

Springvale Water Treatment Project

State Significant Development 7592
Environmental Impact Statement

Volume 2 Part 1 - Appendices A to B

September 2016



EnergyAustralia

Centennial Coal

Appendix A – SEARS

Table A.1 Secretary's Environmental Assessment Requirements

Category	Secretary's requirements	Where it is addressed in the EIS
General Requirements	The Environmental Impact Statement (EIS) for the development must comply with the requirements in Clauses 6 and 7 of Schedule 2 of the Environmental Planning and Assessment Regulation 2000. In particular, the EIS must include:	EIS has been prepared in accordance with the requirements for form and content of an EIS
	Full description of the development, including: details of construction, operation and rehabilitation; a site plan showing all surface infrastructure and facilities (including any infrastructure that would be required for the development, but the subject of a separate approvals process); a water management plan, having regard to the requirements and recommendations from EPA, WaterNSW and DPI Water; the likely interactions between the development and any other existing, approved or proposed development in the vicinity of the site;	 Chapter 5 Chapter 5 Chapters 5 and 10 Chapter 3
	Analysis of any feasible alternatives to the carrying out of the development and justification as to why they have been rejected in the proposal	Chapter 4
	A list of any approvals that must be obtained before the development may commence;	Chapter 6
	An assessment of the likely impacts of the development on the environment, focusing on the specific issues identified below, including: a description of the existing environment likely to be affected by the development, using sufficient baseline data; an assessment of the likely impacts of all stages of the development, including any cumulative impacts, taking into consideration any relevant legislation, environmental planning instruments, guidelines, policies, plans and industry codes of practice; a description of the measures that would be implemented to mitigate and/or offset the likely impacts of the development, and an assessment of: whether these measures are consistent with industry best practice, and represent the full range of reasonable and feasible mitigation measures that could be implemented; the likely effectiveness of these measures, including performance measures where relevant; and whether contingency plans would be necessary to manage any residual risks; a description of the measures that would be implemented to monitor and report on the environmental performance of the development if it is approved;	 Chapter 2 and Chapters 9 – 15 Chapters 9 – 15 Chapter 16 Chapter 16
	A consolidated summary of all the proposed environmental management and monitoring measures, identifying all the commitments in the EIS;	Chapter 16

Category	Secretary's requirements	Where it is addressed in the EIS
	Consideration of the development against all relevant environmental planning instruments; and	Chapter 6
	The reasons why the development should be approved, having regard to biophysical, economic and social considerations, including the principles of ecologically sustainable development.	Chapter 17
	In addition to the matters set out in Schedule 1 of the Environmental Planning and Assessment Regulation 2000, the development application must be accompanied by a signed report from a suitably qualified and experienced person that includes an accurate estimate of the capital investment value (as defined in Clause 3 of the Environmental Planning and Assessment Regulation 2000) of the development, including details of all the assumptions and components from which the capital investment value calculation is derived.	Appendix I
Specific Issues	The EIS must address the following specific issues:	
Water	Assess the likely impacts of the development on the quantity and quality of the region's surface and groundwater resources, particularly having regard to State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 and the requirements and recommendations from EPA, DPI, OEH and WaterNSW	Chapter 10 and Appendix B
Noise	Assess the construction noise impacts of the development in accordance with the Interim Construction Noise Guideline (ICNG) and water treatment plant noise impacts in accordance with the NSW Industrial Noise Policy (INP)	Chapter 13 and Appendix E
Biodiversity	Assess the likely biodiversity impacts of the development, in accordance with the Framework for Biodiversity Assessment, by a person accredited in accordance with s142(B)(1)(c) of the Threatened Species Conservation Act 1995, and having regard to requirements and recommendations from OEH and DPI	Chapter 11 and Appendix C
Land	Assess the compatibility of the development with other land uses in the vicinity of the development in accordance with the requirements from DRE, paying particular attention to the agricultural and forestry and future exploration land uses in the region	Chapters 2 and 15
Heritage	Assess the likely Aboriginal and historic heritage (cultural and archaeological) impacts of the development, having regard to requirements from the OEH	Chapter 12 and Appendix D
Transport	Assess the likely construction traffic impacts of the development on the capacity, condition, safety and efficiency of the local and State road network, having regard to requirements from Transport for NSW and RMS	Chapter 14 and Appendix F
Waste	Assess the likely impacts associated with disposal of the additional brine and residuals produced and whether existing infrastructure at MPPS has sufficient capacity to store the waste;	Chapters 3 and 15

Category	Secretary's requirements	Where it is addressed in the EIS
Visual	Assess the likely visual impacts of the development on private landowners in the vicinity of the development and key vantage points in the public domain;	Chapter 15
Air	Assess the likely air quality impacts of the development, having regard to requirements from the EPA	Chapter 15
Consultation	During the preparation of the EIS, you must consult with relevant local, State or Commonwealth Government authorities, service providers, community groups and affected landowners. The EIS must describe the consultation that was carried out, identify the issues raised during this consultation, and explain how these issues have been addressed in the EIS	Chapter 7

Table A.2 Government Agency correspondence

Category	Agency requirements	Where it is addressed in the EIS
Department of Primary Industries – Water		
Water	Annual volumes of surface water and groundwater proposed to be taken by the activity (including through inflow and seepage) from each surface and groundwater source as defined by the relevant water sharing plan.	Chapters 3, 10 and Appendix B
	Assess any volumetric water licensing requirements (including those for ongoing water take following completion of the project).	Chapters 6 and 10
	Identify an adequate and secure water supply for the life of the project. Confirmation that water can be sourced from an appropriately authorised and reliable supply. This is to include an assessment of the current market depth where water entitlement is required to be purchased.	Chapters 3 and 10
	A detailed and consolidated site water balance.	Chapter 10 and Appendix B
	A detailed assessment against the NSW Aquifer Interference Policy (2012) using DPI Water's assessment framework.	Chapter 10 and Appendix B
	Assess impacts on surface and ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	Chapter 10 and Appendix B
	Full technical details and data of all surface and groundwater modelling, and an independent peer review.	Appendix B. Water balance model included mine inflow projections from hydrogeological modelling undertaken by CSIRO which has been subject to peer review
	Proposed surface and groundwater monitoring activities and methodologies.	Chapter 10 and Appendix B
	Proposed management and disposal of produced or incidental water.	Chapters 5, 10 and Appendix B
	Details of the final landform of the site, including final void management (where relevant) and rehabilitation measures.	Chapter 5
	Assess any potential cumulative impacts on water resources, and any proposed options to manage the cumulative impacts.	Chapter 10 and Appendix B
	Consider relevant policies and guidelines.	

Category	Agency requirements	Where it is addressed in the EIS
	A statement of where each element of the SEARs is addressed in the EIS (i.e. in the form of a table).	Chapter 7 and Appendix B
Department of Primary Industries Water – Detailed comments		
Water	The EIS should take into account the objects and regulatory requirements of the Water Act 1912 (WA 1912) and Water Management Act 2000 (WMA 2000), and associated regulations and instruments, as applicable.	Chapters 6, 10 and Appendix B
Water Sharing Plans	Demonstrate consistency with the relevant rules of the Water Sharing Plan including rules for access licences, distance restrictions for water supply works and rules for the management of local impacts in respect of surface water and groundwater sources, ecosystem protection (including groundwater dependent ecosystems), water quality and surface-groundwater connectivity.	The Project will not alter water take or existing operations in accordance with current water access licences. Described in Chapter 3, 6, 10 and Appendix B.
	Describe any site water use (amount of water to be taken from each water source) and management including all sediment dams, clear water diversion structures with detail on the location, design specifications and storage capacities for all the existing and proposed water management structures.	The Project will not alter water take under existing water access licences. The use of water is described in Chapter 5, 10 and Appendix B
	Analyse the proposed water supply arrangements against the rules for access licences and other applicable requirements of any relevant WSP, including: Sufficient market depth to acquire the necessary entitlements for each water source. Ability to carry out a “dealing” to transfer the water to relevant location under the rules of the WSP. Daily and long-term access rules. Account management and carryover provisions. Provide a detailed and consolidated site water balance.	Not applicable - The Project will not alter the water take under existing water access licences. The use of water is described in Chapter 5, 10 and Appendix B

Category	Agency requirements	Where it is addressed in the EIS
Licensing Considerations	Identify water requirements for the life of the project in terms of both volume and timing (including predictions of potential ongoing groundwater take following the cessation of operations at the site – such as evaporative loss from open voids or inflows). Details of the water supply source(s) for the proposal including any proposed surface water and groundwater extraction from each water source as defined in the relevant Water Sharing Plan/s and all water supply works to take water. Explanation of how the required water entitlements will be obtained (i.e. through a new or existing licence/s, trading on the water market, controlled allocations etc.). Information on the purpose, location, construction and expected annual extraction volumes including details on all existing and proposed water supply works which take surface water, (pumps, dams, diversions, etc). Details on all bores and excavations for the purpose of investigation, extraction, dewatering, testing and monitoring. All predicted groundwater take must be accounted for through adequate licensing. Details on existing dams/storages (including the date of construction, location, purpose, size and capacity) and any proposal to change the purpose of existing dams/storages Details on the location, purpose, size and capacity of any new proposed dams/storages. Applicability of any exemptions under the Water Management (General) Regulation 2011 to the project. Water allocation account management rules, total daily extraction limits and rules governing environmental protection and access licence dealings also need to be considered.	The use of water is described in Chapter 5, 10 and Appendix B

Category	Agency requirements	Where it is addressed in the EIS
Surface Water Assessment	The predictive assessment of the impact of the proposed project on surface water sources should include the following: – Identification of all surface water features including watercourses, wetlands and floodplains transected by or adjacent to the proposed project. – Identification of all surface water sources as described by the relevant water sharing plan. – Detailed description of dependent ecosystems and existing surface water users within the area, including basic landholder rights to water and adjacent/downstream licensed water users. – Description of all works and surface infrastructure that will intercept, store, convey, or otherwise interact with surface water resources. – Assessment of predicted impacts on the following: ▪ flow of surface water, sediment movement, channel stability, and hydraulic regime, ▪ water quality, ▪ flood regime, ▪ dependent ecosystems, ▪ existing surface water users, and ▪ planned environmental water and water sharing arrangements prescribed in the relevant water sharing plans.	Chapter 10 and Appendix B

