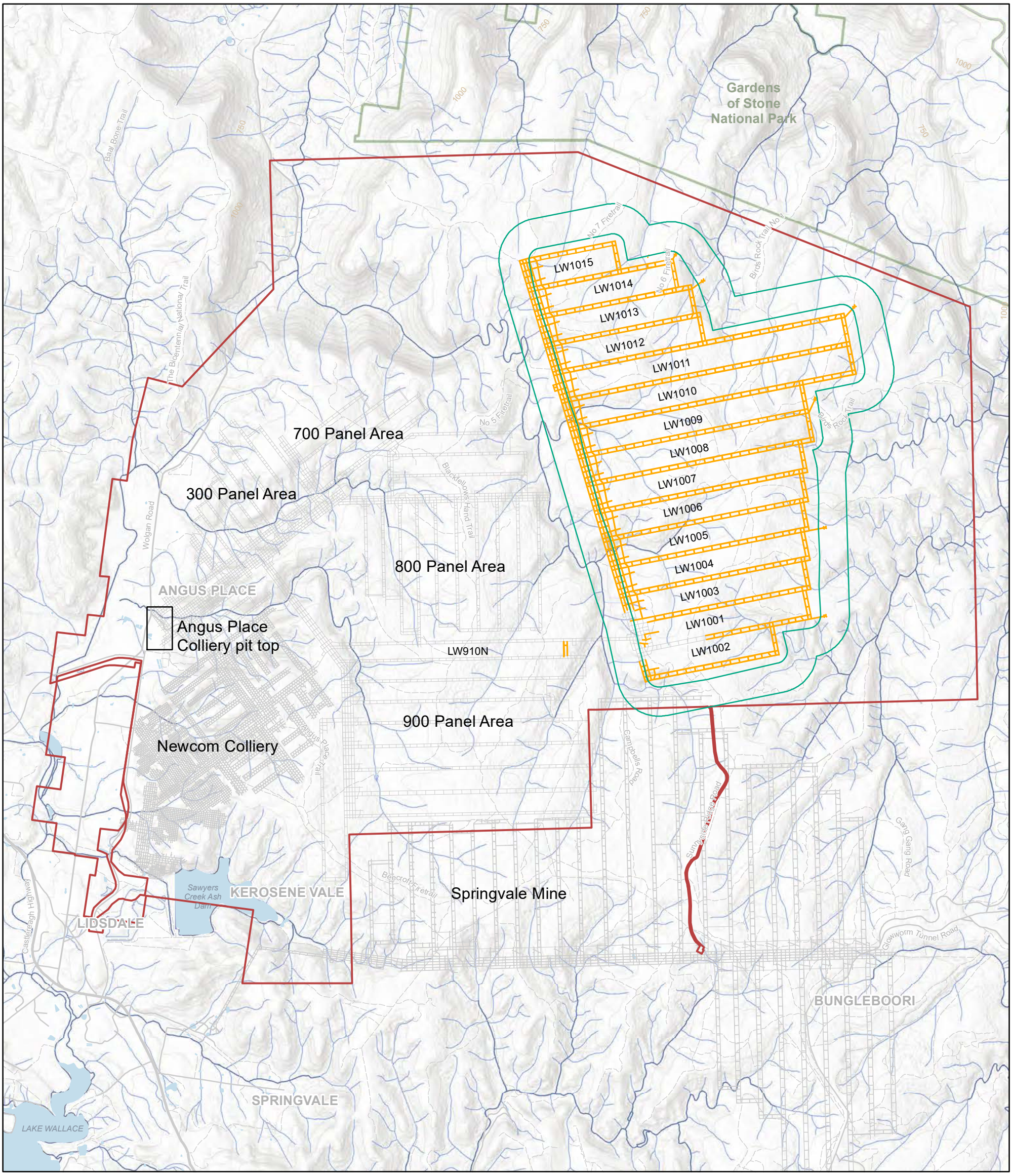
Aspect	Data Utilised	Comment
Topographic data (existing)	2m LiDAR obtained from ELVIS (https://elevation.fsdf.org.au/)	Used for hydraulic modelling (existing case)
	1 second SRTM obtained from ELVIS (https://elevation.fsdf.org.au/)	Used for GIS
Topographic data (subsidence predictions)	(MSEC, 2019)	Used for hydraulic modelling (developed case)
Design storm data	Australian Rainfall and Runoff (ARR) Data Hub	Intensity Frequency Duration (IFD) data, temporal patterns, loss parameters
Aerial imagery	Detailed aerial imagery provided by Centennial	

1.3 Project Study Area and Watercourse Nomenclature

The Angus Place Colliery is located in the Western Coalfield of New South Wales, 15 kilometres northwest of the city of Lithgow and 120 kilometres west northwest of Sydney. Angus Place pit top is accessed via the Castlereagh Highway and is located 5 kilometres north of the village of Lidsdale, and 7.4 kilometres northeast of Wallerawang. The APMEP Application Area comprises an area of 10,551 ha and is defined by the Mining Lease (ML 1434) and Exploration Licence boundaries (EL6856 and EL6293), as shown on Figure 1.1.

For the purpose of this assessment however, the area considered has generally been limited to that within the predicted angle of draw of the proposed longwalls. Within and adjacent to this area a number of key watercourses and drainage lines have been identified. Adopted nomenclature for unnamed drainage lines has been based on that developed by (MSEC, 2019) and is shown on Figure 1.1 and Figure 4.5.

Figure 1.1: Project Location and Study Area



Infrastructure
- Proposed Workings
- Existing Workings

Project Area
- Project Area

APE Study Areas
- 600 m area

Contours
- 50 Metre

Hydrology
- Waterareas
- Stream Order 1 - 2
- Stream Order 3 - 6

Tenures
- National Parks



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Angus Place Amended Project

Data Sources - Centennial Angus Place Pty Ltd: Project Area, Infrastructure (2019); NSW Government Public Data: Roads, Hydrology, Placenames; Geosciences Australia (ELVIS): 50m Contours; Office of Environment and Heritage NSW: Tenures; ESRI ArcGIS Image Service: World Elevation Terrain, World Topographic Map

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1.4 Assessment Scope and Limitations

The scope of this assessment has been partly informed by comments made by the NSW Office of Environment and Heritage (OEH, 2014) in response to review of the Springvale Mine Extension Project (SSD 5594), Angus Place Mine Extension Project (SSD 5602) and Angus Place Development Continuity Project (PA_0021 Modification 4). Specifically, OEH recommended (3.1) that 3rd order (Strahler) streams be monitored to determine whether post-mining impacts occur.

The scope of this assessment is therefore outlined as follows:

Geomorphology Assessment

- Mapping of stream Strahler order based on the Water Management (General) Regulation 2018, Hydro Line spatial data set;
- Stream characterisation using River Styles classification[1], including descriptions and profiles for all major and minor drainages near the APMEP;
- Field inspection and ground-truthing of selected locations to confirm the above, and identification of areas of risk with respect to water way stability;
- Selection of ground-truthing locations prioritised according to:
    - Proximity to key swamps;
    - Stream order of 3 or greater;
    - Proximity to potential waterfalls (or other areas of significant aesthetic appeal); and
    - Proximity to areas of maximum potential subsidence.

Two additional sites were also considered for comparative purposes as being representative of previously impacted sites. These sites (Carne West and Gang Gang swamps) overlie previously mined areas (e.g. Carne West Swamp has been impacted by undermining of LW 418 and 419) and have been impacted by changes to the hydrological regime. This has resulted in lowering of the swamp standing water levels and subsequent dieback of shallow rooted ferns and sedges.

It is not within the scope of this assessment to develop a detailed monitoring program however high-level recommendations are provided in Section 7.

Hydraulic Assessment

- Preparation of a hydraulic catchment runoff and flow model for the major watercourses in vicinity of the APMEP to assess potential changes in key hydraulic indices as a result of subsidence:
    - Hydraulic modelling conducted using a direct rainfall (rain on grid) TUFLOW simulation for key design storms using topographic data representative of both pre- and post-mining conditions;
    - The model boundary limits excluded Carne Creek and the Wolgan River and were generally located upstream of any escarpment of the newness Plateau;

[1] This fluvial geomorphology assessment has been, where relevant, completed through the application of established fluvial geomorphological principles that are consistent with the River Styles Framework. No claim is made however that this report constitutes a River Styles report and the authors are neither provisional or accredited River Styles practitioners.

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- Assessment of potential changes in flow under constant environmental conditions due to changes to surface topography due to mine subsidence over life of mining, including identification of areas at risk of increased scouring or sedimentation.

Impact Assessment

Completion of an assessment of potential environmental impacts to the existing fluvial geomorphological environment within the APMEP area as well as recommendations for the development of a suitable monitoring program.

2. Fluvial Geomorphic Concepts

2.1 Fluvial Processes and Landforms

Fluvial geomorphology is the study of river process and form. It describes the form of landscapes in relation to watercourses, and identifies key processes that have taken place historically, and in the present landscape, to develop that form. As water flows through a channel it may transfer sediment in solution, suspension or in contact with the bed (i.e. rolling, sliding, or saltating (hopping) along the channel bed). The interactions between water, sediment, hydraulic geometry of the channel and changes in flow velocity and volume create distinctive forms that can be described via bedforms, cross-sectional geometry and channel planform. These interactions leave distinctive sedimentary deposits that can be used to infer characteristics of past channels.

Key processes contributing to the fluvial geomorphic character of a catchment may include:

- The movement of sediment through the system via erosion, transport, and depositional processes;
- The interaction between the hydraulic geometry of the river channel and changes in flow velocity and volume;
- The formation and/or influence of in-channel geomorphic features such as vegetated islands and bars (sediment deposits located within the channel).

The amount of energy and type of material (such as gravel, bedrock, sand, or fine sediments such as clay and silt) are key drivers of the physical form of a watercourse. The supply and movement of material is typically in a form of dynamic equilibrium. However, they fall out of balance if they are changed dramatically or intensively over a short time period (compared with the natural rate of change). This can subsequently lead to the acceleration of processes that are detrimental to the long-term condition of the watercourse's natural geomorphic character. It is this imbalance, or potential for change that is outside of what appears to be the natural regime within the catchment, that would be considered an adverse impact on the system.

2.2 The River Styles Framework

This fluvial geomorphology assessment has been completed using established geomorphological principles that are consistent with the River Styles Framework. While this report does not constitute a River Styles report, description, classification and presentation of fluvial geomorphological diversity found across the Study Area has been completed in a similar format.

The River Styles Framework is designed to provide a set of generic procedures with tools for interpreting river character, behaviour, condition and recovery potential. The explanatory and predictive basis of the Framework provides a rigorous foundation for decision making in river management (River Styles, 2019). The framework applies a set of hierarchical principles to differentiate reaches, interpret their process-based behaviour and examine interactions between patterns of reaches at the catchment scale (Fryirs & Brierley, 2018).

The River Styles approach to river type is based on identification of:

- Valley setting;
- Channel planform;
- Geomorphic units; and
- Bed material texture.

Figure 2.1 below shows the generic River Styles procedural tree used to identify a particular River Style. Valley setting provides the first level of differentiation and describes the level of confinement (confined, partly confined, laterally unconfined) the watercourse has within its valley setting. Within each valley setting, River Styles are

further identified on the basis of channel and floodplain character. Finally, identification of representative geomorphic units and bed material.

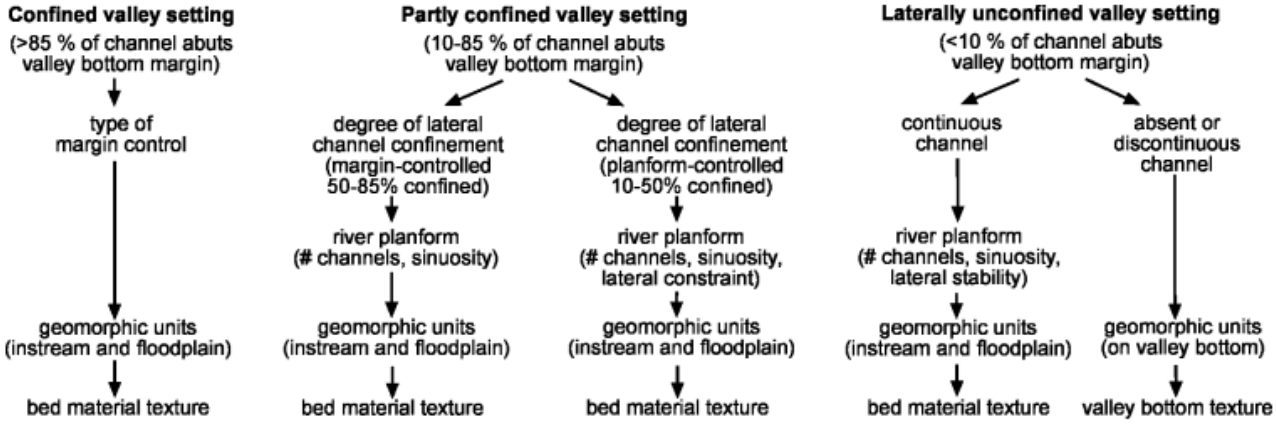


Figure 2.1: River Styles Procedural Tree for Identifying Different River Types (Fryirs & Brierley, 2018)

2.3 Stream Power

Stream power is a measure of the main driving forces acting in a channel and determines a river's capacity to transport sediment and perform geomorphic work (Bizzi & Lerner, 2015). It is the product of stream discharge, stream slope and weight of water and has a direct relationship with the transport of sediment (Gartner, 2016). Total and unit stream power (stream power per unit channel width) are calculated as follows:

$$Total\ Stream\ Power, TSP = \gamma QS$$

$$Specific\ Stream\ Power = \frac{TSP}{w}$$

Where γ is the unit weight of water, Q is discharge (m^3/s), S is the energy slope (m/m) and w is the channel bankfull width.

Critical stream power is the power needed to transport sediment load and increases with sediment size. At very low stream power, sediment flux is minimal to non-existent, but above the threshold for sediment transport there is a clear positive relationship such that higher stream power produces greater sediment flux (Gartner, 2016).