Category	Agency requirements	Where it is addressed in the EIS
Groundwater Assessment	Include adequate details to assess the impact of the project on all groundwater sources including: – Works likely to intercept, connect with or infiltrate the groundwater sources. – Any proposed groundwater extraction, including purpose, location and construction details of all proposed bores and expected annual extraction volumes. – Bore construction information is to be supplied to DPI Water by submitting a “Form A” template. DPI Water will supply “GW” registration numbers (and licence/approval numbers if required) which must be used as consistent and unique bore identifiers for all future reporting. – A description of the watertable and groundwater pressure configuration, flow directions and rates and physical and chemical characteristics of the groundwater source (including connectivity with other groundwater and surface water sources). – Sufficient baseline monitoring for groundwater quantity and quality for all aquifers and GDEs to establish a baseline incorporating typical temporal and spatial variations. – The predicted impacts of any final landform on the groundwater regime. – The existing groundwater users within the area (including the environment), any potential impacts on these users and safeguard measures to mitigate impacts. – An assessment of groundwater quality, its beneficial use classification and prediction of any impacts on groundwater quality. – An assessment of the potential for groundwater contamination (considering both the impacts of the proposal on groundwater contamination and the impacts of contamination on the proposal). – Measures proposed to protect groundwater quality, both in the short and long term. – Measures for preventing groundwater pollution so that remediation is not required. – Protective measures for any groundwater dependent ecosystems (GDEs). – Proposed methods of the disposal of waste water and approval from the relevant authority. – The results of any models or predictive tools used.	Chapter 10 and Appendix D

Category	Agency requirements	Where it is addressed in the EIS
	Where potential impact/s are identified the assessment will need to identify limits to the level of impact and contingency measures that would remediate, reduce or manage potential impacts to the existing groundwater resource and any dependent groundwater environment or water users, including information on: – Any proposed monitoring programs, including water levels and quality data. – Reporting procedures for any monitoring program including mechanism for transfer of information. – An assessment of any groundwater source/aquifer that may be sterilised from future use as a water supply as a consequence of the proposal. – Identification of any nominal thresholds as to the level of impact beyond which remedial measures or contingency plans would be initiated (this may entail water level triggers or a beneficial use category). – Description of the remedial measures or contingency plans proposed. – Any funding assurances covering the anticipated post development maintenance cost, for example on-going groundwater monitoring for the nominated period.	Chapter 10 and Appendix D
Groundwater Dependent Ecosystems	The EIS must consider the potential impacts on any Groundwater Dependent Ecosystems (GDEs) at the site and in the vicinity of the site and: – Identify any potential impacts on GDEs as a result of the proposal including: – the effect of the proposal on the recharge to groundwater systems; – the potential to adversely affect the water quality of the underlying groundwater – system and adjoining groundwater systems in hydraulic connections; and – the effect on the function of GDEs (habitat, groundwater levels, connectivity). – Provide safeguard measures for any GDEs.	Chapter 10 and Appendix D

Category	Agency requirements	Where it is addressed in the EIS
Watercourses, Wetlands and Riparian Land	The EIS should address the potential impacts of the project on all watercourses likely to be affected by the project, existing riparian vegetation and the rehabilitation of riparian land. It is recommended the EIS provides details on all watercourses potentially affected by the proposal, including: Scaled plans showing the location of: – wetlands/swamps, watercourses and top of bank; – riparian corridor widths to be established along the creeks; – existing riparian vegetation surrounding the watercourses (identify any areas to – be protected and any riparian vegetation proposed to be removed); – the site boundary, the footprint of the proposal in relation to the watercourses and riparian areas; and – proposed location of any asset protection zones. – photographs of the watercourses/wetlands and a map showing the point from which the photos were taken. – a detailed description of all potential impacts on the watercourses/riparian land. – a detailed description of all potential impacts on the wetlands, including potential impacts to the wetlands hydrologic regime; groundwater recharge; habitat and any species that depend on the wetlands. – a description of the design features and measures to be incorporated to mitigate potential impacts. – geomorphic and hydrological assessment of water courses including details of stream order (Strahler System), river style and energy regimes both in channel and on adjacent floodplains.	Chapter 10 and Appendix D
Drill Pad, Well and Access Road Construction	Any construction activity within 40 m of a watercourse, should be designed by a suitably qualified person, consistent with the NSW Guidelines for Controlled Activities on Waterfront Land (July 2012). Construction of all wells must be undertaken in accordance with the Minimum Construction Requirements for Water Bores in Australia (3rd edition 2012) by a driller holding a bore drillers' licence valid in New South Wales. The length of time that a core hole is maintained as an open hole should be minimised.	Chapter 5, 10 and Appendix B

Category	Agency requirements	Where it is addressed in the EIS
Landform rehabilitation	Where significant modification to landform is proposed, the EIS must include: – justification of the proposed final landform with regard to its impact on local and regional surface and groundwater systems; – a detailed description of how the site would be progressively rehabilitated and integrated into – the surrounding landscape; – outline of proposed construction and restoration of topography and surface drainage features if affected by the project; – detailed modelling of potential groundwater volume, flow and quality impacts of the presence of an inundated final void (where relevant) on identified receptors specifically considering those environmental systems that are likely to be groundwater dependent; – an outline of the measures to be put in place to ensure that sufficient resources are available to implement the proposed rehabilitation; and – the measures that would be established for the long-term protection of local and regional – aquifer systems and for the ongoing management of the site following the cessation of the project.	Not applicable. Chapter 5 describes proposed rehabilitation measures.
Department of Primary Industries – Lands		
Land	The proponent should identify any Crown land affected by the proposal. Prior to preparation of the EIS it is recommended that the proponent undertake a Crown Land Status search available through Crown Lands.	Chapter 2
Environment Protection Authority		
General	It is the expectation of the EPA that Springvale Coal Pty Ltd will meet these respective deadlines for reductions in salinity, and the elimination of toxicity by 30 June 2017, as required by EPL 3607. The EA needs to provide a timetable for works for Package 1 (Transfer System) and Package 2 (Water Treatment System) to ensure compliance with Development Consent Condition 12 - Water Management Performance Measures. Similarly, the abovementioned timetable for works for Package 1 (Transfer System) and Package 2 (Water Treatment System) is also required to ensure compliance with Condition U1 (U1 .1) - Pollution Studies and Reduction programs of EPL 3607. Compliance with Condition U (U 1.1) is required to achieve the salinity concentrations of the discharge from the Springvale Delta Mine Water Transfer Scheme (SDMWTS) specified by that condition by 30 June 2017 and 30 June 2019, respectively. This licence condition also requires the elimination of the toxicity of the mine water discharge from Licensed Discharge Point (LDP009) by 30 June 2017.	Chapter 1 and Chapter 5

Category	Agency requirements	Where it is addressed in the EIS
Water	– The current quality of the discharge from LDP006 and the concentrations of water quality parameters. – The characteristics of toxicity from the current discharge of LDP006. – The concentration of water quality parameters and quality of the treated water to be directed to LDP006. – The toxic characteristics of the treated water. – The concentration of water quality parameters, quality and toxic characteristics of the blend of treated mine water with groundwater seepage and rainfall runoff that will be discharged through LDP006.	Chapter 10 and Appendix B
	– Potential impacts on the aquatic ecology of Wangcol Creek and the upper Coxs River of (a) the blend of the water sources and (b) when the discharge is only groundwater seepage and/or with rainfall runoff. – An assessment of the groundwater and groundwater seepage that may be occurring within the general area of the Western Coal Services site and the Mt Piper ash emplacement area, that is not captured and discharged through LDP006, and has the potential to disperse off-site within the upper Coxs River catchment and impact on the aquatic ecology of Wang col Creek and the upper Coxs River. – Address the need to implement a reliable groundwater monitoring program between the Western Coal Services site and Wangcol Creek. – For the water quality parameters list above, they should be assessed, and expressed in both Total and Acid Extractable concentrations, for the following: ▪ Total suspended solids, turbidity, pH, salinity {Electrical Conductivity - EC), total oil and grease. ▪ Fluoride. ▪ Elements and metals: aluminium, arsenic, barium, beryllium, boron, cadmium, calcium, chromium (III and VI), cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, sodium, sulphur, uranium, zinc. ▪ Anions: chloride, sulphate. ▪ Alkalinity (carbonate, bicarbonate and total). ▪ Nitrogen and phosphorus: total nitrogen, total Kheljdahl nitrogen, nitrite, nitrate, total ammonium N, total phosphorus. ▪ Phenolic compounds (total).	Aquatic ecology addressed in Chapter 15 and Appendix H
	Compare the various proposed combinations of discharges from LDP006 with the ecosystem protection levels of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment and Conservation Council 2000 -ANZECC 2000).	Chapter 10 and Appendix B

Category	Agency requirements	Where it is addressed in the EIS
Volume of Mine Water	The Development Consent for the Springvale Mine Extension Project does not allow the duplication of pipelines or an increase in capacity of the SDWTS, effectively limiting the capacity at 30 ML/d. Provide the reasons why the volume of the pipeline needs to be increased to 36 ML/d, and the source of the additional mine water directed to the SDWTS. For example, is the additional capacity required to include sources such as mine water from Angus Place Colliery, and mine water from the Renoun Workings which is currently discharged through LDP001 of EPL 3607.	Chapter 4 and 5
Sludge Disposal	Provide the following details of the sludge from the proposed water treatment process intended for disposal in the tailings dams at the Springvale coal services site: – quantities of sludge to be disposed per annum – chemical composition of the sludge – classification of the sludge under the Protection of the Environment Operations Act 1997 (Waste Act and Regulations 2014) – suitability for co-disposal with tailings.	Chapters 5 and 15
Brine Management and Disposal	Address brine management and disposal and specifically the points set out below: – volume of brine concentrate/crystals to be directed annually to the MPPS ash emplacement area. – potential the leakage of saline water from the MPPS ash emplacement area to link with the groundwater below this facility, and for dispersal via subsurface groundwater plumes towards the Coxs River. – need for a reliable groundwater monitoring program around the current ash dam (ie multiple piezometers with groundwater quality testing in between the ash dam wall and Coxs River). – need to include proper monitoring/estimation of wet weather flows with the potential to transport salt and ash over the dam wall. – assess the potential for prolonged, heavy rainfall to cause the capacity of the MPPS ash emplacement area to be exceeded, with the potential for brine concentrate and ash to be flushed into the Coxs River. – impact of the disposal of this additional brine concentrate on the capacity, and life, of the MPPS ash emplacement area. – leakage of salt from the salt ponds into the local groundwater. – measures to achieve compaction to prevent the leakage of salt to the local groundwater	Chapter 5, 10 and 15
Amenity	Include information about the construction of the pipelines to ensure the amenity of the local residents of Lidsdale, Wallerawang and Blackman's Flat is not impacted by either air (dust, fumes) or noise pollution.	Chapter 13, 15 and Appendix E

Category	Agency requirements	Where it is addressed in the EIS
Construction of the Pipelines	Provide information on the sediment and erosion control measures that will be implemented during the construction of the pipelines.	Chapter 15 and Appendix B
	Assess the potential for an increase in noise emissions from Mt Piper Power Station associated with the water treatment process.	Chapter 13 and Appendix E
	Address the management strategies to be followed when there is either routine maintenance of the pipeline or water treatment system, or a failure of either system.	Chapter 5
	Clearly address the procedures being proposed to handle untreated mine water in the case of either routine maintenance or an emergency situation, to avoid the discharge of untreated mine water into the upper Coxs River or other local surface waters within the catchment. Given the environmental gains that would be made by using the mine water at MPPS, the discharge of untreated mine water needs to be avoided.	Chapter 5
Consideration of Alternative Options	It is conventional for EAs/EISs to include the consideration of alternatives to the one being proposed, indicating why they were rejected. The EA/EIS needs to consider alternative options for ways of managing the mine water, still based on a treatment to remove salts (and by association other pollutants) and using the treated mine water for industrial purposes at MPPS. Two options which should-be considered in the EA are set out below.	Chapter 4
Use of Thompson's Creek Dam	Consider options such as treating the mine water elsewhere and then delivering treated water to MPPS. One option is to treat the mine water at the former Wallerawang Power Station site, utilising the existing infrastructure for Reverse Osmosis (RO) and then: – transferring the brine slurry using the existing pipeline to the Mt Piper brine concentrator; and, – transferring the treated water via a pipeline to Thompson's Creek Dam, from where it can be transferred to the MPPS. A benefit of this option is that by utilising Thompson's Creek Dam, the operators overcome the management constraints caused by the predicted variations to water demand at the MPPS thereby eliminating the need for a discharge of excess treated water to Wangcol Creek at the Western Coal Services site (LDP006), because water in excess to demand can remained stored in Thompson's Creek Dam, and be available for later use. Furthermore, Thompson's Creek Dam would also act as storage during times of scheduled maintenance or malfunction of the system, avoiding the short-term need to potentially discharge untreated mine water into the upper Coxs River. This would represent an acceptable environmental outcome.	Chapter 4

Category	Agency requirements	Where it is addressed in the EIS
Use of De-alkalisation	Consider de-alkalisation as an alternative to RO as a treatment option. The Springvale mine water has a high salinity because of the high sodium bicarbonate concentration of the mine water. It is understood that treatment to alter the water chemistry to reduce the sodium bicarbonate load which in turn lowers the salinity, instead of using micro-filtration of the mine water, can substantially reduce the amount of brine waste produced. Management of the brine waste is a key consideration of the Project.	Chapter 4
NSW Department of Industry – Resources and Energy		
Mining	Assess potential impacts on any significant mineral resources, including: Any operating mines, extractive industries or known mineral or petroleum resources. Exploration activities in the vicinity of the proposed development. Access for future exploration in the area.	Chapter 2 and 15
	The proponent should consult with the operator of ML1637 (Enhance Place Pty Ltd) regarding potential impacts associated with the proposal, with a record of consultation included in the EIS.	Chapter 7
Lithgow City Council		
PEA	PEA describes the project in general terms and Council has no objection to submission of the DA for the Project.	Noted
	Council would like to reserve the right to enter into discussions with the applicant to enter into a Voluntary Planning Agreement	Noted – VPA agreed as part of Springvale MEP SSD consent and Project is not considered to trigger need for a new VPA
Office of Environment and Heritage requirements		
Biodiversity	Biodiversity impacts are to be assessed and documented in accordance with the Framework for Biodiversity Assessment, unless otherwise agreed by OEH, by a person accredited in accordance with s142B(1)(c) of the *Threatened Species Conservation Act 1995*.	Chapter 11 and Appendix C

Category	Agency requirements	Where it is addressed in the EIS
	Impacts on the species/populations/ecological communities listed below will require further consideration and provision of the information specified in s9.2 of the Framework for Biodiversity Assessment. – Blue Mountains Swamps in the Sydney Basin Bioregion – Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions – Newnes Plateau Shrub Swamp in the Sydney Basin Bioregion – White Box Yellow Box Blakely's Red Gum Woodland – *Anthochaera Phrygia*, Regent Honeyeater – *Hoplocephalus bungaroides*, Broad-headed Snake – *Petalura gigantean*, Giant Dragonfly – *Caesia parviflora var. minor*, Small Pale Grass-lily – *Eucalyptus aggregate*, Black Gum – Eucalyptus pulverulenta, Silver-leafed Gum – *Leucopogon fletcheri subsp. fletcheri*, *Prasophyllum fuscum*, Slaty Leek Orchid	Chapter 11 and Appendix C
	In the case of a project that adjoins, is in the immediate vicinity of a park or upstream, the assessment of impacts must address the matters to be considered outlined in the Guidelines for developments adjoining land and water managed by DECCW (DECCW 2010) and include the: – nature of the impacts, including direct and indirect impacts. – extent of the direct and indirect impacts. – duration of the direct and indirect impacts. – objectives of the reservation of the land. – measures proposed to prevent, control, abate, minimise and manage the direct and indirect impacts including an evaluation of the effectiveness and reliability of the proposed measures. – residual impacts.	Chapter 11 and Appendix C
Aboriginal cultural heritage	Identify and describe the tangible and intangible Aboriginal cultural heritage values that exist across the whole area that will be affected by the Springvale Water Treatment Pipeline and document these in the EIS. This may include the need for surface survey and test excavation. The identification of cultural heritage values should be guided by the Guide to investigating, assessing and reporting on Aboriginal Cultural Heritage in NSW (DECCW, 2011) and consultation with OEH regional officers.	Chapter 12 and Appendix D

Category	Agency requirements	Where it is addressed in the EIS
	Where Aboriginal cultural heritage values are identified, consultation with Aboriginal people must be undertaken and documented in accordance with the Aboriginal cultural heritage consultation requirements for proponents 2010 (DECCW). The significance of cultural heritage values for Aboriginal people who have a cultural association with the land must be documented in the EIS.	Chapter 12 and Appendix D
	Impacts on Aboriginal cultural heritage values are to be assessed and documented in the EIS. The EIS must demonstrate attempts to avoid impact upon cultural heritage values and identify any conservation outcomes. Where impacts are unavoidable, the EIS must outline measures proposed to mitigate impacts. Any objects recorded as part of the assessment will be documented and notified to OEH.	Chapter 12 and Appendix D
	The assessment of cultural heritage values must include a surface survey undertaken by a qualified archaeologist in areas with potential for subsurface Aboriginal deposits. The result of the surface survey is to inform the need for targeted test excavation to better assess the integrity, extent, distribution, nature and overall significance of the archaeological record. The results of surface surveys and test excavations are to be documented in the EIS.	Chapter 12 and Appendix D
	Outline procedures to be followed if Aboriginal objects are found at any stage of the life of the Springvale Water Treatment Pipeline to formulate appropriate measures to manage unforeseen impacts. Outline procedures to be followed in the event Aboriginal burials or skeletal material is uncovered during construction to formulate appropriate measures to manage the impacts to this material.	Chapter 12 and Appendix D
Water and soils	Map the following features relevant to water and soils including: – Acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soil Planning Map). – Rivers, streams, wetlands, estuaries (as described in Appendix 2 of the Framework for Biodiversity Assessment). – Groundwater. – Groundwater dependent ecosystems. – Proposed intake and discharge locations.	Chapter 10 and Appendix B

Category	Agency requirements	Where it is addressed in the EIS
	Describe background conditions for any water resource likely to be affected by the Springvale Water Treatment Pipeline, including: Existing surface and groundwater. Hydrology, including volume, frequency and quality of discharges at proposed intake and discharge locations. Water Quality Objectives (as endorsed by the NSW Government http://www.environment.nsw.gov.au/ieo/index.htm) including groundwater as appropriate that represent the community's uses and values for the receiving waters. Indicators and trigger values/criteria for the environmental values identified above in accordance with the ANZECC (2000) Guidelines for Fresh and Marine Water Quality and/or local objectives, criteria or targets endorsed by the NSW Government.	Chapter 10 and Appendix B
	Assess the impacts of the Springvale Water Treatment Pipeline on water quality, including: – The nature and degree of impact on receiving waters for both surface and groundwater, demonstrating how the Springvale Water Treatment Pipeline protects the Water Quality Objectives where they are currently being achieved, and contributes towards achievement of the Water Quality Objectives over time where they are currently not being achieved. This should include an assessment of the mitigating effects of proposed stormwater and wastewater management during and after construction. – Identification of proposed monitoring of water quality.	Chapter 10 and Appendix B
	Assess the impact of the Springvale Water Treatment Pipeline on hydrology, including: – Water balance including quantity, quality and source. – Effects to downstream rivers, wetlands, estuaries, marine waters and floodplain areas. – Effects to downstream water-dependent fauna and flora including groundwater dependent ecosystems. – Impacts to natural processes and functions within rivers, wetlands, estuaries and floodplains that affect river system and landscape health such as nutrient flow, aquatic connectivity and access to habitat for spawning and refuge (e.g. river benches). – Changes to environmental water availability, both regulated/licensed and unregulated/rules- based sources of such water. – Mitigating effects of proposed stormwater and wastewater management during and after construction on hydrological attributes such as volumes, flow rates, management methods and re-use options. – Identification of proposed monitoring of hydrological attributes.	Chapters 10 and 15 Appendix B and H

Category	Agency requirements	Where it is addressed in the EIS
Flooding	The EIS must map the following features relevant to flooding as described in the Floodplain Development Manual 2005 (NSW Government 2005) including: – Flood prone land – Flood planning area, the area below the flood planning level. – Hydraulic categorisation (floodways and flood storage areas).	Chapter 10 and Appendix B
	Describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 1 in 10 year, 1 in 100 year flood levels and the probable maximum flood, or an equivalent extreme event.	Chapter 10 and Appendix B
	Model the effect of the proposed Springvale Water Treatment Pipeline (including fill) on the flood behaviour under the following scenarios: – Current flood behaviour for a range of design events as identified above. – The 1 in 200 and 1 in 500 year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	Chapter 10 and Appendix B
	Modelling must consider and document: – The impact on existing flood behaviour for a full range of flood events including up to the probable maximum flood. – Impacts of the development on flood behaviour resulting in detrimental changes in potential flood affection of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazards and hydraulic categories. – Relevant provisions of the NSW Floodplain Development Manual 2005.	Chapter 10 and Appendix B