2.3.1 Hydraulic Modelling

A 2-dimentional hydraulic model was developed to assess potential changes to stream power as a result of the proposed subsidence. The modeling compared estimated specific stream power for two cases; the existing topography and the resulting subsidence surface predicted by (MSEC, 2019). Results of the modelling is discussed further in Section 6.2 and the hydraulic modeling technical memo is provided in Appendix A

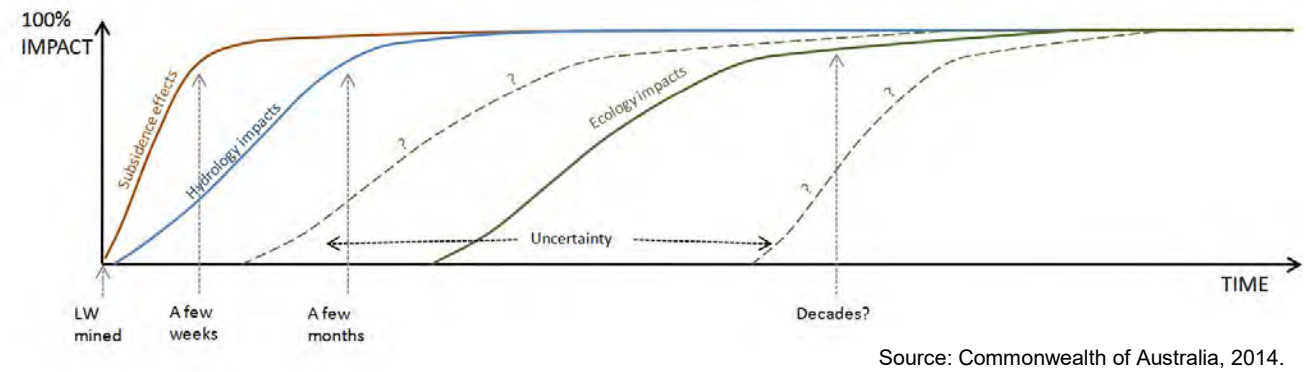
3. Potential Impacts of the Angus Place Mine Extension Project

3.1 Longwall Subsidence Effects

Subsidence has the potential to impact directly on the hydrological and hydrogeological regimes that underpin watercourses and swamps across the study area. The IESC (Commonwealth of Australia, 2014a) presents three broad impact categories that reflect the time lag between mining and potential impact (Figure 3.1):

- First-order subsidence impacts, which refer to the immediate impacts of subsidence (also called subsidence effects), such as cracking, shearing, tilting and reopening of bedding planes and joints within the sandstone
- Second-order hydrological impacts, which refer to the impacts that result from subsidence effects, such as changes to swamp hydrology from altered groundwater or surface water flow paths, and water quality impacts
- Third-order ecological impacts, which are the result of changes to swamp hydrology and water quality, such as peat erosion and the ecological response of flora and fauna.

It is noted that third-order impacts have the potential to lag significantly behind initial undermining and the occurrence of subsidence and hydrological impacts, potentially by years or even decades. In addition to the potential impacts of being directly under mined, Centennial (Centennial, 2018) note the potential for swamps, which reside in structurally controlled valleys, to be impacted by longwalls up to two kilometres away if the geological structure is intercepted by the longwall (refer to Groundwater Impact assessment (Jacobs, 2019a) for further information).



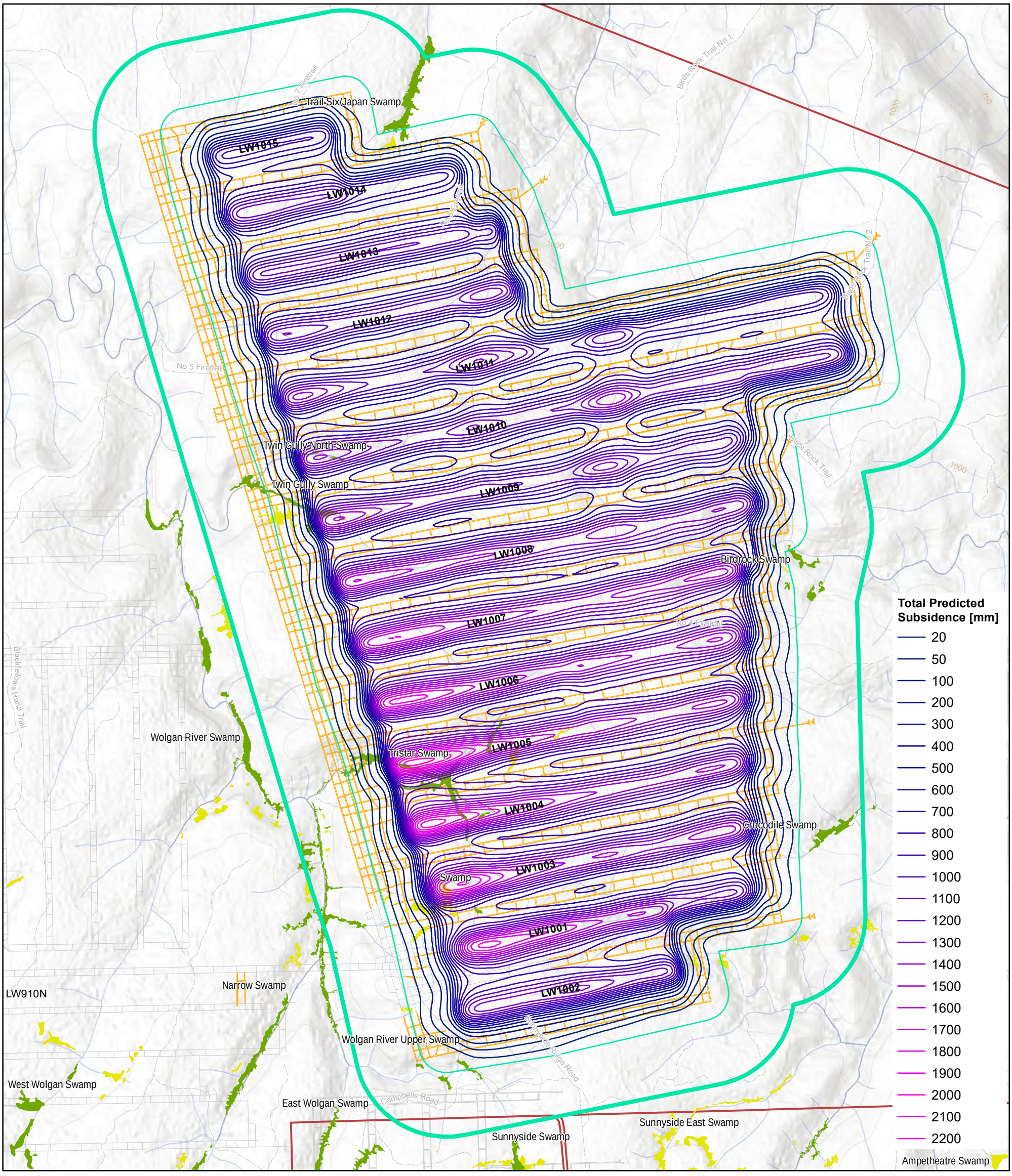
Source: Commonwealth of Australia, 2014.

Figure 3.1: Potential Timeline for Observation of Impacts

3.1.1 Subsidence Report

Predicted mine subsidence is presented and discussed in the Subsidence Impact Assessment (MSEC, 2019). Total predicted subsidence for the 1000 panel area is shown on Figure 3.2. Maximum predicted subsidence is of the order of 2.3m above longwall LW1005 and beneath Tri Star Swamp. Subsidence is maximised due to the increased seam thickness and reduced depth of cover in the Tri Star swamp valley. Subsidence diminishes to the north with reduced seam thickness and height of extraction.

Figure 3.2: Total Predicted Subsidence



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4. Existing Environment

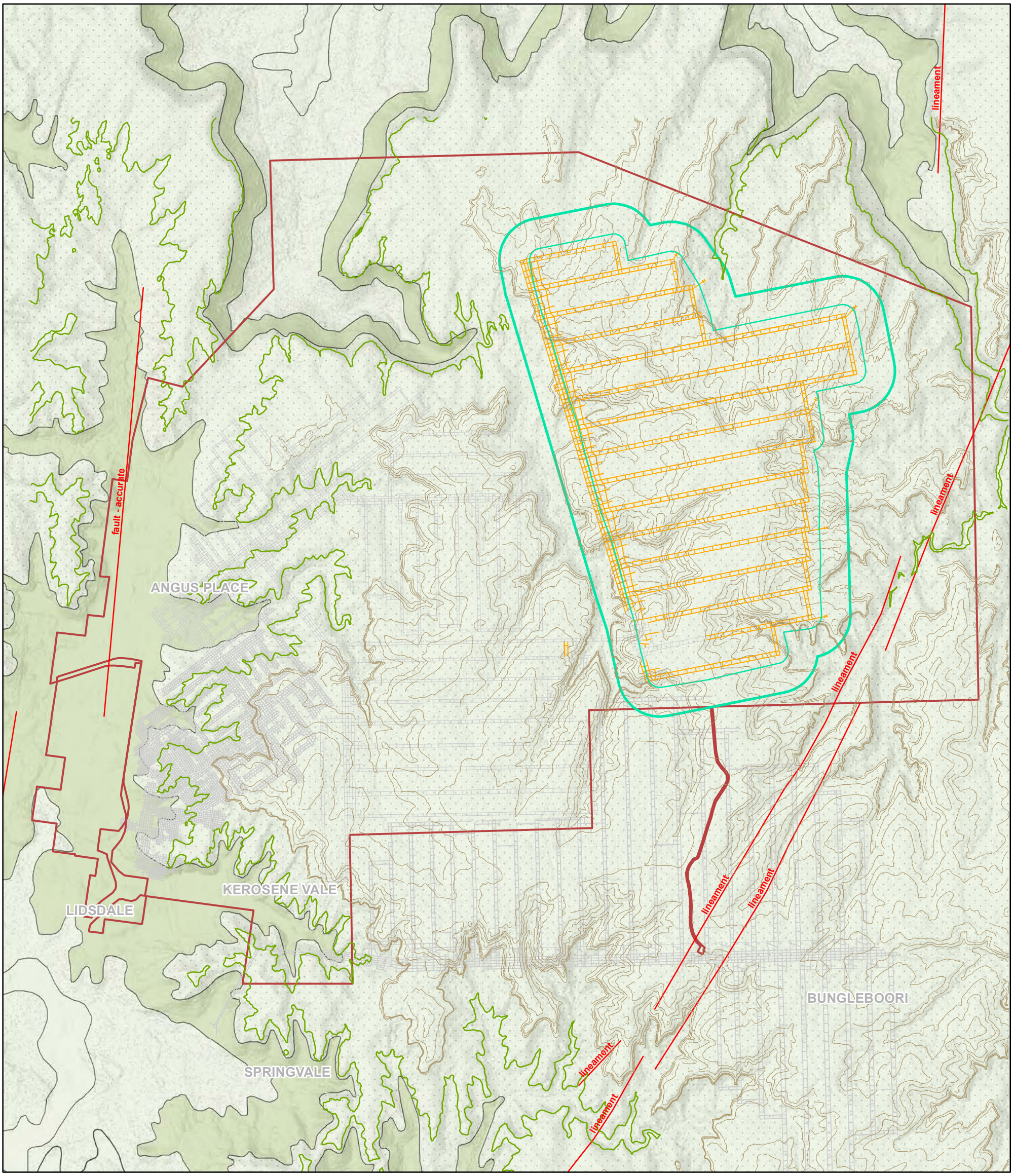
4.1 Geology

The APMEP and the existing operations at Springvale and Angus Place Collieries extract coal from the Lithgow Seam of the Permian age Illawarra Coal Measures of the Sydney Basin. The Lithgow Seam is up to 400m below the surface of the Newnes Plateau and outcrops/sub-crops in areas of the Coxs River Valley and the Wolgan Valley.

The Illawarra Coal Measures are unconformably overlain by the lithologies of the Triassic Narrabeen Group and are unconformably underlain by the lithologies of the early Permian Shoalhaven Group (Yoo, Tadros, & Bayly, 2001). West of the coal bearing Permian strata, the older sediments, meta-sediments and granitic bodies of the underlying Silurian and Devonian age rocks of the Lachlan Fold Belt dominate the surface geology. These older strata also extend beneath the Sydney Basin lithologies.

The Narrabeen Group was formed in an estuarine and alluvial plain and includes the Burralow Formation and Banks Wall Sandstone. These medium to coarse-grained sandstone units dominate the landscape as plateaus, cliff formations, deeply incised valleys and gorges (Commonwealth of Australia, 2014a). The presence of thin but persistent, widely spaced claystone units in the Banks Wall Sandstone has a tendency to weather into silicate karst landforms, known as pagoda weathering. Temperate peat swamps form predominately on Hawkesbury Sandstone and Banks Wall Sandstone. Regional geology is shown on Figure 4.1.

Figure 4.1: Regional Geology



Western Coalfield Geology

Quaternary

Qa – Alluvium

Triassic

Tn – Narrabeen Group

Burralow Formation YS Ply Outcrop

Mount York Claystone Outcrop

Permian

Pi – Illawarra Coal Measures

Pn-Ps Nile Subgroup - Shoalhaven Group

Ps – Shoalhaven Group

Pz - Undifferentiated Palaeozoic

Carboniferous

Cg – Granite

Geologic Structures

Various

Infrastructure

Proposed Workings

Existing Workings

Project Area

26.5 degree AoD

600m Study Area



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Angus Place Amended Project

Data Sources - Centennial Angus Place Pty Ltd: Project Area, Infrastructure (2019); NSW Government Public Data: Roads, Hydrology, Placenames; Geosciences Australia (ELVIS): 50m Contours; Yoo E.K., 1992, Western Coalfield Regional Geology (southern part) 1:100 000, 1st edition. Geological Survey of New South Wales, Sydney; ESRI ArcGIS Image Service: World Elevation Terrain, World Topographic Map

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4.2 Soil Landscapes

The Soil Landscape Units within the APMEP Application Area have been mapped by the former NSW Department of Land and Water Conservation, incorporating the NSW Soil Conservation Service (now part of the DPI), at the scale of 1:100,000 (King, 1993)A detailed soil and land capability assessment was undertaken for the 2014 Angus Place Extension Project EIS (GSS, 2014). A summary of the soil landscapes present in the APMEP Application Area is provided in Table 4.1.

The dominant soil landscape units in the APMEP Application Area are Wollangambe, which is an erosional landscape comprised of rounded convex crests and moderately to steeply inclined side slopes on sandstone, and Newnes Plateau, which is a residual landscape comprised of level to gently undulating wide crests and ridges on plateau surfaces of sandstone.