Category	Agency requirements	Where it is addressed in the EIS
	Assess the impacts on the proposed Springvale Water Treatment Pipeline on flood behaviour, including: – Whether there will be detrimental increases in the potential flood affectation of other properties, assets and infrastructure. – Consistency with Council floodplain risk management plans. – Compatibility with the flood hazard of the land. – Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of the land. – Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site. – Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses. – Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the SES and Council. – Whether the proposal incorporates specific measures to manage risk to life from flood. i. Emergency management, evacuation and access, and contingency measures for the development considering the full range or flood risk (based upon the probable maximum flood or an equivalent extreme flood event). These matters are to be discussed with and have the support of Council and the SES. – Any impacts the development may have on the social and economic costs to the community as consequence of flooding	Chapter 10 and Appendix B
Cumulative Impacts	The cumulative impacts from all clearing activities and operations, associated edge effects and other indirect impacts on cultural heritage, biodiversity and OEH Estate need to be comprehensively assessed in accordance with the Environmental Planning and Assessment Act 1979. This should include the cumulative impact of the proponent's existing and proposed development and associated infrastructure (such as access tracks etc) as well as the cumulative impact of other developments located in the vicinity. This assessment should include consideration of both construction and operational impacts.	Chapter 11 and 12 and Appendix C and D

Category	Agency requirements	Where it is addressed in the EIS
Roads and Maritime Services		
Roads	A traffic impact study prepared in accordance with the methodology set out in Section 2 of the RTA's Guide to Traffic Generating Developments 2002 and including: For the construction of the treatment plant and associated infrastructure, road transport volumes and vehicle types broken down into: – origin and destination – travel routes, including travel on both private and public roads. – peak hours. The study is to provide details of projected transport operations including: – traffic volumes – materials to be transported and vehicle types used for transport – physical constraints on the haulage route – access points to and from the Castlereagh Highway. – measures to be put in place to ensure a high level of safety for all road users interacting with construction traffic. Any over size and over mass vehicles and loads expected for the construction and operation of the project. The shortest and least trafficked route should be given priority for the movement of construction materials and machinery to minimise the risk and impact to other motorists so far as is reasonably practicable. Temporary and permanent staff numbers (including employees and contractors) and staff parking arrangements during construction and operation of the project. Measures to be employed to ensure traffic efficiency and safety on the public road network during construction and operation of the project.	Chapter 14 and Appendix F
	Access locations and treatments need to be identified and in accordance with Austroads Guide to Road Design and Roads and Maritime supplements, including safe intersection sight distance.	Chapter 14 and Appendix F
	Details of proposed new pipe crossings under the Castlereagh Highway. Any new work beneath the Castlereagh Highway will, in accordance with section 138(2) of the Roads Act 1993, require the concurrence of Roads and Maritime.	Chapter 5 and 6
	Details of discharge of treated water into Wangcol Creek and identification of any impacts discharge will have on the existing stormwater management system adjoining the Castlereagh Highway.	Chapter 10 and Appendix B

Category	Agency requirements	Where it is addressed in the EIS
WaterNSW requirements		
Water	Assess the project for consistency with the aims of State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 and demonstrate compliance with clauses 9 and 10 of the SEPP. In particular the assessment must describe how the project would have a neutral or beneficial effect on water quality during the construction, operational and decommissioning stages.	Chapter 6, 10 and Appendix B
	How will the project achieve 'improved environmental outcomes for the catchment and meet the water quality performance measures for salinity for mine water discharges required under the Springvale MEP SSD Consent (SSD 5594).	Chapter 10 and Appendix B
	Outline the expected water quality within the Coxs River downstream of Lake Lyell and in Lake Burragorang as result of the project and in comparison with the expected quality at these locations if the permitted discharges under the Springvale MEP SSD Consent (SSD 5594) occurred	Chapter 10 and Appendix B
	Identify whether the construction of new salt ponds, Water Treatment Plant, installation of a crystalliser and any other infrastructure and disposal of additional brine at the MPPS site and increased impacts on groundwater will trigger a modification to the MPPS existing consent.	Chapter 3
	Identify if treated water discharges to Wangcol Creek will be directed to LDP006 or whether a new licenced discharge point will need to be approved, and	Chapter 5, 10 and Appendix B
	Determine if a variation to the existing Springvale Mine Environment Protection Licence (EPL 3607) would be required for the changes to discharges at LDP006 (or new discharge point along Wangcol Creek) and LDP009.	Chapter 3, 6, 10 and Appendix B

Category	Agency requirements	Where it is addressed in the EIS
General	The detailed description of the project should also address the following:	
	– aspects of the project which have the potential to impact on the environment and should also address the quality and quantity of surface and ground waters at and adjacent to the project	Chapter 10 and Appendix B
	– location, mapping and geomorphology of all creeks and water resources in close proximity to the proposed discharge points	Chapter 10 and Appendix B
	– location, sizing and description of all existing and proposed water management measures including the proposed salt ponds at the MPPS site, and details of the existing structures, structural stability, integrity and ongoing maintenance and monitoring of all site water management measures over the life of the project	Chapter 5, 10 and Appendix B
	– specific details of the water treatment plant processes and the proposed quality of treated water including details of how the plant will achieve water quality improvements including salinity concentrations of 500us/cm EC (90%ile)	Chapter 5, 10 and Appendix B
	– specific details of the quantity and quality of the sludge, brine and other waste material generated from the water treatment process annually	Chapter 10, 15 and Appendix B
	– disposal of sludge, brine and other waste material from the water treatment process. In particular, the volume of sludge, brine and any other waste material proposed to be disposed of annually and justification that the existing and proposed infrastructure has capacity to receive this material	Chapter 3, 5 and 15
	– consideration of alternative options and justification as to why they have been rejected in the proposal. Alternative options may include: ▪ all treated water that is not received by the MPPS (where the power station is operating at reduced capacity) is directed to a discharge point located outside of the Sydney drinking water catchment or to the Thompson Creek Reservoir, with no treated water discharges to Wangcol Creek, and ▪ all of the existing water discharges to LDP006 also redirected to the MPPS for treatment and reuse	Chapter 4
	– location, management and storage of any chemicals and hazardous materials.	Chapter 5

	Address the following within the water balance assessment: – predictions of the frequency, quantity and quality of mine water transfers to the proposed water treatment plant – predictions of the frequency, quantity and quality of treated water being transferred for use by the MPPS and predictions of the frequency and quantity of any water extractions from local waterways to meet additional make-up water demand at the MPPS when the treated water volumes are not enough – predictions of the frequency, quantity and quality of treated water being discharged to Wangcol Creek when the MPPS is operating at reduced capacity and is unable to take some or all of the treated water from the water treatment plant – predictions of the frequency, quantity and quality of mine water if and when it is not feasible to transfer to the water treatment plant including additional 6ML proposed to be transferred than the existing discharges of 30ML allowed in EPL for LDP009 and describe the scenarios and likelihood when this may occur – details of the measures to manage site water associated with transferring and treating mine water, general stormwater runoff and any human activities likely to affect water quality at the site, and how the neutral of beneficial effect on water quality test will be assessed and applied within the surface water assessment: – comparison of the pre and post development volumes of water extracted from and mine water discharged to the Coxs River catchment (treated and untreated) – provide estimates of the volume; quality and pollutant loads of discharges into the Coxs River catchment annually and shall make clear statement as to whether the project would have a neutral of beneficial effect on water quality – specific comparison of the quality and quantity of water currently being discharged from LDP006 with the total quality and quantity of discharges post development including from the Water Treatment Plant – the potential impacts of any discharges on the water quality of receiving waters and whether there would be any consequences on geomorphology or ecology (flora and fauna) of the receiving watercourses – the potential impacts to receiving waters from LDP009 (or any other discharge location) when mine water is not feasible to transfer to the water treatment plant and whether water quality performance measures required by the Springvale Mine Extension Project will be achieved if this does occur – clarification of the timeframes for the project with respect to meeting the timeframes for pollution reduction contained in the consent for the Springvale Mine Extension Project. – impacts of increased brine and sludge production and disposal at MPPS on groundwater and whether existing infrastructure has capacity to receive and store the additional brine and sludge produced and the proposed management measures	Chapter 10 and Appendix B

Category	Agency requirements	Where it is addressed in the EIS
	– the location and description of all water monitoring points (surface and ground waters) including details of proposed monitoring of surface water flows, groundwater and surface water quality, along with information as to how the proposed monitoring will be used to monitor and, if necessary, mitigate impacts on surface water and groundwater resources beyond those predicted – details of measures proposed to be adopted to offset impacts associated with construction activities e.g. earthworks, vegetation clearing, transfer pipeline construction etc.	
	Include concept plans, protocols and/or procedures for the following: – Water Management Plan including surface water management plan, groundwater management plan and surface and ground water monitoring programs – Soil and Water Management Plan which shall consider the principles outlined in the Managing Urban Stormwater - Soils and Construction - Installation of Services Manual prepared by the Department of Environment and Climate Change (2008) – Details of the practices proposed to ensure mine water and waste materials transported to and from the sites do not spill or otherwise cause soil or water pollution – Procedures for managing spills and emergency situations – Rehabilitation Plan.	Chapter 10, 16 and Appendix B

Appendix B Water resources

Springvale Coal/EnergyAustralia

Springvale Water Treatment Project
Water Resources Impact Assessment

August 2016

Executive summary

Springvale Coal Pty Limited (Springvale Coal) is seeking consent for the Springvale Water Treatment Project (the Project). Springvale Coal and EnergyAustralia NSW Pty Ltd have agreed to work together to develop the Project under a joint venture. The Project involves the establishment of a pipeline and ancillary facilities to transfer water from the existing or approved dewatering facilities on the Newnes Plateau for treatment and reuse at Mount Piper Power Station (MPPS). The Project will achieve improved environmental outcomes for the upper Coxs River catchment and meet the water quality performance measures for mine water discharges required under the development consent for the Springvale Mine Extension Project.

A Water Resources Impact Assessment has been developed to determine the potential impact of the Project on surface water and groundwater environments. The assessment investigated the environment specific to the Coxs River catchment, it determined baseline conditions from available monitoring data, it developed predictive models to understand the consequences of the Project actions and assessed environmental risk from proposed waste streams created by the Project. The Project required the consideration of water quality impact outcomes at both a site and regional scale, as the potential benefits of the Project can extend hundreds of kilometres from the site of treated water discharge.

Existing conditions

The assessment of existing conditions of the catchment has included quantification of surface and groundwater environments at key points of interest within the Coxs River catchment. The outcomes of this indicated a historically modified catchment from mining and agricultural landuses.

The evaluation of the existing regional water and salt balance indicated that existing conditions and industrial operations control the existing levels of electrical conductivity of waterways within much of the upper Coxs River catchment.

The assessment of hydrology and hydraulics within Wangcol Creek was visually assessed to determine the geomorphic processes currently influencing the form of the creek. This indicated that the creek is in a poor to moderate state but would be resilient to increased flow as a result of the Project.

The characterisation of water quality within the local catchment and regionally was undertaken to determine baseline conditions. Catchment specific guideline values were derived from Neubecks Creek monitoring data given water in that creek is not influenced by mining and other industrial activities in the area. Wangcol Creek quality was more subject to groundwater influences whereas Coxs River was dominated by mine water discharges at Springvale Mine's licensed discharge point (LDP) LDP009.

The summary of ecotoxicology assessments undertaken previously on discharges and within the catchment were provided to support aquatic ecology outcomes.

The existing groundwater environment and its potential interaction with the Project was assessed for levels and quality. This indicated a poor water quality source within areas of historical mining due to elevated presence of metals and electrical conductivity due to geochemical processes from exposed coal seams. It was determined that within areas of underground and open cut mining, groundwater to surface water connectivity was more prevalent. Groundwater quality from the existing ash emplacement area at MPPS indicates some elevated chloride and sulfate ion concentrations within boundary groundwater bores. Some of the MPPS bores have historically had high concentrations of parameters typically found as trace elements of brine conditioned ash within the ash emplacement area at MPPS site. Whilst this was evident, groundwater contours for the shallow groundwater environment indicates there is a flow from west to east and south west to north east. It was determined the Project would not increase the potential for impact to the groundwater environment from the current conditions.

The assessment of surface and groundwater users indicated that it was unlikely that the Project would directly influence the viability of existing basic landowner rights. A small number of surface water users is present within the catchment above Lake Wallace. Groundwater users are dominated by monitoring and stock and domestic users.

Proposed conditions

Generally, the Project will serve a benefit to the upper Coxs River catchment water quality. This has been supported by the following assessment outcomes.

The Project considers the construction of infrastructure including pipeline capable of transferring up to 36 ML/day from the existing Springvale Mine gravity tank, to a proposed water treatment plant (WTP) at MPPS. The WTP will utilise a reverse osmosis treatment process which will achieve a high percentage reduction of parameters typical within mine water at Angus Place Colliery and Springvale Mine.

The identification and assessment of all works required to implement the Project has included the in direct consequences of the works on other related operations. Where required this has provided conceptual diagrammatic representation of typical layouts for various project components and the extension of predictive models.

The Project will achieve a maximum yield of 32 ML/day (at the peak of mine dewatering activities) for reuse at MPPS or discharge to Wangcol Creek. As there is uncertainty surrounding the future power generation rates at the MPPS the assessment of five proposed scenarios covered the likely range of influences of the Project. Modifications to the water and salt balance developed for the Coxs River catchment indicated that there was an improvement in water quality downstream of the existing LDP009 discharge point due to the proposed Project. Despite a potential increase in the salt load and electrical conductivity within the Wangcol Creek catchment, the Project was predicted by the water and salt balance model to provide an overall benefit for the Coxs River catchment for all proposed scenarios compared to the existing conditions and do nothing scenario.

In the event that the discharge of treated water is required to Wangcol Creek, hydrological and hydraulic models have been developed to consider the consequences of a peak discharge of up to 32 ML/day. The results of these models indicate a minor increase in velocity and flood depth for events between a 1 year ARI to a 100 year average recurrence interval event. When considering a peak discharge in dry weather conditions, the consideration of how baseflow conditions would be modified were considered. The results of this test indicated the greatest change with increase in flow depths of between 0.1 m to 0.2 m and flow velocity increases of 0.2 m/s to 0.4 m/s.

Soils across the Project area were categorised with respect to their erosion risk. Erosion risk was typically associated with steeper areas of the Project, located in pockets, off the Newnes Plateau. A number of high erosion risk areas were identified that intercept the pipeline alignment. Soil material within MPPS and Springvale Coal Services site (SCSS) is typically representative of a modified soil landscape.

The geomorphic conditions of Wangcol Creek indicate a low risk to erosion as a result of peak discharges from the proposed LDP. Some infrastructure risks were identified within the creek however these can be mitigated with monitoring. Trenchless crossings were assessed as part of options to construct the pipeline across the Coxs River. Under boring using horizontal directional drilling the creek is likely to be the least impacting option for Coxs River and is unlikely to modify the river's geomorphology. The pipeline extent from the Gravity Tank on the Newnes Plateau to Sawyers Swamp Creek was identified as being a potential risk given the steep grades of the valley. The pipeline is likely to follow existing corridors set out by previous logging activities. Erosion of the gully can be mitigated if the pipeline can be located outside of the primary flow path.

Water quality was assessed as a result of the Project considering the likely treatment plant performance and load reduction that is likely to be achieved, the management of runoff quality from the WTP site, and construction impacts to water quality. The water and salt balance covers the assessment of water quality with respect to salt loads on the catchment.

The groundwater environment was assessed with respect to interception due to the pipeline's construction. It is unlikely that the construction of the pipeline will intercept significant volumes of groundwater however there is likely to be some areas of exception. These are likely to be associated with areas of alluvial material, or shallow groundwater environments.

The location of surface and groundwater users were considered as part of the Project's impacts. It was determined that the Project would generally benefit surface water users upstream of Lake Wallace through improved water quality. The location of users was such that, the removal of flow volumes from the waterway was unlikely to directly influence the availability of water from licenced users upstream of Lake Wallace. There are no known groundwater users likely to be impacted by the Project's operation.

With the development of the WTP, the creation of two waste streams requires management as part of the Project. The key waste stream that already exists, but the Project will contribute to, is the brine management system at MPPS. This consists of brine concentrators, brine storage ponds, processes in which ash can be conditioned with brine, and proposed as part of the Project, a salt crystalliser. Disposal of brine conditioned ash is only undertaken at levels above 946 m AHD, with ash placed below this level conditioned with water. This approach allows for brine conditioned ash not to be in direct contact within any potential shallow groundwater environment. As a result of the construction of the proposed WTP at MPPS, the brine generation volume is likely to increase. The inclusion of a crystalliser in the Project is aimed to compensate the potential increase in brine through a process of concentration, leading to reductions in volume by up to 60%. The concentration process does increase total dissolved solid concentrations from 180,000 mg/L up to 500,000 mg/L however this increase will be managed as part of the existing ash emplacement management and strategy in place at MPPS. Annual brine generation will depend upon typical power generation rates and the actual treated water volume from the proposed WTP. The management of residual material from the WTP pre-treatment process will be disposed of within the REA at SCSS. This will increase discharges at LDP006 by 0.2 ML/day on average. This is due to the fact that the residuals are majority water which is taken up within SCSS water management system.

The Water Resources Impact Assessment considered the water licensing obligations of the Project. As a result of the supply of up to 36 ML/day of water to MPPS from the Springvale-Delta Water Transfer Scheme (a maximum of 32 ML/day of which can be yielded) from Springvale Mine and Angus Place Colliery, there would be a likely reduction in the required water take from the Coxs River via Lake Lyell and Thompsons Creek Reservoir and the Fish River water supply scheme into the future.

The operation of the WTP would be regulated by a new Environment Protection Licence (EPL). Whilst this licence would ultimately be the responsibility of Springvale Coal as the applicant of the Project, a third party contractor would be responsible for the compliant operation of the plant. As part of this assessment, recommendations for EPL conditions have been proposed, based on site specific guideline values derived by the Project. Following the commissioning of the plant the potential revision of concentration limits are recommended to be considered as part of a review one year following commencement. The plant will typically operate to a higher standard than the derived site specific guideline values hence allowing for a buffer between EPL limits and operation specifications. Operation of a new discharge point would be included as part of this EPL with a volumetric limit equal to the expected peak discharge of the plant (approximately up to 32 ML/day).

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Glossary

Alluvial	Deposition from running waters. In this context, it refers to 'alluvium' — soils such as the fertile floodplain soils that consist of fine-grained sediments including clays, silts and sands.
Bank	Refers to the streambank of a stream channel; they appear as the steeply sloped outer walls of the channel.
Baseflow	The component of streamflow that originates from groundwater.
Bore	A constructed connection between the surface and a source of underground water that enables the underground water to be transferred to the surface either naturally or through artificial means.
Bund	An impervious embankment of earth or a brick wall, which may form part or all of the perimeter of a compound that is provided to retain liquid.
Catchment	The land area draining through the main stream and tributary streams to a particular location.
Clay	A weathered form of aluminosilicate mineral particles, less than 0.004 mm in diameter.
Clean catchment areas	Catchments in which there are no exposed or disturbed surfaces containing coal, mined carbonaceous material or active construction areas.
Clean water	Surface runoff from clean catchment areas and uncontaminated water supplied by external sources.
Cohesive sediments	Composed primarily of clay-sized material, which have strong interparticle forces which acts to hold them together.
Colluvial	Deposition of loose earth material at the base of a hill, through the action of gravity, as piles of talus, avalanche debris, and sheets of detritus moved by soil creep or frost action.
Cut through	Underground mine access ways between the development headings. They occur at regular intervals along the development headings.
Default guideline values (DGV)	Previously referred to as default trigger values. DGVs are water quality concentrations developed by ANZECC (2000a) that are applicable for broad catchment types at a state level used in the absence of appropriate site specific monitoring data.
Deposition	The dropping of material which has been picked up and transported by wind, water, or other processes.
Depression storage	The volume of water that is contained in natural depressions in the land surface.
Dewatering	Transfer of water from the underground mine workings to the surface or other underground areas.
Dirty catchment areas	Catchments in which coal or mined carbonaceous materials are present or areas where the topsoil has been disturbed.