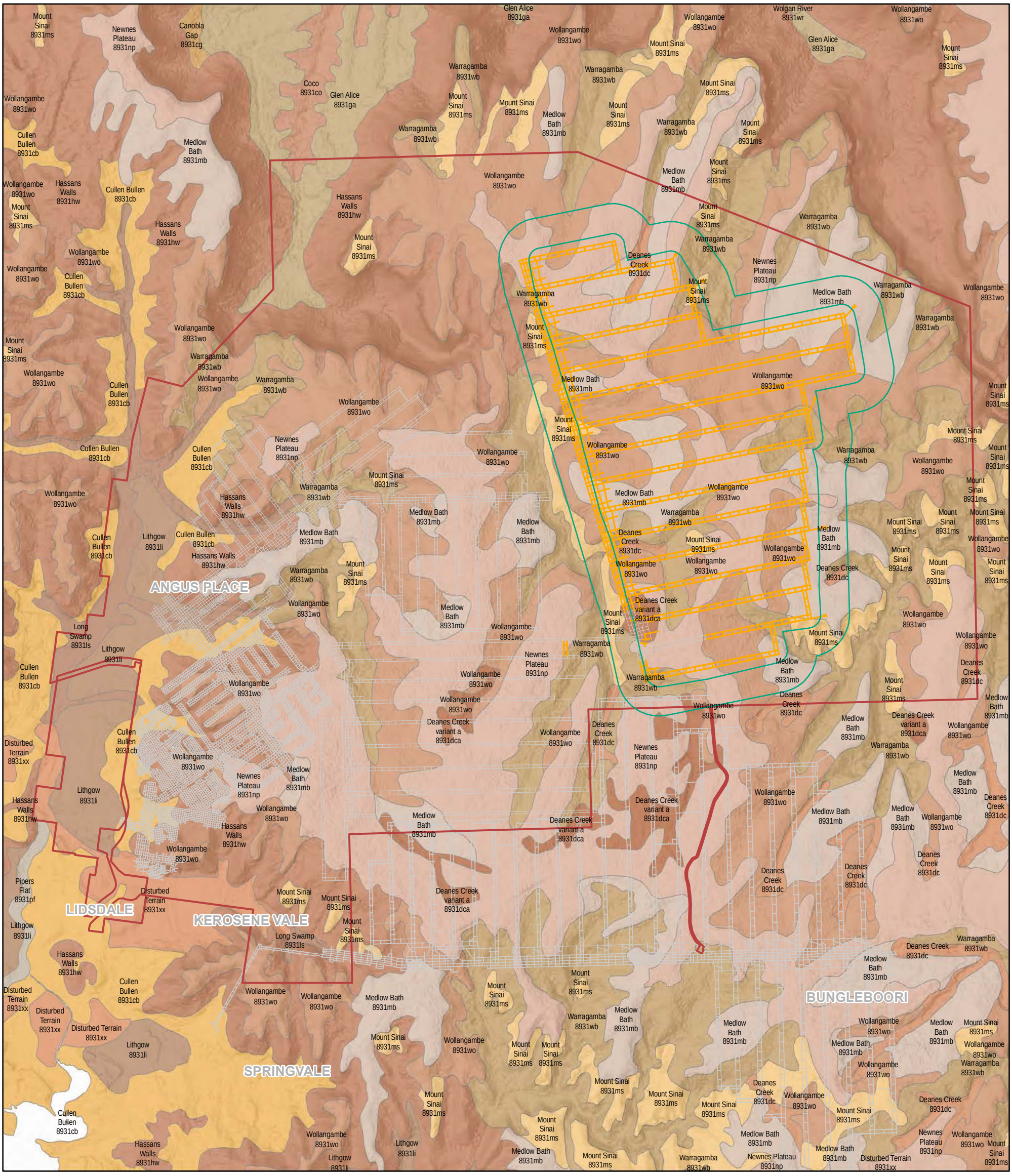
Other substantial soil landscapes include Warragamba, Hassans Walls, and Medlow Bath. Soil types associated with swamps include Deanes Creek soil types on the Newnes Plateau and Long Swamp soil types in the Coxs River valley. Soils in the vicinity of the Angus Place pit top are dominated by Lithgow Soils. Minor soil landscapes in the APMEP Application Area include Mt Sinai, Cullen Bullen and Glen Alice.

Table 4.1: Soil Landscape Characteristics

Soil Landscape	Approximate area (ha)	Topographic Occurrence	Key characteristics
Wollangambe	2672	Rounded convex crests and moderately to steeply inclined side slopes on Narrabeen Group sandstones. Slopes usually <35 per cent.	High to severe water erosion, steep slopes, shallow soils, localised rock fall hazard, localised rock outcrop and low soil fertility.
Newnes Plateau	2036	Level to gently undulating low crests and ridges on plateau surfaces of Triassic Sandstone. Slopes <10 per cent, and infrequent rock outcrop.	Highly permeable, stony soils of low fertility, low water holding capacity, high potential aluminium toxicity and localised shallow soils.
Warragamba	1609	Narrow convex crests and ridges and steep colluvial side slopes on Narrabeen Group sandstones with minor cliffs and scarps on steeper slopes. Slopes typically >35 per cent.	Mass movement hazard, steep slopes, sever water erosion hazard, rock fall hazard, acidic, stony soils of low fertility and rock outcrop.
Hassans Walls	1418	Cliffs derived from Narrabeen Group sandstones and steep colluvial talus side slopes developed over the Illawarra Coal Measures and the Shoalhaven Group. Slopes mostly >40 per cent.	Rock fall hazard, steep slopes, extreme water erosion, mass movement, localised shallow soils, high run-on, non-cohesive soils.
Medlow Bath	1097	Consists of narrow crests and moderately inclined side slopes on Narrabeen Group sandstones. Slopes of 10 – 20 per cent.	Shallow, stony, acid soils of low fertility, high potential aluminium toxicity, moderate erodibility and localised rock outcrop.
Mt Sinai	397	Narrow, rocky undulating crests and steep side slopes with many rocky benches and pagoda formations on Narrabeen Group Sandstones.	Extreme water erosion hazard, rock outcrop, steep slopes, rock fall hazard, wind erosion hazard, and stony shallow, acid, non-cohesive highly permeable soils with low fertility.

Soil Landscape	Approximate area (ha)	Topographic Occurrence	Key characteristics
Lithgow	335	Consists of flat to undulating rises and broad valley floors on Illawarra Coal Measures and the Berry Formation. Slopes <10 per cent.	Hard setting top soils, high run-on, localised rock fall hazards and localised potential aluminium toxicity.
Cullen Bullen	305	Rolling low hills and rises on Illawarra Coal Measures and the Berry Formation. Localised rock outcropping occurs as small isolated low scarps. Slopes are typically 10 – 25 per cent.	Dispersibility, erodibility, hard setting surface, acidity, low fertility, low wet bearing strength.
Long Swamp	236	Level to very gently inclined swamps on recent alluvium overlying the Permian Illawarra Coal Measures. Slopes mainly <3 per cent.	High run-on, permanent high water tables, waterlogging, high foundation hazard, and highly organic acid soils of low fertility.
Deanes Creek	131	Consists of narrow, gently inclined elongated valley-side tree swamps along drainage lines on Narrabeen Group Sandstones.	Permanently high water tables and periodic to permanent waterlogging, acid soils of low fertility, high run-on, and high foundation hazard.
Glen Alice	122	Rolling rises and low hills on Shoalhaven Group sediments in the Wolgan and Capertee Valley. Slopes of 5 - 20 per cent.	Hard setting top soils, localised salinity, localised alkalinity, high water erosion hazard, localised steep slopes and occasional localised flooding.

Figure 4.2: Soil Landscapes



Infrastructure
- Proposed Workings
- Existing Workings

Project Area
- Project Area

APE Study Areas
- 600 m area

Soil Landscapes
- Canobla Gap
- Coco
- Cullen Bullen
- Deanes Creek
- Deanes Creek variant a
- Disturbed Terrain
- Glen Alice
- Hassans Walls
- Lithgow
- Long Swamp
- Medlow Bath
- Mount Sinai
- Newnes Plateau
- Pipers Flat
- Warragamba
- Wolgan River
- Wollangambe



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Angus Place Amended Project

Data Sources - Jacobs: Project Area, Infrastructure (2019); NSW Government Public Data: Roads, Hydrology, Placenames; Geosciences Australia (ELVIS): 50m Contours; Department of Planning, Industry and Environment NSW: Soil Landscapes; ESRI ArcGIS Image Service: World Elevation Terrain, World Topographic Map

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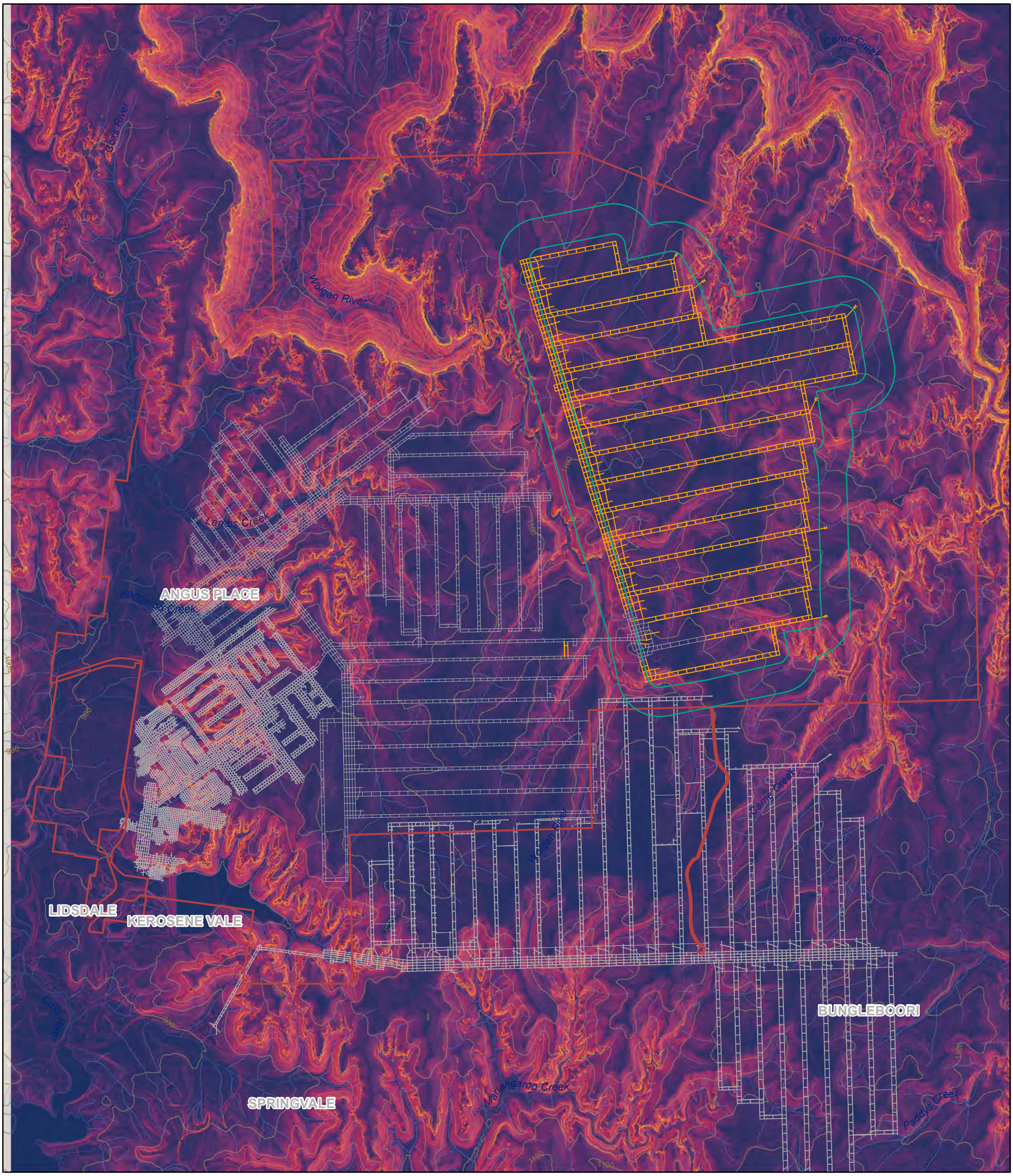
4.3 Topography and Hillslope

Topography and slope gradient are presented on Figure 4.3. Maximum spot heights of up to approximately 1,170m are found across the Study Area. Drainage off the plateau is frequently via deeply incised gully's and gorges in the lower reaches and incorporate numerous cliff lines and pagodas bordering the valley margins. In the upper catchment areas drainage lines are typically poorly defined to non-existent with overland sheet flow being the typical mode of discharge during high rainfall events.

Figure 4.3: Topography and Hillslope



Infrastructure
- Proposed Workings
- Existing Workings

Project Area
- Project Area

APE Study Areas
- 600 m area

Terrain Slope
90 DEG
0 DEG

Contours [mAHD]
- 50 m interval
- Stream Order 1 - 2
- Stream Order 3 - 6



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Data Sources - Centennial Angus Place Pty Ltd: Project Area, Infrastructure (2019); NSW Government Public Data: Roads, Hydrology, Placenames; Geosciences Australia (ELVIS): Elevation, 50m Contours; Office of Environment and Heritage NSW: Tenures; ESRI ArcGIS Image Service: World Elevation Terrain, World Topographic Map

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4.4 Hydrological Setting

4.4.1 Climate

Under the Koppen climate classification the region, including the Newnes Plateau, is broadly classified as temperate with no dry season and a mild summer. Mean summer temperatures range from a maximum of 23.0ºC to a minimum of 9.9ºC. Mean winter maximums and minimum temperatures are 7.8ºC and -0.3ºC respectively. Mean annual rainfall is 1,090mm with a maximum and minimum of 1,889mm and 496mm respectively. Summary statistics from the Bureau of Meteorology (BoM) station 63062 (Lithgow (Newnes State Forest)) are shown below in Table 4.2.

Table 4.2: Climate Summary

Aspect	Statistic
Mean max summer temp	23.0ºC
Mean max winter temp	7.8ºC
Mean min summer temp	9.9ºC
Mean min winter temp	-0.3ºC
Mean annual rainfall	1,090mm
Maximum annual rainfall	1,889mm
Minimum annual rainfall	496mm

Figure 4.4 below shows month rainfall totals from the Newnes Plateau gauge (63062). From the chart it can be seen that monthly rainfall is relatively consistent throughout the year with a slight increase in the months of January through February. Significant variability (as seen by the difference in P5 and P95 monthly rainfall totals) also exists in the monthly data.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	121	114	103	80	81	83	68	84	68	92	89	90
P95	267.5	273	230	229	206	226	163	212	132	204	184	217
P90	209.4	245	217	150	177	177	129	166	109	189	163	198
Median	132.9	91	79	60	63	63	54	67	64	81	79	67
P10	35.3	26	24	16	21	14	19	22	24	24	26	22
P5	21.7	18	17	12	15	12	12	17	20	17	19	7

Figure 4.4: Monthly Rainfall Summary - BoM Station 63062 (Lithgow (Newnes State Forest))

4.5 Surface water Drainage

Surface water drainage across the Newnes Plateau is largely radial with watercourses typically draining in all directions off the Plateau (Figure 4.5). Drainage networks in the southern part of the Study Area (drainage lines 1, 2, 3 and 6) typically exhibit a more dendritic form whereas those to the north (e.g. Drainage Lines 4 and 5) show a more parallel form. Key surface water drainage catchments across the Study Area are as follows:

- Drainage to the west is via Drainage Lines 2 and 3 which are both direct tributaries of the Wolgan River. Both Drainage Lines are approximately 2.5 km in length and fall approximately 140 to 170 m before joining the Wolgan River.
- Drainage Lines 4 and 5 flow in a northerly direction before joining Carne Creek, itself a tributary of the Wolgan River. Drainage line 4 has a catchment area of approximately 550 Ha and falls approximately 530 m over its 6.5 km length. Drainage line 5 is approximately 6.5 km in length and similarly, falls approximately 580 m before its confluence with Carne Creek.
- Drainage Line 1 drains the southern extent of the Study Area and flows in southeastly direction before joining Carne Creek. It falls approximately 170 m over 2.7 km in length.
- Drainage Line 6 flows in an easterly direction to its confluence with Carne Creek, dropping approximately 290m over its 4.3 km length.
- Carne Creek Tributaries 1 and 2 both flow in a north easterly direction for around 3.5 km and both fall approximately 175 m.