Dirty water	Water on the premises that has come into physical contact with coal, mined carbonaceous materials or otherwise contains elevated sediment load.
Discharge	Quantity of water per unit of time flowing in a stream, for example cubic meters per second or megalitres per day.
Electrical conductivity	A measure of concentration of dissolved salts in water.
Erosion	A natural process where wind or water detaches a soil particle and provides energy to move the particle.
Escarpment	A long continuous steep face of a ridge or plateau formed by erosion.
Evapotranspiration	The loss of water from soil by evaporation and from plant surfaces by transpiration.
Floodplain	A level, low-lying area adjacent to streams that is periodically flooded by stream water. Floodplains are composed of sediments carried by rivers (alluvium) and deposited on land during flooding.
Fluvial	Refers to the processes associated with running water such as a river or other freshwater source
Geomorphology	The interdisciplinary and systematic study of landforms and their landscapes, as well as the earth's surface processes that create and change them.
Goaf	That part of a mine from which the mineral has been partially or wholly removed, the waste left in old workings.
Gradient	The degree of ascent or descent with a uniform slope.
Gravel	Sediment with diameters between 2 and 64 mm
Guideline trigger value	Previously referred to as site specific trigger, guideline trigger values are catchment derived water quality concentration triggers that are based on the methodology within ANZECC (2000a)
Gully erosion	The removal of soil by an excessive concentration of running water, resulting in the formation of deep channels.
Headcut/headward erosion	A steep, actively eroding point in the streambed, which migrates in an upstream direction to lower the streambed and cause streambanks to collapse. Also known as a 'nickpoint'.
Hydrogeology	The area of geology that deals with the distribution and movement of groundwater in soils and rocks of the earth's crust.
Infiltration	Natural flow of surface water through ground surfaces as a result of rainfall events.
Licensed discharge point	A location where water is released to the environment in accordance with conditions stipulated within the site Environment Protection Licence.
Lithgow Seam	Deepest coal horizon of the Permian Age Illawarra Coal Measures, with an average depth of 380 m.

Longwall	Longwall mining is a form of underground coal mining where a block of coal is mined using a longwall shearer. The longwall mining method is supported by roadway development, mined using a continuous miner unit.
Mud	Fine sedimentary material, typically comprising both inorganic (mineral) and organic material.
Oil/Water Separator	Device designed to separate oil from water.
Pan factor	Reduction factor applied to measured pan evaporation to simulate evaporation from natural water bodies and surface water storages.
Percentile	The value of a variable below which a certain percent of observations fall. For example, the 80th percentile is the value below which 80 percent of values are found.
Potable water	Water of a quality suitable for drinking.
Recharge	Inflow of water from surrounding strata into underground workings through infiltration. This can be as a result of rainfall events or from surrounding aquifers.
Run of mine coal	Raw or unprocessed coal.
Sand	Sediment with diameters between 0.06 mm to 2 mm
Scour	Streambank, bed or floodplain erosion where particles of sediment are removed individually by plucking or are sheared off. It is caused by the force of running water being greater than the sediment's ability to resist that force.
Sediment	Material of varying sizes that has been or is being moved from its site of origin by the action of wind, water or gravity.
SILO	An enhanced climate data bank based on historical climate data from 1889 provided by the Bureau of Meteorology. Records are mainly based on observed data, with interpolation where there are data gaps.
Silt	Sediment with diameters between 0.002 mm to 0.06 mm
Sinuosity	The extent of curvature or meandering of a stream in comparison to down-valley distance. Highly sinuous streams meander over a low gradient and short distance; streams with low sinuosity are straighter and have a steeper gradient.
Springvale Coal Services site	Site currently used for stockpiling and processing of run of mine coal from Springvale Mine. The site is proposed to be upgraded, as part of the Western Coal Services Project, to increase coal throughput at the site and to provide the coal handling logistics for both Angus Place Colliery and Springvale Mine.
Springvale-Delta Water Transfer Scheme	Pipeline network which transfers extracted groundwater using boreholes from Angus Place Colliery and Springvale Mine to the Wallerawang Power Station via the Springvale LDP009 for discharge into Coxs River.

Strahler Stream Order	A scale-dependent property of drainage networks that describes the position and approximate size of a stream segment in the network. First order streams are headwater streams that have no tributaries. A second order stream is formed where two first order streams join, a third order stream is formed where two second order streams join, etc. Note that the confluence of a second order stream with a first order stream remains a second order stream.
Surface water	Water that is derived from precipitation or pumped from underground and may be stored in dams, rivers, creeks and drainage lines.
Make-up cooling water	Water that is sourced into the cooling process for the power station to supplement the recirculation of water that is being reused internally.
Water treatment plant	Proposed water treatment plant forming part of the Springvale Water Treatment Project

Abbreviations

ADWG	Australian drinking water guideline
AHD	Australian height datum
ARI	Annual recurrence interval
ARR	Australian Rainfall and Runoff
AWBM	Australian Water Balance Model
BOM	Bureau of Meteorology
Centennial Angus Place	Centennial Angus Place Pty Ltd
Centennial Coal	Centennial Coal Pty Limited
Centennial Springvale	Centennial Springvale Pty Limited
CRD	Cumulative rainfall departure
DGV	Default guideline value
DOC	Dissolved organic carbon
DPE	Department of Planning and Environment
DPI-Water	Department of Primary Industries – Office of Water
DTA	Direct toxicity assessment
EC	Electrical conductivity
EC_{XX}	Effective concentration for XX
EIS	Environmental impact statement
EnergyAustralia	EnergyAustralia NSW Pty Ltd
EP&A Act	Environmental Planning and Assessment Act 1979
EPA	Environment Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPL	Environment protection licence
ESA	Ecotox Services Australasia
GDE	Groundwater dependent ecosystem
GHD	GHD Pty Ltd
GMR WSP	Greater Metropolitan Region Groundwater Sources WSP
GMRU WSP	Greater Metropolitan Region Unregulated River Water Sources WSP
ha	Hectare
km	Kilometre
km^2	Square kilometre
L/s	Litre per second
LDP	Licensed discharge point

Lidsdale Siding	Lidsdale Siding Rail Loading Facility
m	Metre
m/s	Metre per second
m^3/s	Cubic metre per second
MHRDC	Maximum harvestable right dam capacity
ML	Megalitre
ML/day	Megalitre per day
ML/year	Megalitre per year
mm	Millimetre
mm/hr	Millimetre per hour
MNES	Matters of national environmental significance
MPPS	Mount Piper Power Station
Mtpa	Million tonnes per annum
NATA	National Association of Testing Authorities
NOEC	No observable effect concentration
NTU	Nephelometric turbidity units
NWQMS	National Water Quality Management Strategy
OEH	Office of Environment and Heritage
POEO Act	Protection of the Environment Operations Act 1997
RCBC	Reinforced concrete box culvert
REA	Reject emplacement area
RMS	Roads and Maritime Services
RO	Reverse osmosis
ROM	Run of mine
SCSS	Springvale Coal Services site
SDWTS	Springvale-Delta Water Trading Scheme
SEARS	Secretary's Environmental Assessment Requirements Application Number SSD 16_7592
SILO	Scientific Information for Land Owners
Springvale Coal	Springvale Coal Pty Limited
Springvale SK Kores	Springvale SK Kores Pty Ltd
SSD	State Significant Development
SSGV	Site-specific guideline values
t/year	Tonnes per year
TDS	Total dissolved solids
TKN	Total Kjeldahl nitrogen
TOC	Total organic carbon

TSS	Total suspended solids
WAL	Water access licence
WM Act	*Water Management Act 2000*
WRIA	Water Resources Impact Assessment
WSP	Water sharing plan
WTP	Water treatment plant
µS/cm	Microsiemens per centimetre

1. Introduction

Springvale Coal Pty Limited (Springvale Coal) is seeking consent for the Springvale Water Treatment Project (the Project). The Project involves the transfer of water from existing underground mine dewatering facilities for industrial reuse at Mount Piper Power Station (MPPS) to improve environmental outcomes and water quality within the upper Coxs River catchment.

GHD Pty Ltd (GHD) has been commissioned to prepare a Water Resources Impact Assessment (WRIA) for the Project. This assessment forms part of an Environmental Impact Statement (EIS) to support a State Significant Development (SSD) application for the Project under Part 4, Division 4.1 of the Environmental Planning and Assessment Act 1979 (EP&A Act). This WRIA has been prepared in accordance with relevant statutory conditions and the Secretary's Environmental Assessment Requirements Application Number SSD 16_7592 (SEARs).

1.1 Background

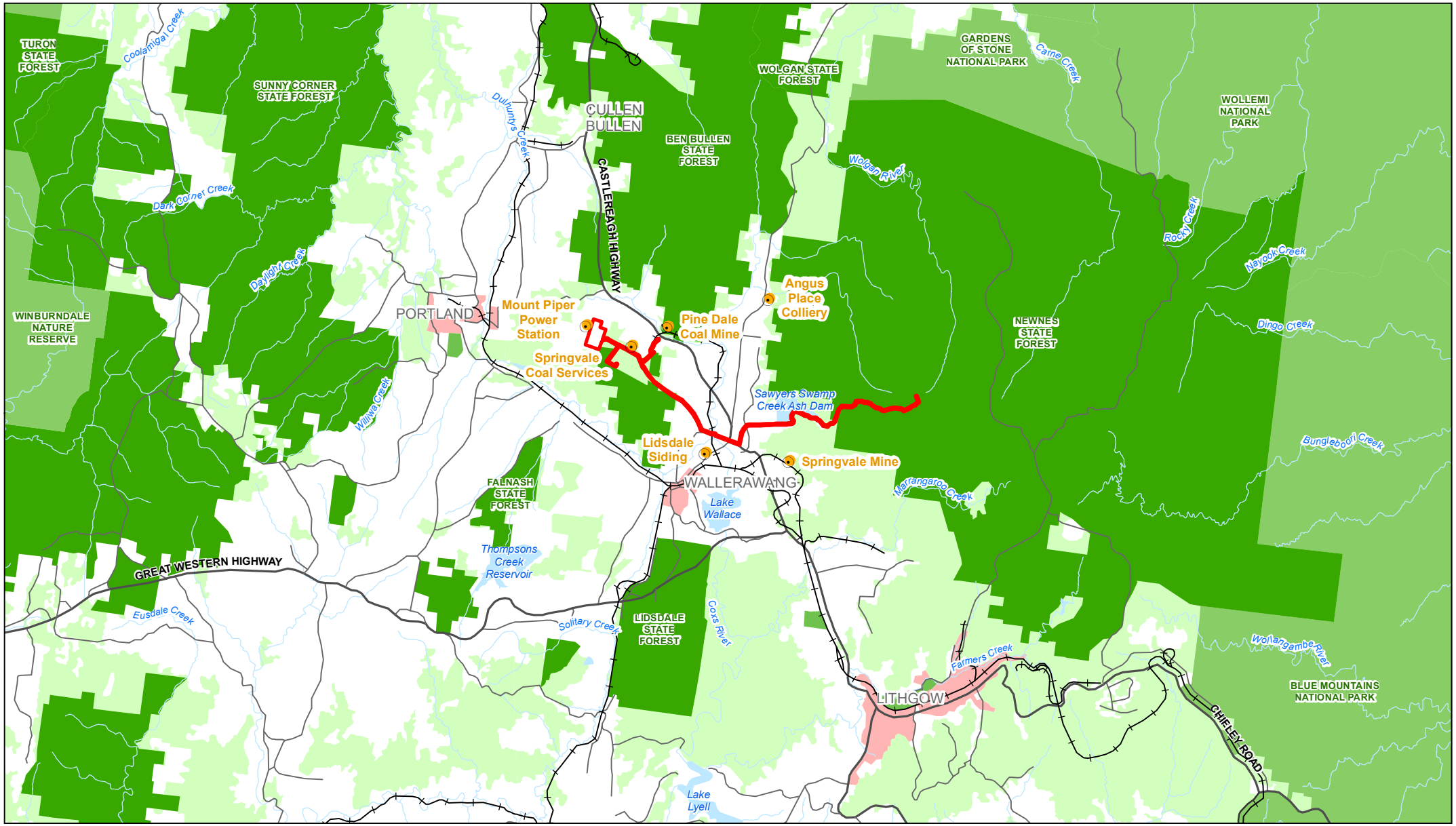
Angus Place Colliery and Springvale Mine are underground coal mining operations in the Western Coalfield of NSW near Lithgow, as shown in Figure 1-1. Angus Place Colliery is located approximately 15 km west of Lithgow and is managed by Centennial Angus Place Pty Ltd (Centennial Angus Place) under a joint venture arrangement between Centennial Springvale Pty Ltd (Centennial Springvale) and Springvale SK Kores Pty Ltd (Springvale SK Kores). Springvale Mine is located approximately 6 km south of Angus Place Colliery and is managed by Springvale Coal under a joint venture arrangement between Centennial Springvale and Springvale SK Kores.

Groundwater inflows into the underground workings at both Angus Place Colliery and Springvale Mine are transferred to the Springvale-Delta Water Transfer Scheme (SDWTS). The SDWTS consists of a pipeline network from existing dewatering facilities on the Newnes Plateau that discharges through Springvale Mine's licensed discharge point (LDP) LDP009 to Sawyers Swamp Creek within the upper Coxs River catchment. Springvale Mine is currently approved to discharge up to 30 ML/day through LDP009. Mine water from Springvale Mine is taken as a priority, with the remaining capacity supplied by mine water from Angus Place Colliery.

MPPS is a coal fired power station owned and operated by EnergyAustralia NSW Pty Ltd (EnergyAustralia), located approximately 17 km north-west of Lithgow and 8 km west of the pit top at Springvale Mine. The power station is one of the greatest users of surface water in the region, due to the significant demand for water required in the cooling water system that is subsequently lost to evaporation. Water for the operation of MPPS is currently supplied from the Coxs River via Lake Lyell and Thompsons Creek Reservoir and is supplemented by the Fish River water supply scheme.

Springvale Mine currently operates under development consent SSD-5594, granted on 21 September 2015 for the Springvale Mine Extension Project. A number of water management performance measures are specified by Schedule 4, Condition 12 of SSD-5594, including the requirement to reduce the electrical conductivity (EC) of mine water discharges to meet the following limits:

- 700 µS/cm (50th percentile), 900 µS/cm (90th percentile) and 1,000 µS/cm (100th percentile) by 30 June 2017.
- 500 µS/cm (90th percentile) by 30 June 2019.



Paper Size A4

0 0.75 1.5 3 4.5 6

Kilometers

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

N

LEGEND

- Project application area
- Principal Road
- Secondary Road
- Minor Road
- Existing Rail
- Waterway
- Waterbody
- Built up area
- Recreation area
- Nature Conservation
- State Forest
- Forest or shrub

Springvale Coal
Springvale Water Treatment Project
Water Resources Impact Assessment

Job Number 21-25109
Revision 0
Date 10 Aug 2016

Locality Plan

Figure 1-1

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Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

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Data source: Commonwealth of Australia (Geoscience Australia); 250K Topographic Data Series, 2006. Created by: tmorton

Springvale Coal and EnergyAustralia have agreed to work together to develop the Project under a joint venture. The Project involves the establishment of a pipeline and ancillary facilities to transfer water from existing or approved mine dewatering facilities on the Newnes Plateau for treatment and reuse at MPPS. The Project will achieve improved environmental outcomes for the upper Coxs River catchment and meet the water quality performance measures for mine water discharges required under development consent SSD-5594 for Springvale Mine.

1.2 Project objectives

The key objective of the Project is to improve environmental outcomes for the receiving waters in the upper Coxs River catchment. This will be achieved through:

- Treatment of all mine water to a standard suitable for either industrial reuse or environmental release.
- Maximising reuse of mine water within the MPPS cooling water system.
- Reducing the reliance on extraction of water from the upper Coxs River catchment to meet the demand for make-up water within the MPPS operations.
- Avoiding untreated mine water discharges to the environment.
- Compliance with water management performance measures required under development consent SSD-5594 for Springvale Mine.

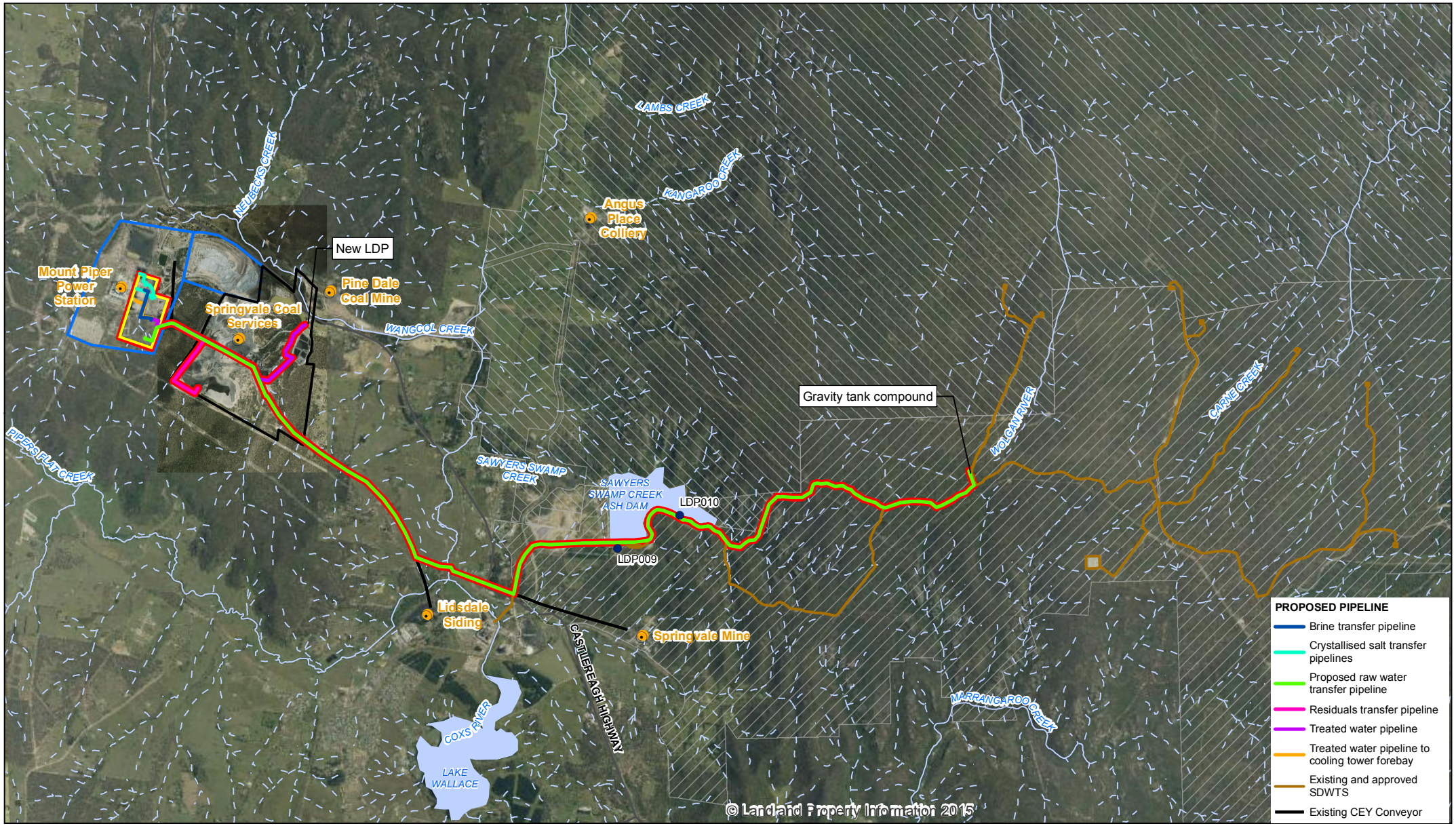
1.3 Project description

An overview of the Project is provided in Figure 1-2. The Project includes the following major elements:

- A system to transfer up to 36 ML/day of dewatered mine water from the existing gravity tank forming part of the approved dewatering facilities on the Newnes Plateau to a new water treatment plant (WTP) to be located at the MPPS site.
- A WTP incorporating desalinisation processes to reduce the salinity in mine water to a standard suitable for either industrial reuse or environmental release.
- Transfer of treated water from the WTP to the MPPS cooling water system to contribute to the demand for make-up water.
- Discharge of any excess treated water not able to be reused within the MPPS cooling water system to Wangcol Creek via a new licensed discharge point to be located within the Springvale Coal Services site (SCSS).
- Transfer of residual material from the pre-treatment process to the existing reject emplacement area (REA) at the SCSS.
- Transfer of the saline brine stream from the WTP to the MPPS cooling water system for integration with existing treatment and brine disposal practices.
- Installation of a crystalliser to provide further treatment of the additional salt load generated as a result of the WTP.