Table 4.3 below summarises key attributes for key drainage lines across the Study Area.

Table 4.3: Study Area Drainage – Key Attributes

Feature	Catchment (Ha)	Start Elevation (m AHD)	End Elevation (m AHD)	Approximate Length (km)
Drainage Line 1	381	1,142	973	2.7
Drainage Line 2	351	1,153	1,017	2.5
Drainage Line 3	344	1,158	1,006	3.2
Drainage Line 4	552	1,102	570	5.9
Drainage Line 5	730	1,166	580	6.5
Drainage Line 6	437	1,150	860	4.3
Carne Creek tributary 1	292	1,161	985	3.5
Carne Creek tributary 2	309	1,168	994	3.5

4.5.1 Indicative Flood Hydrology

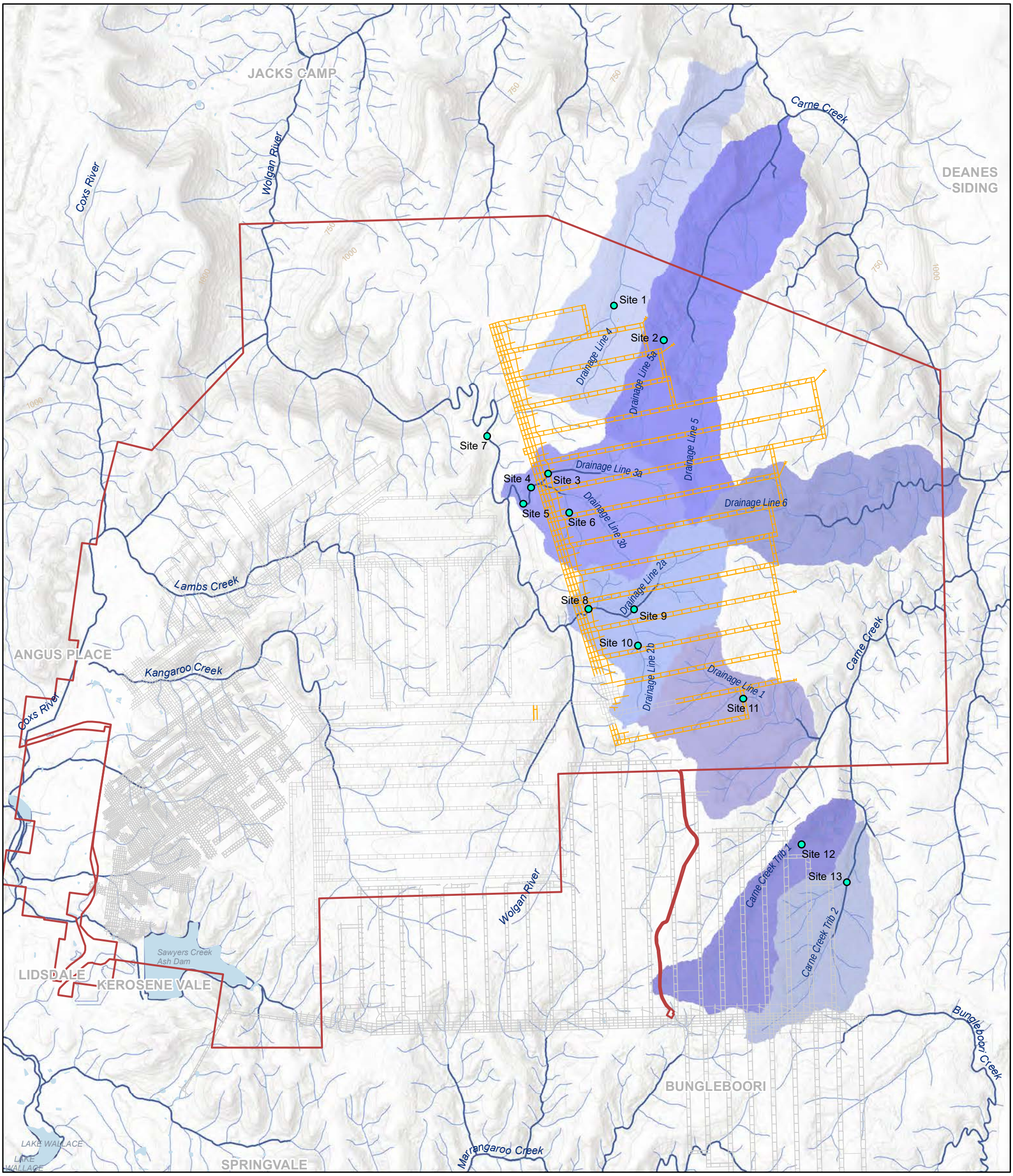
Indicative flood hydrology for a number of locations across the Study Area is presented in Table 4.4 below. Locations broadly correspond to those locations that were evaluated as part of the site assessments (refer to Figure 1.1and Table 5.1). Peak discharge flows should only be considered as indicative; hydraulic modelling was completed as a relative assessment to compare pre- and post-subsidence conditions. As such, only a single storm duration (12 hour) and temporal pattern were utilised[2] and the results shown below may not represent the critical duration or temporal pattern.

Table 4.4: Indicative Peak Discharge (Existing Conditions)

Site Location	Flood Frequency (AEP)/m^3/s				
	50%	20%	10%	5%	2%
1	9.48	10.51	15.82	19.14	22.58
2	4.53	5.09	7.49	9.10	10.75
4	15.19	16.83	25.38	30.66	36.18
6	2.00	2.23	3.33	4.03	4.76
8	15.31	16.75	25.65	31.23	36.78
9	7.38	8.00	12.39	15.01	17.69
10	2.88	3.18	4.82	5.86	6.92
11	7.62	8.39	12.66	15.04	17.99

[2] The primary aim of the study was to identify potential impacts to surface water resources. It does not constitute a flood study and as such, consideration of critical duration for each event is not of material interest. The hydraulic assessment has been conducted in order to determine the relative change in stream power between pre- and post-subsidence conditions only.

Figure 4.5: Surface Water Drainage



Drainage Catchment
- Drainage Line 4
- Drainage Line 5
- Drainage Line 6
- Drainage Line 3
- Drainage Line 2
- Drainage Line 1
- Carne Creek Trib 1
- Carne Creek Trib 2

Infrastructure
- Proposed Workings
- Existing Workings

Project Area
- Project Area

Contours
- 50 Metre

Hydrology
- Water Areas
- Stream Order 1 - 2
- Stream Order 3 - 6
- Site Inspection Locations



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5. Fluvial Geomorphology Assessment

A total of 13 different sites were visited as part of a fieldwork program conducted in July 2019 (Table 5.1 and Figure 1.1). Sites were selected on the basis of stream order (typically third order), relevance to swamps that have potential to be impacted by mining, and proximity to potential waterfall locations. Two additional reference sites (Carne West Swamp and Gang Gang Swamp) were also visited as examples of sites previously impacted by mining subsidence.

Table 5.1: Site Inspection Locations

Site No.	Lat:Long (dd)	Site Name	Watercourse	Stream Order	Upstream Catchment Area (ha)	River Style
1	-33.304 150.177	Trail Six / Japan Swamp	Drainage Line 4	2	201	Intact valley infill
2	-33.308 150.184	Waterfall Site	Drainage Line 5a	2	101	Gorge
3	-33.325 150.166	Twin Gully Northern Tributary - Upstream	Drainage Line 3a	3	117	Channelised fill
4	-33.327 150.163	Twin Gully Downstream	Drainage Line 3	3	321	Transition (channelised fill to gorge)
5	-33.328 150.168	Twin Gully Downstream at Cascade	Drainage Line 3	3	334	Gorge
6	-33.33 150.169	Twin Gully Southern Tributary Upstream	Drainage Line 3b	2	41	Channelised fill
7	-33.32 150.157	Wolgan River	Wolgan River	4	1,913	Gorge
8	-33.343 150.171	Tristar Swamp Downstream	Drainage Line 2	3	330	Gorge
9	-33.343 150.179	Tristar Swamp Upstream	Drainage Line 2a	3	157	Channelised fill
10	-33.348 150.179	Tristar Swamp Upsteam Southern Tributary	Drainage Line 2b	2	64	Channelised fill
11	-33.355 150.195	Southern Panels	Drainage Line 1	2	160	Gorge
12	-33.374 150.203	Carne West Swamp Downstream	Carne Creek Trib 1	2	227	Steep headwater
13	-33.379 150.21	Gang Gang Swamp Downstream	Carne Creek Trib 2	3	278	Steep headwater

5.1 River Styles

5.1.1 Intact Valley Infill (Swamp)

This river style is characterised by low gradient, intact, concave valley infill that covers the valley floor. Flow is typically subsurface with occasional surface expressions occurring at low points in the surface elevation. Drainage channels are typically absent. Representative sites assessed include Trail Six / Japan Swamp, Twin Gully Swamp, Tristar Swamp, Gang Gang Swamp and Carne West swamp

Table 5.2: Intact Valley Infill River Style Summary

Watercourse Character		
Representative reaches		Site 1 (Trail Six / Japan Swamp), Tristar Swamp, Gang Gang Swamp, Carne West Swamp
Valley setting		Alluvial valley setting. The swamp surface abuts the confined valley margins which are continuous and have moderate to steep slopes.
River planform		Intact valley fill covering the valley floor. No channels are present
Bed Material Texture		Coarse organic particulate matter Occasional minor deposits of silty sand noted at some surface expression locations
Geomorphic units	Instream - Channel Geometry	Channel is typically poorly defined, absent or discontinuous.
	Instream - bedrock	N/A
	Instream - Alluvial	N/A
	Floodplain	N/A
Vegetation association	Instream geomorphic units	Swamp surface is comprised of Sphagnum bogs and ferns, tending to sedges, shrubs and riparian Eucalypts on margins.
	Floodplain geomorphic units	N/A
River Behaviour		
Low flow stage - Flow is typically transmitted via subsurface flows with occasional surface expressions occurring at low points in the surface elevation. The swamp acts to attenuate downstream flows providing a relatively continuous baseflow to the downstream channel (Trail Six / Japan, Tristar and Twin Gully Swamps) High flow stage - High flows typically comprise of sheet flow with some concentrated flows in existing seepage locations. During high flows deposition of fine sand drapes and coarse silts will occur as a result of reduced flow velocities. Upstream catchments are relatively small and unlikely to generate significant streamflow.		
Controls		
Upstream catchment area		Typically, between 200 to 400 Ha
Landscape unit and within-catchment position		Upper headwater tributaries over 1,000m elevation
Process zone		Sediment storage

Watercourse Character	
Valley morphology (size and shape)	Moderately to steep-sided valleys that typically narrow downstream and transition to steep headwater then gorge River Style. Valley dimensions vary in width from 200-1,000m and depth from 20-approximately 60m.
Valley slope	Relatively low gradient, 2-5% (m/m)



Figure 5.1: Tristar Swamp (Looking Upstream from Site 8) showing concave nature of the infill surface and its extent across the valley floor



Figure 5.2: Site 1 (Trail Six / Japan Swamp) – Showing small surface flow expression (looking upstream) and substrate (coarse organic particulate matter, silty sand)



Figure 5.3: Downstream swamp rock controls. Left image -downstream of Twin Gully Swamp showing emergent baseflow. Right image shows Gang Gang Swamp which has been previously impacted by subsidence

5.1.2 Channelised Infill

This river style is typically found on the inflow tributaries to the swamps and is characterised by low sinuosity, discontinuous channels located within an infilled, confined valley setting where the infilled surface typically abuts the valley margin. Alternate phases of channel entrenchment (gullying) and filling occur. Where present channels are typically small and trench-like. Elsewhere, the valley floor is effectively the channel with shallow swale-like channels tending to poorly defined, discontinuous drainage lines. Lateral inflow tributaries drop steeply down the valley sides at grades greater than 20% to join the main channel at typically perpendicular to near-perpendicular confluences.

Table 5.3: Channelised Infill River Style Summary

Watercourse Character		
Representative reaches		Sites 3, 6, 9 and 10
Valley setting		Continuous, confined. Infill surface typically abuts the valley margin.
River planform		Low order (stream order 3 and lower), low sinuosity (less than 1.3) discontinuous channel. Alternating phases of cut and fill occurring with cut phases initiated as a result of infrequent, higher energy flood events.
Bed Material Texture		Loamy silts, coarse silty sand to silty sand, coarse organic particulate matter, woody debris
Geomorphic units	Instream - Channel Geometry	Where present, the small, trench-like channels are typically 1-2m wide and less than 0.5m deep. The exception to this being Site 10 where a 4-5m wide and 2.5m deep channel was noted. This appeared to be significantly oversized and likely the result of a large, historical flood event. When present channels are stable, well vegetated and show no indication of active adjustment. No flows present. Sites also showed a large number of wombat holes in channel banks and nick points at the start of channels. Unclear how this effects long-term stability.
	Instream - bedrock	Absent except in the case of site 10 where the channel head cut consists of a bedrock run
	Instream - Alluvial	Typically absent, occasional mid channel bars and sand sheets comprising of silty sands.
	Floodplain	None present
Vegetation association	Instream geomorphic units	Shrubs, ferns, eucalypts, dense ground cover of leaf litter and other organic debris
	Floodplain geomorphic units	N/A

Watercourse Character	
River Behaviour	
Low flow stage – during low flows fine-grained sediments are gradually moved downstream through the channelised sections and deposited as fans when the flow expands at the end of the channel or as flow enters the downstream swamp. Swampy conditions are likely to persist where the channel is absent with some subsurface transmission of flow likely. High flow stage – during high flows active gullying process are likely to facilitate the headward extension of channels and generation of locally high stream powers. During these infrequent, large events rapid and large-scale movement of material may occur with incision down to bedrock (e.g. Site 10) with continued lateral channel expansion through bank undercutting and slumping. Sediments are worked downstream and deposited as flows expand and slow as the discontinuous channels run out into shallow swale-like features and sheet flow dominates.	
Controls	
Upstream catchment area	Less than 200 Ha
Landscape unit and within-catchment position	Upper headwater tributaries over 1,000m elevation
Process zone	Sediment storage but can be significant source during large flood events
Valley morphology (size and shape)	Range in width from 100 to 250m in width, narrowing downstream before entering swamps.
Valley slope	Ranges from 2-8% (m/m)



Figure 5.4: Tributary to Tristar Swamp (site 9), looking to left bank and slightly downstream (flow is left to right) and showing infilled surface



Figure 5.5: Northern tributary to Twin Gully Swamp (Site 3, looking downstream) showing complete absence of channel incision (3rd order stream at this location)



Figure 5.6: Left image – trench-like channel looking upstream to head cut (site 10). Right image showing shallow swale-like channel (site 6, looking downstream)



Figure 5.7: Enlarged channel (site 10, looking upstream) showing undercutting on right bank[3] and rotational slumping on left bank



Figure 5.8: Channel headcut to bedrock (site 10)

[3] Right and left banks are conventionally named whilst looking downstream

5.1.3 Steep Headwater

This river style is characterised by steep-graded, bedrock confined channels located in narrow, confined valley settings that typically lead into downstream gorges. Bedrock steps (waterfalls) and runs and cascades are prevalent.

Table 5.4: Steep Headwater River Style Summary

Watercourse Character		
Representative sites		Sites 12 and 13
Valley setting		Confined, continuous. Steep to vertical-sided.
River planform		Very low sinuosity (1.1), bedrock-controlled, single channel with no floodplain. Channel alignment is dictated by that of the valley.
Bed Material Texture		Boulders, bedrock, woody debris, sandy sand, organic material
Geomorphic units	Instream - Channel Geometry	Bed profile is stepped and characterised by bedrock steps, cascades and rock runs.
	Instream - bedrock	Bedrock steps (waterfalls) up to 10m with plunge pools Steep bedrock and boulder runs Potholes
	Instream - Alluvial	Massive and uniform silty sand sheet infilling of plunge pools and interconnecting channels. This material appears, in part to have originated from the access tracks that cross each watercourse at the top of each reach.
	Floodplain	None present
Vegetation association	Instream geomorphic units	Relatively thick growth of groundcovers and shrubs.
	Floodplain geomorphic units	N/A
River Behaviour		
Low flow stage – during low flows the bedrock steps, cascades and rock run assemblages continue to transport sediment downstream. However, over longer periods between large, high magnitude event, accumulation of material in the lower energy pools and connecting riffles may result in gradual infilling and, over longer periods, floral recolonisation. High flow stage – rare, high magnitude flood events generate sufficiently high levels of energy to drive adjustments related to scour and/or sediment accumulation. During these events plunge pools may be scoured out, vegetation washed away and the largest bedload material (boulders) moved. The vertical and lateral bedrock confinement ensures that the channel remains stable.		
Controls		
Upstream catchment area		200-300 Ha
Landscape unit and within-catchment position		Upper headwater tributaries over 1,000m elevation

Watercourse Character	
Process zone	Source; natural upstream supply of sediment is typically limited due to the swamps located immediately upstream however erosion from the access tracks immediately upstream appear to be contributing sediment.
Valley morphology (size and shape)	High gradient, narrow (20-80m), steep to vertical-sided. Typically opening into large gorges.
Valley slope	20-40% (m/m)



Figure 5.9: Looking upstream from base of steep bedrock run (approximately 20m in height, Site 13). Note almost complete vegetative colonisation of the surface.



Figure 5.10: Potholes located toward base of steep bedrock run (Site 13).



Figure 5.11: Site 12, looking downstream from right bank towards steep bedrock step of approximately 15m. Note large accumulation of organic debris and plant growth across full width of the step.



Figure 5.12:Left image - Infilled pool at base of first bedrock step downstream of Carne West Swamp (Site 12). Right image – outwash fan of sand originating from access track and leading to watercourse (Site 13)

5.1.4 Gorge

This river style is characterised by a confined valley setting where the single, continuous channel abuts the valley margin more than 90% of the time with no floodplain present. Valley sides are steep to vertical (cliffs), sometimes deeply dissected by inflow tributaries leading to bedrock spurs which force the main channel to adopt a meandering path around them and resulting in a relatively sinuous planform. Lower gradient sites with a wider valley setting also comprise some alluvial infilling of the valley floor into which the channel is incised.

Table 5.5: Gorge River Style Summary

Watercourse Character		
Representative reaches		Sites 2, 5, 7, 8, 11
Valley setting		Confined
River planform		Stable, single channel, typically of moderate sinuosity (1.5 -1.9). Alignment is dictated by that of the valley with frequent meanders around bedrock spurs and outcrops.
Bed Material Texture		A relatively diverse range of material including coarse particulate organic particulate matter, sands, sandy silts, bedrock, gravels, cobbles to boulder-sized.
Geomorphic units	Instream - Channel Geometry	The single channel is well incised and typically 2-4m wide and up to 2m deep. Banks are steep to vertical, stable and well vegetated when not bedrock confined.
	Instream - bedrock	Bedrock and boulder steps (waterfalls) with plunge pools. Waterfalls can be up to 10m in height Runs – steep bedrock to large boulder. Cascades around localised debris from cliff collapses
	Instream - Alluvial	Pool and riffle sequences Bank attached and mid channel bars, often debris-induced
	Floodplain	None present
Vegetation association	Instream geomorphic units	Some fringing vegetation however instream assemblages typically absent
	Floodplain geomorphic units	N/A
River Behaviour		
Low flow stage – during low flow there is insufficient energy to move all but the finest bedload material which is typically flushed downstream. Low gradient/energy reaches (Site 7) show deposition of finer grade sediments though pool and riffle sequences. High flow stage – the stable, bedrock channels have limited capacity for adjustment. During the large, infrequent, high energy flows high velocities and stream powers are able to move even the largest boulders and may remove vegetation established since the last large event. Reaches typically act as throughput zones however where gradients are lower (e.g. Site 7) deposition of sediments occur.		

Watercourse Character	
Controls	
Upstream catchment area	200-300 Ha for sites within the Study Area. Significantly larger for Wolgan River site (Site 7)
Landscape unit and within-catchment position	Typically rugged, deeply incised reaches draining away from the Plateau. Mid to lower reaches of each drainage line. Wolgan River site (Site 7) considered upper catchment
Process zone	Sediment throughput
Valley morphology (size and shape)	Within the Study Area typically narrow and widening dowsntream (10 to 50m
Valley slope	A large variety of gradient is found ranging from 2-30% (m/m). Locally high gradient are found as a result of various bedrock and boulder steps, cascades, etc.



Figure 5.13: Narrow slot gully (Site 2)



Figure 5.14: Left image – looking downstream at bedrock-induced pool upstream of steep bedrock run into narrow gorge (Site 5). Right image -narrow gorge (looking downstream, Site 5)



Figure 5.15: Meander bend incised into alluvial material (Site 7, flow is from right to left) noting vertical gorge sides in background.



Figure 5.16: Left image – channel confined by gorge cliff (Site 7, looking upstream). Right image – lateral bank-attached bar comprised of coarse sand (Site 7, looking upstream)



Figure 5.17: Bedrock spur (Site 11, looking upstream)

5.2 Existing Geomorphic Condition

Intact Valley Infill (Swamps)

With the exception of sites Carne West and Gang Gang Swamps (which were selected as previously impacted reference sites), all sites were found to be in good condition and no concerns were noted. Each site appeared to be in good condition showing an appropriate behaviour and character for the river style.

Channelised Infill

All sites visited exhibited an appropriate behaviour and character for the river style. This river style is characterised by alternate phases of channel entrenchment (gullying) and filling with entrenchment typically initiated during infrequent high energy floods. All sites visited typically appeared to be in good condition with no adverse concerns; processes of channel development and infilling appeared to be in balance and riparian vegetation was found to be intact and undisturbed.

One site (Site 10) was noted however to have some relatively large-scale erosion and scour features including inflow gullying and undercutting and slumping of the over-large channel banks. The reach comprising of the enlarged channel was approximately 150m long and discontinuous. Continued upstream propagation of channel erosion is limited due to headcut down to bedrock and downstream the channel progressively reduces in size until it disappears. With the exception of a large inflow gully (which appeared to be actively headcutting) the channel appeared stable and well vegetated.

Steep Headwater

This river style is characterised by steep-graded, bedrock confined channels located in narrow, confined valley settings that typically lead into downstream gorges. Bedrock steps (waterfalls) and runs and cascades are prevalent. All sites visited within the Study area appeared to be in good condition showing an appropriate behaviour and character for the river style.

Two sites outside of the Study area that were visited (sites 12 and 13) were found to be moderately impacted. Both sites are located downstream of impacted swamps (Gang Gang and Carne West). The standing water level in both swamps has been lowered as a result of previous mining subsidence. This has caused a drying of the swamps and reduction/elimination of downstream baseflow. Downstream of the swamps the reaches exhibited infilling of plunge pools and the channel as well as a change in vegetation. Significant growths of vegetation within the channel including almost complete coverage of bedrock runs and rock ledges was seen. It is acknowledged that a large flood flow would likely scour out the plunge pools and remove a large proportion of the vegetative growth however the loss of baseflow and probable reduction in low flows appears to have reduced the ability to throughput sediment being supplied from the access tracks located immediately upstream at both sites.

Gorge

This river style is characterised by a confined valley setting with valley sides that are steep to vertical (cliffs). Valley sides are sometimes deeply dissected by inflow tributaries leading to bedrock spurs which force the main channel to adopt a meandering path around them and resulting in a relatively sinuous planform. All sites visited were found to be in good condition showing a behaviour and character appropriate to the river style. It is noted that, similar to Sites 12 and 13 (Steep Headwater), Site 7 also exhibited some minor, localised impact from the vehicle access track which resulted in some minor sedimentation in the River adjacent to where water crossings were present or where track runoff entered the River.

6. Potential Fluvial Geomorphic Impacts

6.1 Subsidence Impacts in Watercourses

Post-mining subsidence has the potential to cause a number of impacts on watercourses across the Study Area. Changes to the frequency and magnitude of energy (i.e. streamflow) along with changes to the existing balance of material supply and movement within a reach can subsequently lead to the acceleration of processes that are detrimental to the long-term condition of the watercourse's natural geomorphic character.

6.1.1 Loss of watercourse flow

Development of fractures within the sandstone bedrock underling watercourses across the Study Area caused by mining subsidence could significantly increase localised rates of hydraulic conductivity from around $1x10^{-6}$ m/s to as high as 0.1 to 1 m/s **(Commonwealth of Australia, 2014)**. This can significantly reduce, or in some cases effectively eliminate baseflow as well as shortening flow recession after flow events. This loss of flow can lead to the progressive drying of downstream swamps which can result in impacts including loss of wetland plant species, drying and desiccation of the swamp peat, increased potential for incision and erosion of the swamp surface during high flow events. During high flow events however, the increased surface flow will likely exceed the capacity of any subsurface fracture network surface and hence ensure continuation of surface flow.

Swamps also provide significant attenuation of flows and afford affective regulation of downstream stream flow and supply of sediment. This attenuation serves to sustain flows downstream during prolonged dry periods whilst moderating the impacts of larger flows as well as limiting the supply of sediment throughput.

(MSEC, 2019) note that the APMEP will likely result in surface cracking. Crack widths are expected to be typically between 10 mm and 50 mm although localised cracking with widths greater than 50 mm can also develop. Outside of the proposed mining area, the crack widths are expected to be typically less than 10 mm; however, localised cracking with widths greater than 25 mm can also develop. Additionally, (MSEC, 2019) also note that mining-induced compression due to valley closure effects could also result in dilation and the development of bed separation in the topmost bedrock, as it is less confined. This dilation due to valley closure is expected to develop predominately within the top 10 m to 20 m of the bedrock. Compression can also result in buckling of the topmost bedrock resulting in heaving in the overlying surface soils.

The extent to which loss of flow is propagated downstream is dependent on the nature of the watercourse. In gaining systems (i.e. the groundwater levels adjacent to the river channel are higher than the river channel) the water lost to the fracture network will return to the surface further downstream in unimpacted areas. Reemergence of flow is however dependent on no further downward flows into the mine workings as a result of more generalised subsidence impacts within the overburden strata (Commonwealth of Australia, 2014).

In losing systems there is already an existing tendency for water to naturally move away into the groundwater system. However, this process can be enhanced by the development of a mining-induced fracture network resulting in the loss of additional surface flows. In this instance, surface flow losses are not returned to the downstream channel and surface flows will only be reestablished when the watercourse becomes a gaining system further downstream.

6.1.2 Ponding, flooding and erosion

Post-mining tilt (i.e. changes in the slope of the ground as a result of differential subsidence) can alter the existing gradient of the surface which can result in a number of impacts including:

- Redirection of surface flows which may result in scouring and erosion of surface soils;
- Localised ponding caused by reduced or reversed streambed gradients;
- Increased potential for flooding or overbank flow due to bank subsidence; and
- Localised changes to stream power (increases or reductions) resulting in enhanced sediment transport or deposition.

(MSEC, 2019) predict that the predicted maximum tilt within the Study Area is 25mm/m (2.5%). This is contrasted to the average natural gradients of drainage lines which typically vary between 25 mm/m and 300 mm/m (i.e. 30 %) directly above the proposed longwalls. The predicted maximum tilt is therefore less than the existing streambed gradients and it is therefore considered unlikely that this will have an impact on surface flows as they will continue to remain free draining.

Changes to the surface profile of the catchment areas reporting to each drainage line may result in minor changes to the volume and timing of runoff entering the channel. This might occur through ponding, changes to watersheds or reductions in the time for flow concentration to occur. These changes are considered to be minor however and unlikely to have a material impact.

6.2 Hydraulic Modelling Results

2-dimensional rain on grid hydraulic modelling was completed for the Study Area using TUFLOW software. The results of the modelling are discussed below while Appendix A provides a detailed summary of the model inputs, assumptions and results. Key inputs and assumptions are shown in Table 6.1 below.

Table 6.1: Hydraulic Modelling - Key Inputs and Assumptions

Aspect	Description	Comment
Topography	2m LiDAR obtained from ELVIS (https://elevation.fsdf.org.au/)	Base case
Topographic data (subsidence predictions)	(MSEC, 2019)	Used for hydraulic modelling (developed case)
Storm events modelled	1, 2, 5, 10 and 20 year AEP	AEP – annual exceedance probability
Temporal patterns storm duration	Single temporal pattern and 12-hr storm	

Changes to Peak Flows

Results of the hydraulic modelling indicated the potential for small changes to the estimated peak discharge. Relative changes in discharge varied across from location to location assessed and were typically in the order of +/- 1% and are not considered of material impact. Larger changes in the order of +2 to +4% were noted in

relation to a channel immediately downstream of Site 10 however the value of the absolute change was no greater than 0.27 m^3/s which is again considered negligible.

Changes to Stream Power

Modelling indicated several locations where there is a significant proportional increase in stream power. Referring to Figure 6.1, a total of 10 locations (labelled A to J) were identified where stream power is expected to increase by more than 50% during the 5% AEP event. For these locations, the existing and post-subsidence stream powers are shown in Table 6.2It should be noted that stream power typically shows significant spatial variability and that the values shown are only indicative of stream power values in the immediate vicinity of these locations.

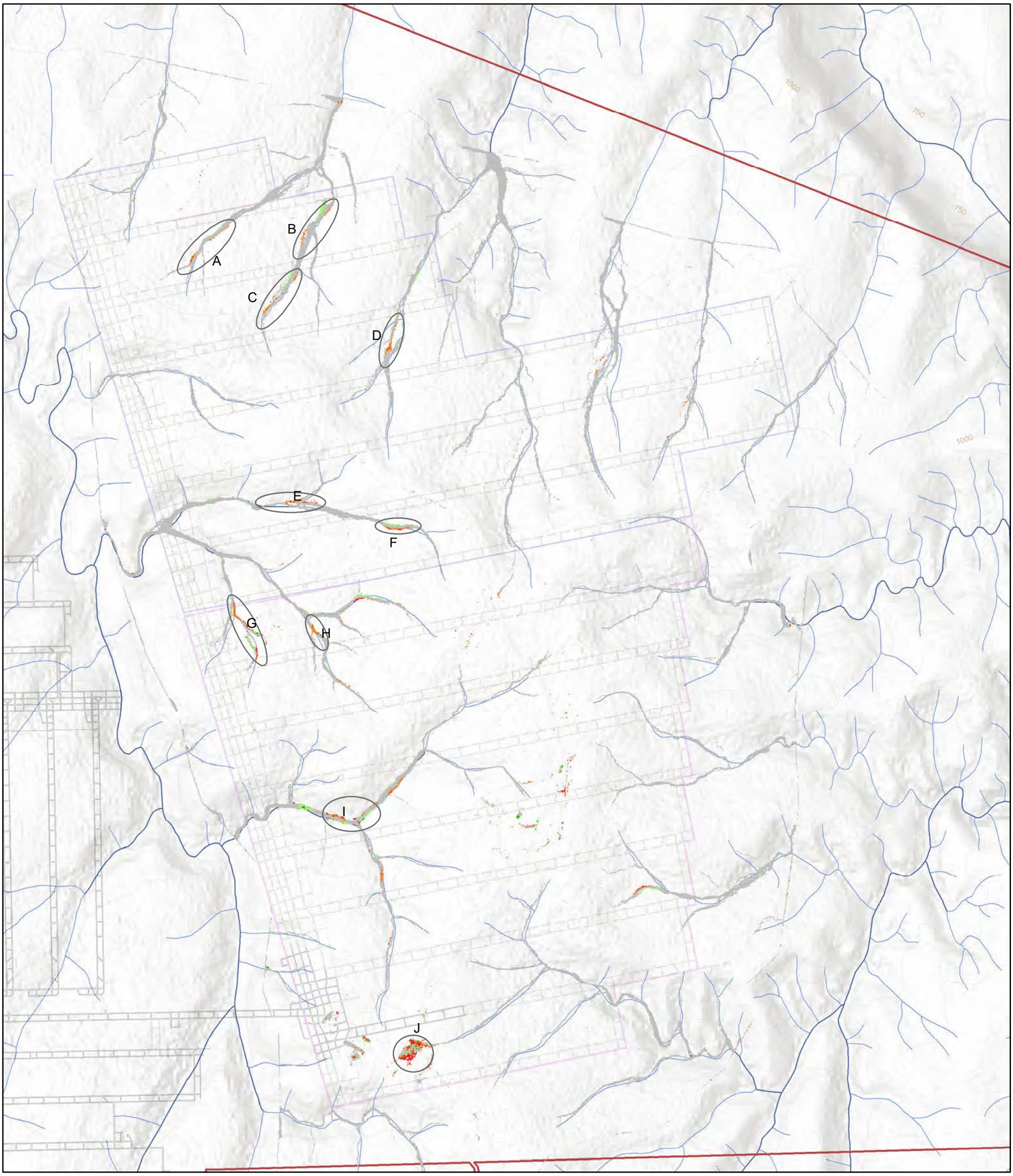
For locations C, F, and J both existing and developed stream power values typically remain below 50 W/m^2. While the change as a percentage is significant, it expected that the increased stream power does not present a significant additional risk of erosion due to the dense riparian vegetation and intact nature of the existing channels.

For locations E and F existing stream power can be as high as 1,000 W/m^2 to 2,000 W/m^2. At this magnitude, removal of riparian vegetation and some erosion is possible under existing conditions. Increased stream power in the post-subsidence case is therefore not expected to present a significant additional erosional risk above that already experienced under existing conditions.

For the remaining locations (A, B, D, G and H), the increased levels of stream power may still be insufficient to initiate erosion given the dense riparian vegetation and intact nature of the existing channels. It is recommended that site specific investigations be conducted at each location following significant flood events in order to assess existing resilience and to develop a baseline level of understanding of the potential for erosion at these locations.

In several locations, reductions in stream power can be seen in the model results. These can be explained by a slight reduction in peak discharge at some locations, a reduction in bed slope, or a combination of these two factors.

Figure 6.1: Angus Place Surface Water Assessment - 1:20 AEP Stream Power Impacts



Change in Stream Power 1:20 AEP event

Change (%)

- -100 to -50
- -50 to -25
- -25 to 25
- 25 to 50
- 50 to 100

Project Area

Watercourse - Order

- Stream Order 1 - 2
- Stream Order 3 - 6



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Angus Place Amended Project

Source: Organisation1: Dataset Name, (Year); Organisation2: Dataset Name, (Year)
Group same yeared datsets together if they belong in same organisation. Can run over two lines. see example below.

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Table 6.2: Locations with greater than 50% Increases in Stream Power (5% AEP Event)

Location (refer to Figure 6.1)	% Change	Baseline Stream Power (W/m²)	Post-Subsidence Stream Power (W/m²)
A	50 to 100	< 50	< 100
B	50 to 100	< 50	< 100
C	50 to 100	< 50	< 50
D	50 to 100	< 150	< 200
E	50 to 100	50 to 1000	50 to 1000
F	50 to 100	< 50	< 50
G	50 to 100	< 150	< 200
H	50 to 100	< 100	< 150
I	50 to 100	< 2000	< 2000
J	50 to 100	< 10	< 10

7. Monitoring and Management

It is recommended that a site monitoring program be developed as a means with which to monitor existing baseline conditions and to assess potential geomorphological impacts resulting from the APMEP. The program should include sites that are:

- Representative of each of the river styles found in the Study Area;
- Include existing higher risk sites e.g. that overly areas of maximum predicted tilt OR exhibit existing erosional concerns (e.g. Site 10); and
- Sites that are outside of the proposed subsidence area for reference.

Establishing an understanding of the existing balance of erosion and sediment movement is critical to understanding whether observed impacts are part of naturally-occurring process or have been enhanced or induced by post-mining subsidence. Of key importance is understanding existing patterns of erosion and sedimentation resulting from bankfull discharges (typically 1-2-year AEP) events as these relatively frequent events and are significant drivers of geomorphological change.

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Appendix A. Hydraulic Modelling

JACOBS

Memorandum

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Subject	Hydraulic Assessment	**Project Name**	Angus Place Amended Project
Attention	Greg Sheppard	**Project No.**	IA161511
From	Ramchandra Kavanekar / Michiel Riesenkamp		
Date	September 19, 2019		
Copies to	Wallis, Timothy		

This technical memorandum summarises modelling components considered in TUFLOW hydraulic modelling developed for the Centennial Coal Angus Place Mine Extension Project.

1. Project Description

The Angus Place Mine Extension Project (APMEP) consists of a proposed extension to the existing Angus Place underground mine. The APMEP provides for an additional 13 years of longwall mining with the development of a total of 15 longwall panels (LW1001 to LW1015, see Figure 2-1). Goaf collapse as each panel progresses is predicted to result in varying levels of surface subsidence (MSEC, 2019) which could potentially impact both surface and groundwater resources.

2. Hydraulic Modeling

The primary objective of the APMEP pre and post subsidence hydraulic modelling is to identify potential impacts to the surface water resources in the form of:

- Changes to the key fluvial geomorphic indicator, stream power, that might indicate the potential for enhanced erosional or depositional processes; and
- Changes to key physical dimensions such as flow width, depth, etc. that might indicate the presence of ponding or increased break put due to subsidence of channel banks.

2.1 Methodology

The TUFLOW rain on grid modelling for 63%, 50%, 20%, 10% and 5% annual exceedance probability (AEP) events was undertaken for existing and design (including subsidence) scenarios. These more frequent events are considered to be key drivers of channel morphological change as opposed to the large, less frequent events which underpin rapid and large-scale channel modification.

The terrain elevation data for the pre-subsidence scenario comprised of LiDAR with a 2m resolution, obtained from ELVIS (ANZLIC Committee on Surveying and Mapping). The terrain elevation data for post-subsidence scenario was provided by Mine Subsidence Engineering Consultants and comprised the total predicted subsidence for LW1001 to LW1015 superimposed on the 2m LiDAR data.

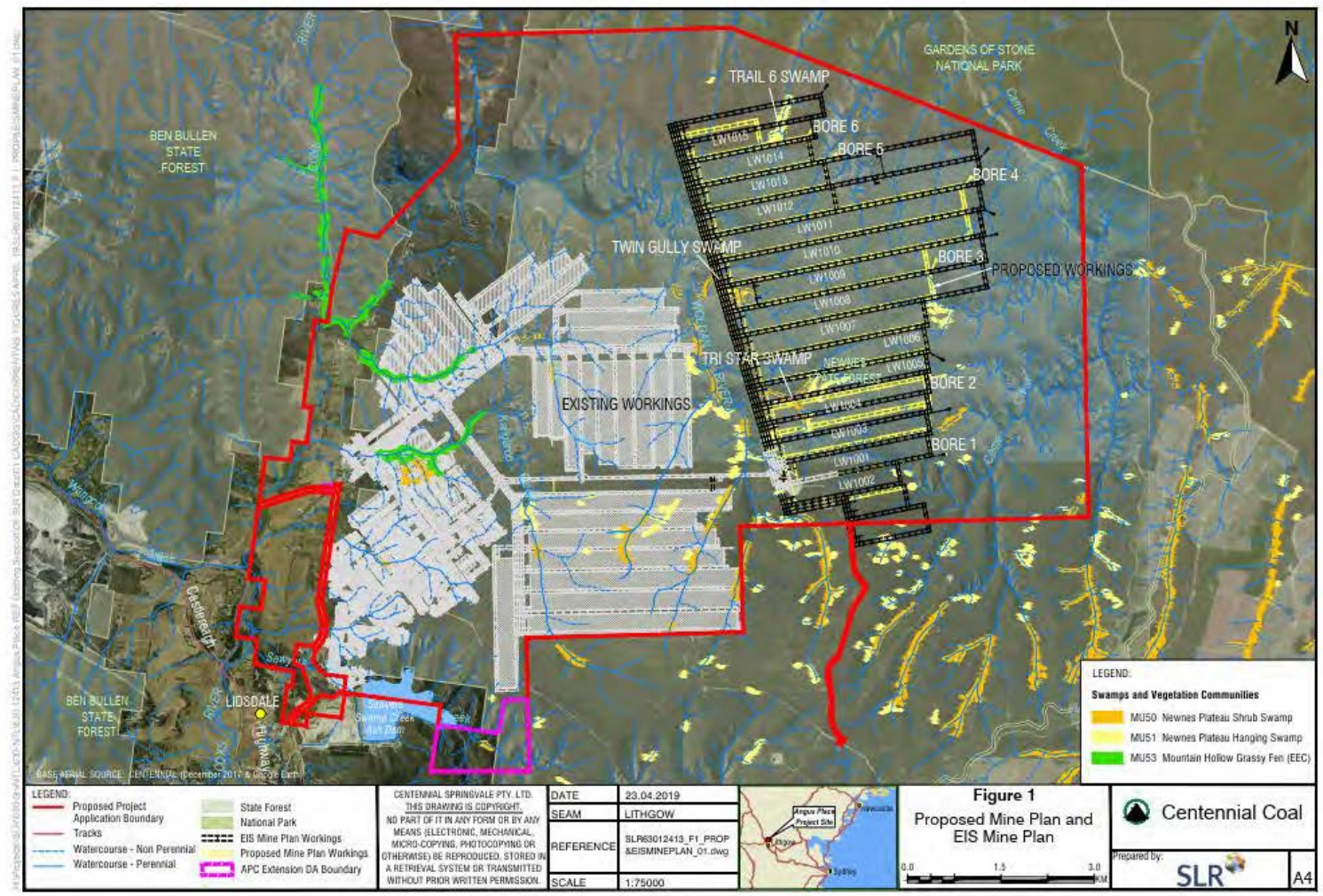


Figure 2-1 Project General Arrangement

Outputs from the modelling were used to identify potential changes that could result in negative impacts to channel geomorphological process. It is not the intention of the modelling to consider potential loss of flows, just the impact of the change in topography.

2.2 Software used

The hydrodynamic model selected for use in this study is the TUFLOW modeling system (WBM, 2016). TUFLOW simulates hydraulic conditions on a fixed grid by solving the full two-dimensional depth averaged momentum and continuity equations for free surface flow. The TUFLOW model was used to estimate flow extent, depths and velocities for the 63%, 50%, 20%, 10% and 5% AEP rainfall events for the existing and subsided conditions.

2.3 Model Setup

2.3.1 Schematization: Fixing of TUFLOW model boundary

The model boundary was defined to encompass the subsidence area of the APMEP and extending to a minimum distance of 600m from the longwalls and encompassing points of interest from the geomorphological mapping assessment (refer Appendix G of the Surface water Impact Assessment). The model domain, including the geomorphology fieldwork sites (points in yellow color), are shown below on **Figure 2-2**.

Rainfall Depths

The rainfall design data necessary for this study was generated from the Bureau of Meteorology's 2016 Intensity-Frequency-Duration database (BoM, 2016).

Temporal Patterns and duration

Since the aim of this study is limited to identifying potential impacts to the surface water resources, only one (1) temporal pattern was considered in the hydraulic model. The areal temporal pattern (TP01, EventID-1) for 12-hour storm duration for all events were selected to generate the rainfall hyetographs.

While the critical duration is expected to differ in different parts of the site, it was considered that the 12-hour duration would be suitable for the purpose of assessing potential changes in flow behavior. It should be noted that the levels, velocities and flows presented in this memorandum are not to be used as design flows. The AEP of the values presented should be considered to be representative of the actual AEP only.

Rainfall Depths

The rainfall design data necessary for this study was generated from the Bureau of Meteorology's website 2016 Intensity-Frequency-Duration database (BoM, 2016) as presented in Table 2-1.

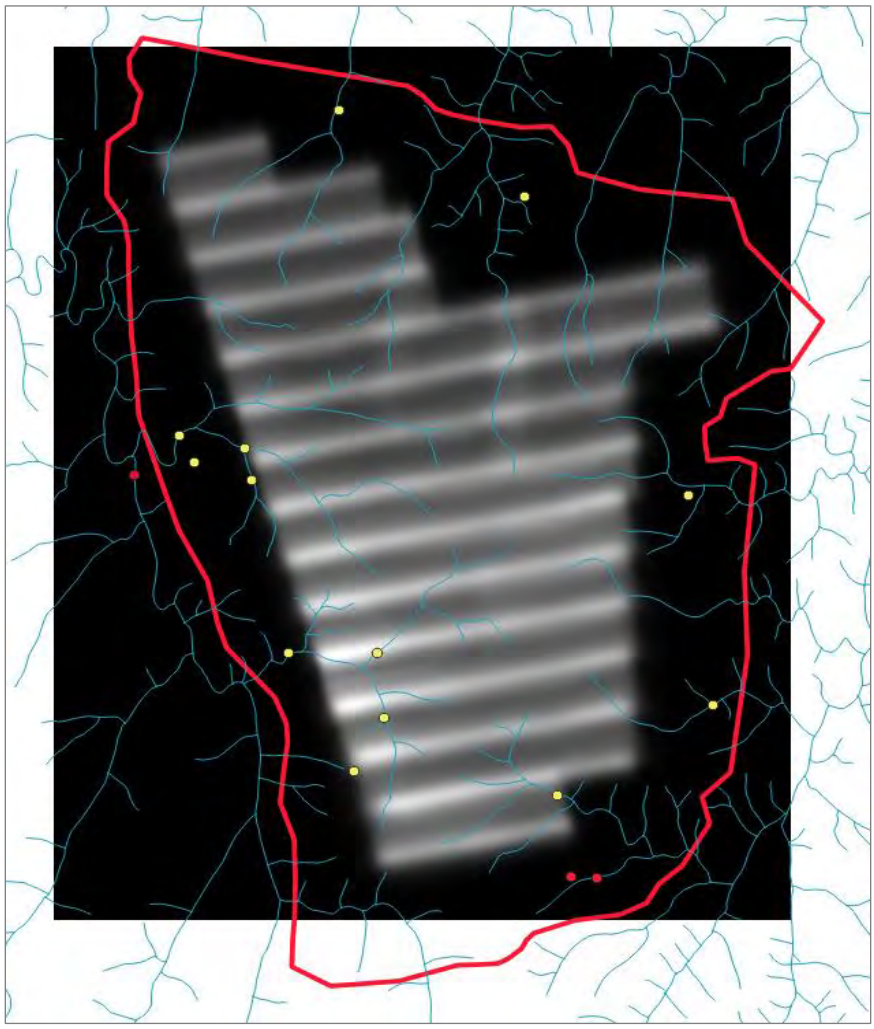


Figure 2-2 The TUFLOW model domain, with locations of subsidence shown in gray

Table 2-1 Data used to estimate rainfall hyetographs

Events (AEP)	12 hour Rainfall depth (mm)
63%	50.0
50%	55.9
20%	74.7
10%	87.6
5%	101.0

2.3.2 Input data for Design Flood Estimation

Temporal Patterns and duration

Since the aim of this flood study is limited to identifying the potential impacts to the surface water resources, only one (1) temporal pattern was considered in the hydraulic model. The areal temporal pattern (TP01, EventID-1) for 12-hour storm duration for all events were selected to generate the rainfall hyetographs.

While the critical duration is expected to differ in different parts of the site, it was considered that the 12-hour duration would be suitable for the purpose of assessing potential changes in flow behavior. It should be noted that the levels, velocities and flows presented in this memorandum are not to be used as design flows. The actual AEP of the values presented should be considered to be indicative representative of the actual AEP only.

Initial and Continuing Rain Losses

The storm initial and continuing loss values as obtained from the Australian Rainfall and Runoff Data Hub (ARR 2019 - Ball *et al*, 2019) were 40 mm and 4.9 mm/hr, respectively. The pre-burst losses were applied based upon the AEP of the event. The initial losses were calculated as per guidelines given in ARR 2019, with the resulting losses shown in Table 2-2.

Initial Loss (Burst Loss) = Storm Loss – Preburst

Table 2-2 Adopted initial and continuing losses

Event	Initial Loss (mm)	Continuing Loss (mm/hr)
63% AEP 12 hour	0	4.9
50% AEP 12 hour	38.7	4.9
20% AEP 12 hour	33.8	4.9
10% AEP 12 hour	30.6	4.9
5% AEP 12 hour	27.4	4.9

2.3.3 Topographic Data

The LiDAR data of 2m spatial resolution obtained from the Elevation Information System (ELVIS - ICSM, 2017) was used for the pre-subsidence scenario. The subsidence topography as provided by Centennial Coal was stamped over 2m LiDAR data for post subsidence scenario in the TUFLOW model setup. The total subsidence depth varies significantly across the Project area from a few millimeters directly over the chain pillars, to a maximum subsidence level to about 2.2m.

2.3.4 Manning's 'n'

The surface roughness in the TUFLOW model was defined in terms of Manning's *n* using information received from a range of sources including photographs captured, available literature. A roughness value

of 0.12 is assigned over the entire model domain as most of the area is densely vegetated having irregular mountain creek with flexible understory plants, few vines or woody shrubs.

2.3.5 Boundary Conditions

A stage-discharge relationship was defined to represent the downstream boundary of the TUFLOW model (HQ boundaries) by applying calculated slope values ranging from 0.04 to 0.3 at different locations along the model domain where the flow tends to exit.

3. Flood Modelling Results

3.1 Peak Discharges

The TUFLOW model was run for the for 63%, 50%, 20%, 10% and 5% AEP events with a 12-hour storm duration. Peak discharges were recorded at reporting locations by using PO lines (refer to Figure 3-1 below). The peak values for discharge, and the change in discharges are represented in Table 3-1 and Table 3-2 respectively.

Review of these two tables shows that small changes in peak flows are expected to occur due to predicted subsidence on site. The direction of change (i.e. an increase or decrease) depends on the intensity of the rainfall event. Typically, however, changes in peak discharges remain below +/- 1%, with the majority of the site showing very little change in discharge. Maximum predicted changes occur at PO_L29 (3.15 increase for 20% AEP) and PO_L30 (4.0% increase for 50% AEP).

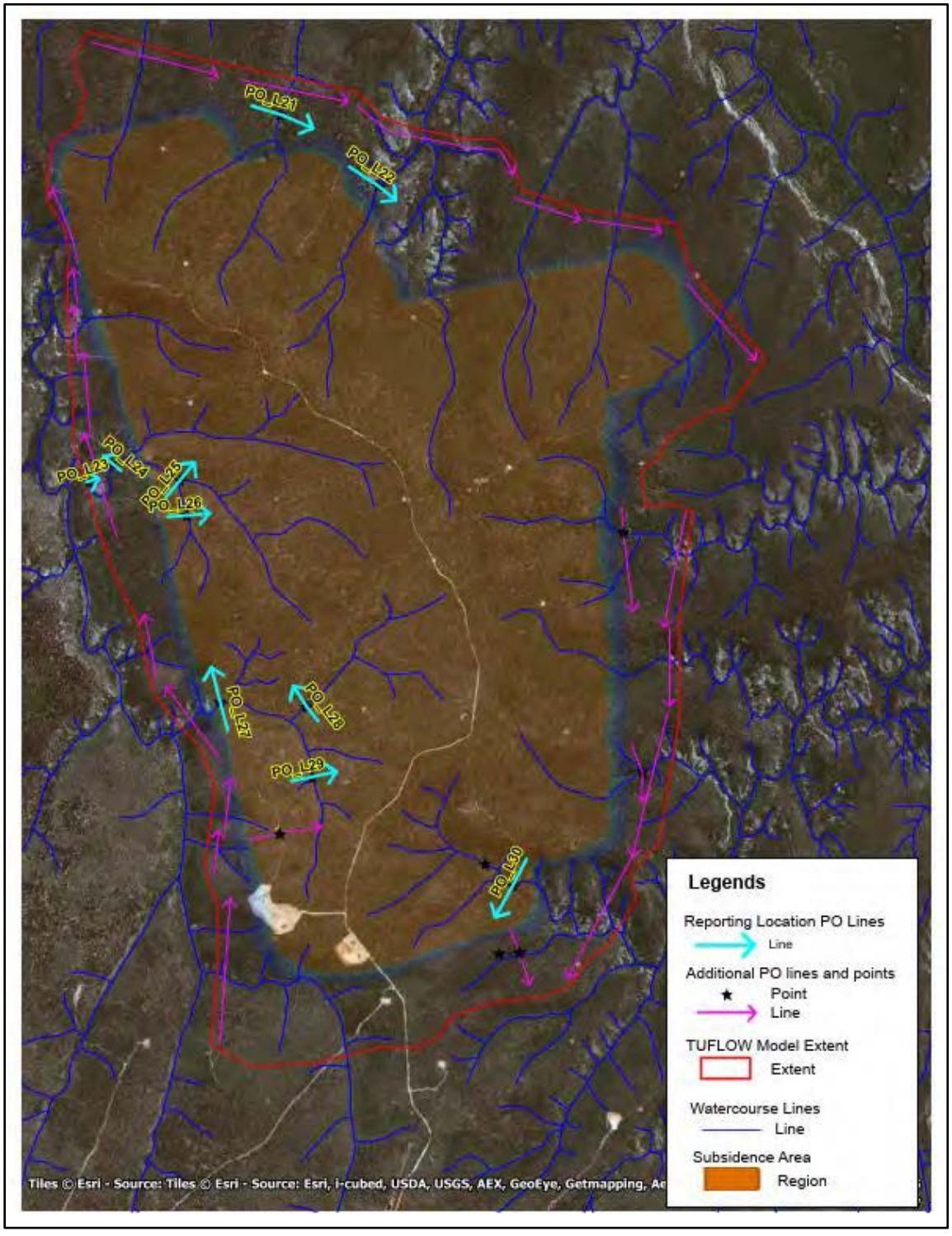


Figure 3-1 Reporting location 2D PO lines

Table 3-1 Peak Discharge at Reporting Locations

Reporting Locations	Baseline Peak Discharge (m^3/s) AEP					Post-subsidence Peak Discharge (m^3/s) AEP				
	63%	50%	20%	10%	5%	63%	50%	20%	10%	5%
PO_L21	9.48	10.51	15.82	19.14	22.58	9.51	10.51	15.83	19.15	22.60
PO_L22	4.53	5.09	7.49	9.10	10.75	4.50	5.05	7.54	9.11	10.75
PO_L24	15.19	16.83	25.38	30.66	36.18	15.17	16.80	25.31	30.66	36.15
PO_L25	8.27	9.19	13.79	16.61	19.60	8.25	9.18	13.71	16.63	19.56
PO_L26	2.00	2.23	3.33	4.03	4.76	1.99	2.20	3.31	4.00	4.73
PO_L27	15.31	16.75	25.65	31.23	36.78	15.39	16.82	25.85	31.35	37.02
PO_L28	7.38	8.00	12.39	15.01	17.69	7.40	8.00	12.40	15.04	17.75
PO_L29	2.88	3.18	4.82	5.86	6.92	2.95	3.25	4.97	6.02	7.19
PO_L30	7.62	8.39	12.66	15.04	17.99	7.60	8.72	12.69	15.52	18.13

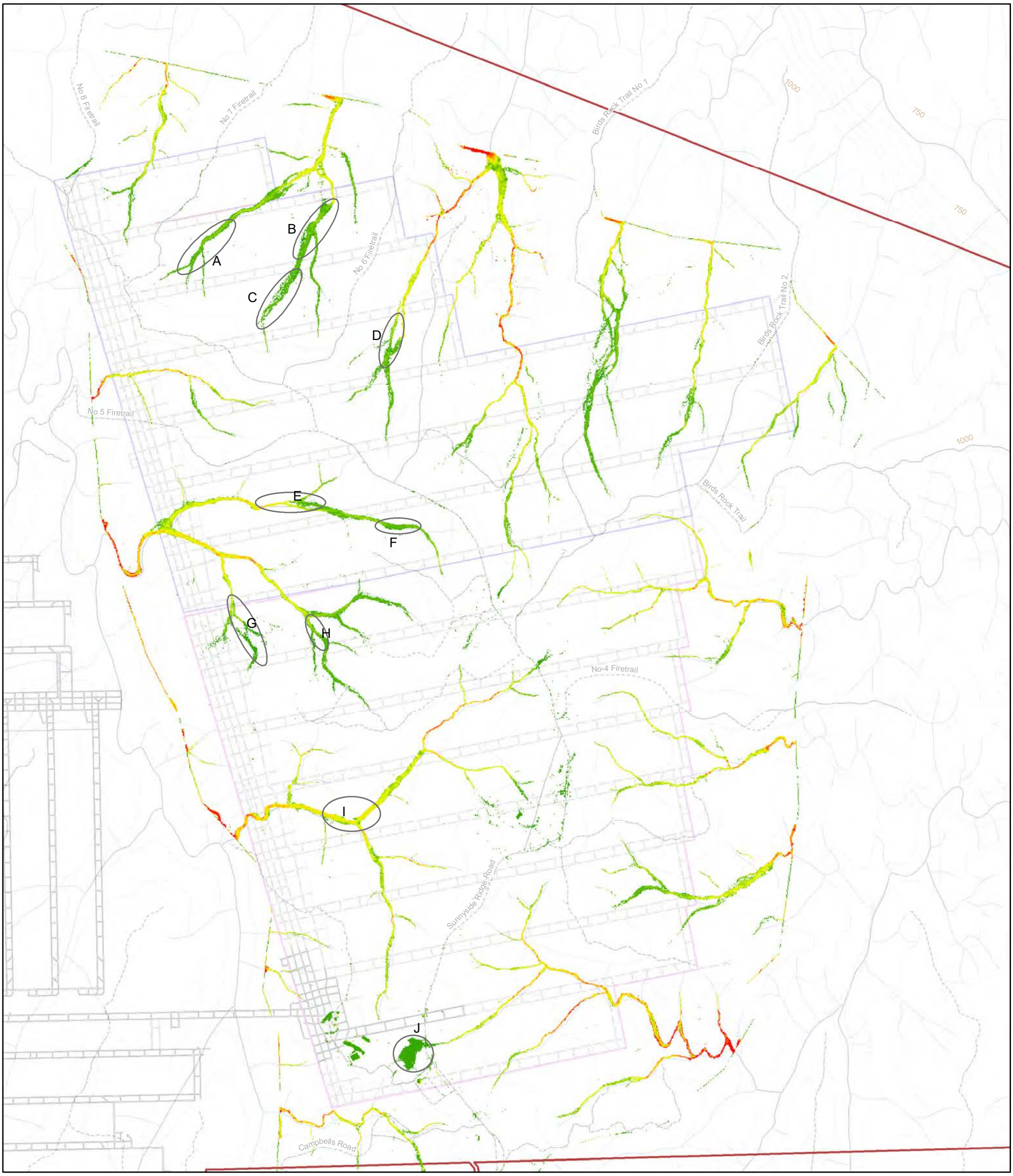
Table 3-2 Change in Peak Discharge at Reporting Locations

Reporting Locations	Difference – Peak Discharge (m^3/s)					Difference %				
	63%	50%	20%	10%	5%	63%	50%	20%	10%	5%
Q_PO_L21	0.02	0.00	0.02	0.02	0.01	0.26	-0.02	0.11	0.09	0.06
Q_PO_L22	-0.03	-0.04	0.05	0.02	-0.01	-0.56	-0.83	0.64	0.17	-0.07
Q_PO_L24	-0.02	-0.03	-0.07	0.00	-0.03	-0.14	-0.17	-0.29	-0.01	-0.09
Q_PO_L25	-0.02	-0.02	-0.08	0.01	-0.03	-0.21	-0.21	-0.61	0.07	-0.18
Q_PO_L26	-0.02	-0.02	-0.03	-0.03	-0.03	-0.92	-1.05	-0.79	-0.69	-0.66
Q_PO_L27	0.07	0.07	0.19	0.12	0.24	0.48	0.45	0.75	0.38	0.64
Q_PO_L28	0.02	0.00	0.02	0.03	0.06	0.30	0.06	0.15	0.17	0.33
Q_PO_L29	0.07	0.07	0.15	0.16	0.27	2.41	2.24	3.15	2.69	3.87
Q_PO_L30	-0.02	0.34	0.03	0.48	0.14	-0.24	4.00	0.23	3.21	0.78

3.2 Stream Power

Stream power was assessed for the existing case and the developed case, as this parameter is a good indicator of erosion potential. Locations showing an expected increase in stream power are expected to be at more risk of erosion. It should be noted that the stream power values in the existing case show a wide range in values, which was expected due to the large range of stream gradients across the model domain. Existing stream power for the 5% AEP (1 in 20 year event) is shown in Figure 3-2, stream power for the design case in Figure 3-3, and the change in percentage Figure 3-4. It was chosen to show these values for the 5% AEP event as this worst case event showed the greatest magnitude of change for the events assessed.

Figure 3-2: Angus Place Surface Water Assessment - 5% AEP Existing Case Stream Power



Project Area

Stream Order 1 - 2

Stream Order 3 - 6

Stream Power 1:20 AEP Existing

W/m²

- 0 to 20
- 20 to 50
- 50 to 100
- 100 to 200
- 200 to 500
- 500 to 1,000
- 1,000 to 2,000
- 2,000 to 5,000
- 5,000 to 10,000
- 10,000 to 100,000



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GDA 1994 MGA Zone 56

A3 1:25,000

N

0 0.5 1

Kilometres

JACOBS

Angus Place Amended Project

Source: Organisation1: Dataset Name, (Year); Organisation2: Dataset Name, (Year)
Group same yeared datsets together if they belong in same organisation. Can run over two lines. see example below.

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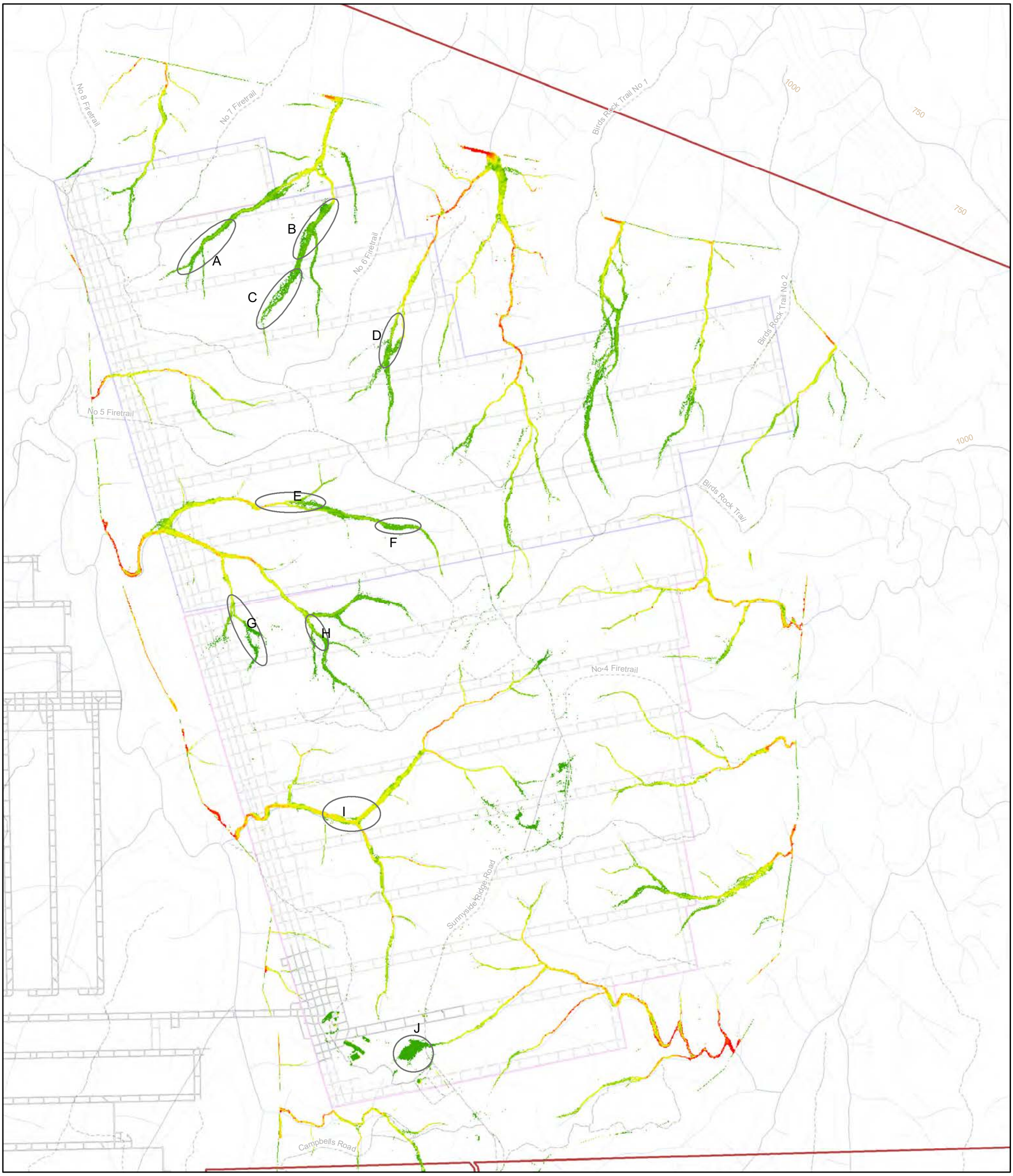
Figure 3-3: Angus Place Surface Water Assessment - 5% AEP Design Case Stream Power



Angus Place Amended Project

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Group same yeared datsets together if they belong in same organisation. Can run over two lines. see example below.

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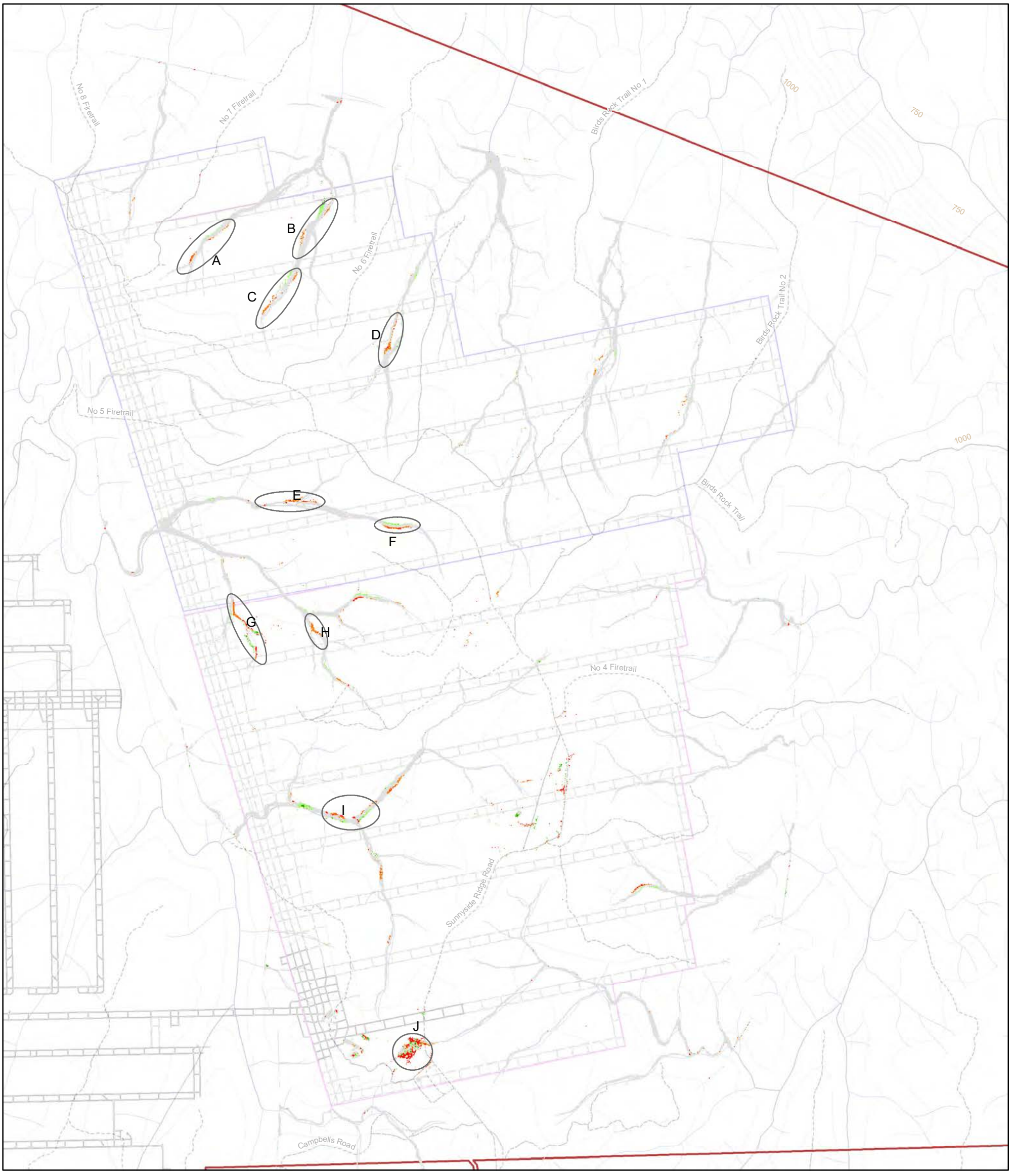
Figure 3-4: Angus Place Surface Water Assessment - 5% AEP Stream Power Impacts



Project Area

Stream Order 1 - 2

Stream Order 3 - 6

Change in Stream Power 1:20 AEP event

Change (%)

-100 to -50

-50 to -25

-25 to 25

25 to 50

50 to 100



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GDA 1994 MGA Zone 56

A3 1:25,000

N

0 0.5 1

Kilometres

JACOBS

Angus Place Amended Project

Source: Organisation1: Dataset Name, (Year); Organisation2: Dataset Name, (Year)
Group same yeared datsets together if they belong in same organisation. Can run over two lines. see example below.

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Review of Figure 3-4 shows ten (10) locations where stream power is expected to increase by greater than 50%. These areas have been labelled A to J. For these locations, the existing and developed stream power are shown in Table 3-3. It should be noted that stream power typically shows significant spatial variability. The values shown in the table are therefore only indicative of the stream power values in the vicinity of these locations.

It is noted that location J is associated with an area of flat ground on the Plateau in the vicinity of the Angus Place Colliery Angus Place east ventilation facility. Existing case stream power is very low and exaggerates the significance of change due to the APMEP. The developed case stream power is also relatively low and the increased stream power does not present a significant additional risk of erosion.

For locations C and F, both existing and developed stream power values typically remain below 50 W/m². While the change as a percentage is significant, it expected that the increased stream power does not present a significant additional risk of erosion due to the dense riparian vegetation and intact nature of the existing channels.

For locations, E and I, existing stream power can be as high as 1,000 W/m² to 2,000 W/m². At this magnitude, removal of riparian vegetation and erosion is expected under the existing condition and it is anticipated that the channel are likely incised at this location. Increased stream power in the design case is therefore not expected to present a significant additional erosional risk above that already experienced under existing conditions.

For the remaining locations (A, B, D, G and H), the increased levels of stream power may still be insufficient to initiate erosion given the dense riparian vegetation and intact nature of the existing channels. It is recommended that site specific investigations be conducted at each location following significant flood events in order to assess existing resilience and to develop a baseline level of understanding of the potential for erosion at these locations.

In several locations, reductions in stream power can be seen in the model results. These can be explained by a slight reduction in peak discharge at some locations, a reduction in bed slope, or a combination of these two factors. It is expected that in these locations an increased potential for vegetation establishment would exist. This, in consequence, may lead to small changes in the alignment of the waterways in these areas. It is not expected that this will lead to significant and noticeable changes.

Table 3-3 Location with significant stream power increases (5% AEP event)

Location (refer to Figure 3-4)	% Change	Stream Power Existing (W/m²)	Stream Power Design (W/m²)
A	50 to 100	< 50	< 100
B	50 to 100	< 50	< 100
C	50 to 100	< 50	< 50
D	50 to 100	< 150	< 200
E	50 to 100	50 to 1000	50 to 1000
F	50 to 100	< 50	< 50

Location (refer to Figure 3-4)	% Change	Stream Power Existing (W/m²)	Stream Power Design (W/m²)
G	50 to 100	< 150	< 200
H	50 to 100	< 100	< 150
I	50 to 100	< 2000	< 2000
J	50 to 100	< 20	< 20

4. Conclusion

The predicted subsidence due to the APMEP is expected to have a minimal impact on stream flows above the longwalls. As the waterways remain free draining (i.e. no grade reversals have been predicted), no significant additional ponding is expected. Several locations have been identified where there is a significant proportional increase instream power. However:

- A number of these sites (E and I) already experience very high levels of stream power and channel morphology and riparian vegetation are likely to have adapted to the existing condition. The predicted increases to stream power are therefore not expected to present a significant additional risk at these locations.
- A number of sites (C, F and J) are estimated to experience a large proportional increase however the existing levels of stream power are low and the additional worst-case estimated increases are not expected to present a significant additional erosional risk at these locations.
- For the remaining sites (A, B, D, G and H), the worst-case estimated increase in stream power may present an increased potential for erosion. For these locations it is recommended that baseline observations be made following significant stream flow events in order to establish an understanding of existing resilience and the potential for change following subsidence.

It is recommended that each of the identified locations described above (A to J), be visited to assess the existing channel morphology and to commence a program of condition monitoring to allow assessment of post subsidence impacts.

5. References

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