1.4 Relationship with other projects

Whilst the proponent for this Project is Springvale Coal, the Project is being undertaken through a joint venture arrangement with EnergyAustralia. The Project is interrelated with the operations at Angus Place Colliery, MPPS, the SCSS and Springvale Mine. The Project will be assessed under its own SSD application.



Paper Size A4

0 0.250.5 1 1.5 2

Kilometers

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

N

LEGEND

- Project application area
- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- Angus Place Colliery boundary
- Springvale Mining lease boundary
- Principal Road
- Watercourse - Non Perennial
- Watercourse - Perennial

Springvale Coal
Springvale Water Treatment Project
Water Resources Impact Assessment

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Revision 0
Date 10 Aug 2016

Project overview

Figure 1-2

G:\22\0105001\GIS\Maps\Deliverables\Western\Springvale\2125109\WRIA\10_3\2125109_WRIA002_Projectoverview_0.mxd

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Data source: LPI: DTDB/Imagery, 2012, 2015; Centennial: Site location, boundaries, alignment, imagery, 2016. Created by: tmorton

An Upper Coxs River Action and Monitoring Plan (UCRAMP) is being developed that considers the regional water quality and stream health objectives for the upper Coxs River catchment (upstream of Lake Lyell). The objectives of this plan are to be consistent with Schedule 4, Condition 13 of SSD-5594 and generally include:

- Regional water management measures specific to the achievement of defined mine water discharge objectives.
- Schedule of reductions in salinity that will be achieved in the future.
- Development of a monitoring program specifically associated with water quality and stream health.
- Deliver implementation status reports to regulatory authorities at key milestones.

1.5 Report objectives

The WRIA has been developed to address the water components of the SEARs, as well as state government agency requirements (refer Section 2). To satisfy the assessment requirements, a detailed assessment of potential impacts of the Project on the surface and groundwater environments was required. In broad terms, this involved an assessment of hydrology, geomorphology, water quality, hydrogeology and impacts on downstream water users.

1.6 Scope of work

The scope of work for the WRIA included:

- Review existing assessments and data relevant to the Project.
- Review relevant statutory requirements and develop impact assessment criteria.
- Establish the existing conditions for surface water and groundwater systems.
- Identify components of the Project with the potential to impact surface water and groundwater environments.
- Undertake an assessment of the potential impacts of the Project on:
  - Water and salt balance.
  - Catchment hydrology and hydraulics.
  - Waterway geomorphology.
  - Soil erosion and sedimentation.
  - Surface water quality.
  - Groundwater.
  - Licensed water users and basic landholder rights.
- Undertake an assessment of the cumulative impacts of the Project in association with other operations in the upper Coxs River catchment.
- Determine the water licensing requirements for the Project.
- Develop measures to avoid, minimise and mitigate potential impacts of the Project and provide recommended management, monitoring and reporting requirements.

1.7 Report structure

Table 1-1 provides a description of the structure of the WRIA.

Table 1-1 Report structure

Section	Content
Section 1 – Introduction	Purpose of the report and scope of work.
Section 2 – Legislation, policies and guidelines	Legislative requirements, policies and guidelines relevant to the assessment of the water management and potential impacts.
Section 3 – Site description	Description of site land use, topography, climate, soils, geology, hydrology, hydrogeology and regional setting, as well as identification of sensitive receptors.
Section 4 – Assessment methodology	Description of assessment methodology used to assess surface water and groundwater aspects of the Project.
Section 5 – Existing conditions	Outlines the existing conditions that are specific to the surface water and groundwater environments.
Section 6 – Impact assessment	Identification and quantification of the potential impacts of the Project and discussion of the risk associated with the impacts occurring.
Section 7 – Cumulative impacts	Description of how the Project will form part of a potential cumulative impact on the upper Coxs River catchment.
Section 8 – Licensing requirements	Description of the water licensing requirements for the Project.
Section 9 – Avoidance, mitigation and management measures	Description of recommended measures to avoid, minimise of mitigate potential impacts to surface water and groundwater as a result of the Project.
Section 10 – Conclusion	Summary of key findings.
Section 11 – References	A list of the documents referenced within this report.

2. Legislation, polices and guidelines

2.1 Legislation

2.1.1 Environment Protection and Biodiversity Conservation Act 1999

The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) is administered by the Commonwealth Department of the Environment and provides a legal framework to protect and manage nationally and internationally significant flora, fauna, ecological communities and heritage places defined as 'matters of national environmental significance' (MNES). Any action that "has, will have or is likely to have a significant impact on a matter of national environmental significance" is deemed to be a 'controlled action' and may not be undertaken without prior approval from the Commonwealth Environment Minister, as provided under Part 9 of the EPBC Act. Approval is also required where actions are proposed on, or will affect, Commonwealth land and its environment.

The EPBC Act identifies MNES as:

- World heritage properties.
- National heritage places.
- Wetlands of international importance (Ramsar wetlands).
- Threatened species and ecological communities.
- Migratory species.
- Commonwealth marine areas.
- Nuclear actions (including uranium mining).
- Great Barrier Reef Marine Park.
- A water resource in relation to coal seam gas development and large coal mining development.

The EPBC Act is also relevant to the determination of the ecological value of a groundwater dependent ecosystem (GDE). If a GDE contains a threatened species as listed under the EPBC Act, the GDE is then taken to have a higher ecological value.

Potential impacts on any MNES are subject to assessments of significance pursuant to the EPBC Act Significant Impact Guidelines 1.1 (Department of the Environment, 2013a). If a significant impact is considered likely, a referral under the EPBC Act must be submitted to the Commonwealth Environment Minister.

The Significant Impact Guidelines 1.3 (Department of the Environment, 2013b) includes general criteria for whether an action is likely to have a significant impact on water resources, which are for the possibility for direct or indirect changes to:

- The hydrology of a water resource.
- The water quality of a water resource.

According to the Significant Impact Guidelines 1.3 (Department of the Environment, 2013b), the value of the water resource needs to be confirmed such that impacts from actions can be evaluated on their significance. The guidelines indicate that key factors for evaluating a water resource's value include its utility for all third party users. Third party user categories specific 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).
- Supporting services (e.g. maintenance of ecosystem function).

If evidence can be provided that proposed actions would not materially affect the availability and quality for third party users, then the likelihood of an action having a significant impact would be reduced (Department of the Environment, 2013b).

An assessment of whether the Project may have a significant impact on any MNES or on the environment of Commonwealth land was undertaken during the EIS investigations and preparation. The Significant Impact Guidelines 1.3 (Department of the Environment, 2013b) states that the development of associated infrastructure, such as pipelines and environment protection, monitoring and associated land management activities, that is not part of the extraction process does not need to be referred for its impacts on a water resource. As the Project involves a water transfer and treatment system that is not part of the extraction process of a large coal mining development, it was determined that the Project did not need to be referred under the EPBC Act. As the Project will not be referred, the review of the Project by the Independent Expert Scientific Committee (IESC) will not be required. Regardless of this the assessment of the Project was undertaken considering the typical IESC requirements and guidelines for assessing potential impact to water resource in relation to coal seam gas development and large coal mining development.

The significant impact guideline and IESC checklist were completed and provided in Appendix A

2.1.2 Environmental Planning and Assessment Act 1979

The EP&A Act, which is administered by the NSW Department of Planning and Environment (DPE), is the core legislation relating to planning and development activities in NSW and provides the statutory framework under which development proposals are assessed. The EP&A Act aims to encourage the proper management, development and conservation of resources, environmental protection and ecologically sustainable development.

The WRIA forms part of an EIS to support an application under Part 4, Division 4.1 of the EP&A Act for the Project. The Minister for Planning and Environment (or delegate, such as the NSW Planning Assessment Commission) is the determining authority for the Project.

The WRIA report address the following component of the SEARs specific to water:

"Water – including an assessment of the likely impacts of the development on the quantity and quality of the region's surface and groundwater resources, particularly having regard to State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 and the requirements and recommendations from EPA, DPI, OEH and WaterNSW."

State government agency requirements from the NSW Environment Protection Authority (EPA), Department of Primary Industries – Office of Water (DPI-Water), Office of Environment and Heritage (OEH) and WaterNSW addressed in the WRIA report are presented in Appendix A.

2.1.3 Protection of the Environment Operations Act 1997

The Protection of the Environment Operations Act 1997 (POEO Act) is administered by the EPA, which is an independent statutory authority and the primary environmental regulator for NSW. The objectives of the POEO Act are to protect, restore and enhance the quality of the environment. Some of the mechanisms that can be applied under the POEO Act to achieve these objectives include programs to reduce pollution at the source and monitoring and reporting on environmental quality. The POEO Act regulates and requires licensing for environmental protection, including for waste generation and disposal and for water, air, land and noise pollution.

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. Licence conditions relate to pollution prevention and monitoring and can control the air, noise, water and waste impacts of an activity.

The Project is a scheduled activity under the POEO Act and will require a new EPL to be issued for the Project's operations. This EPL will cover water treatment of groundwater activities (system capacity greater than 100 ML/year) under Schedule 1 of the POEO Act and propose a new LDP for water discharged to Wangcol Creek.

Further discussion of the licensing conditions of existing operations within the Wangcol Creek catchment is provided in Section 3.7.

2.1.4 Water Management Act 2000

The Water Act 1912 has historically been the main legislation for managing water resources in NSW, however is currently being progressively phased out and replaced by water sharing plans (WSPs) under the Water Management Act 2000 (WM Act). Once a WSP commences, existing licences under the Water Act 1912 are converted to water access licences (WALs) and to water supply works and use approvals under the WM Act.

The aim of the WM Act is to ensure that water resources are conserved and properly managed for sustainable use benefiting both present and future generations. It is also intended to provide formal means for the protection and enhancement of the environmental qualities of waterways and in-stream uses as well as to provide for protection of catchment conditions.

Water sharing plans

Fresh water sources throughout NSW are managed via WSPs under the WM Act. Provisions within WSPs provide water to support the ecological processes and environmental needs of GDEs and waterways. WSPs also provide how the water available for extraction is shared between the environment, basic landholder rights, town water supplies and commercial uses. Key rules within the WSPs specify when licence holders can access water and how water can be traded.

The following two WSPs made under Section 50 of the WM Act are relevant to the Project:

- Greater Metropolitan Region Unregulated River Water Sources WSP (GMRU WSP).
- Greater Metropolitan Region Groundwater Sources WSP (GMR WSP).

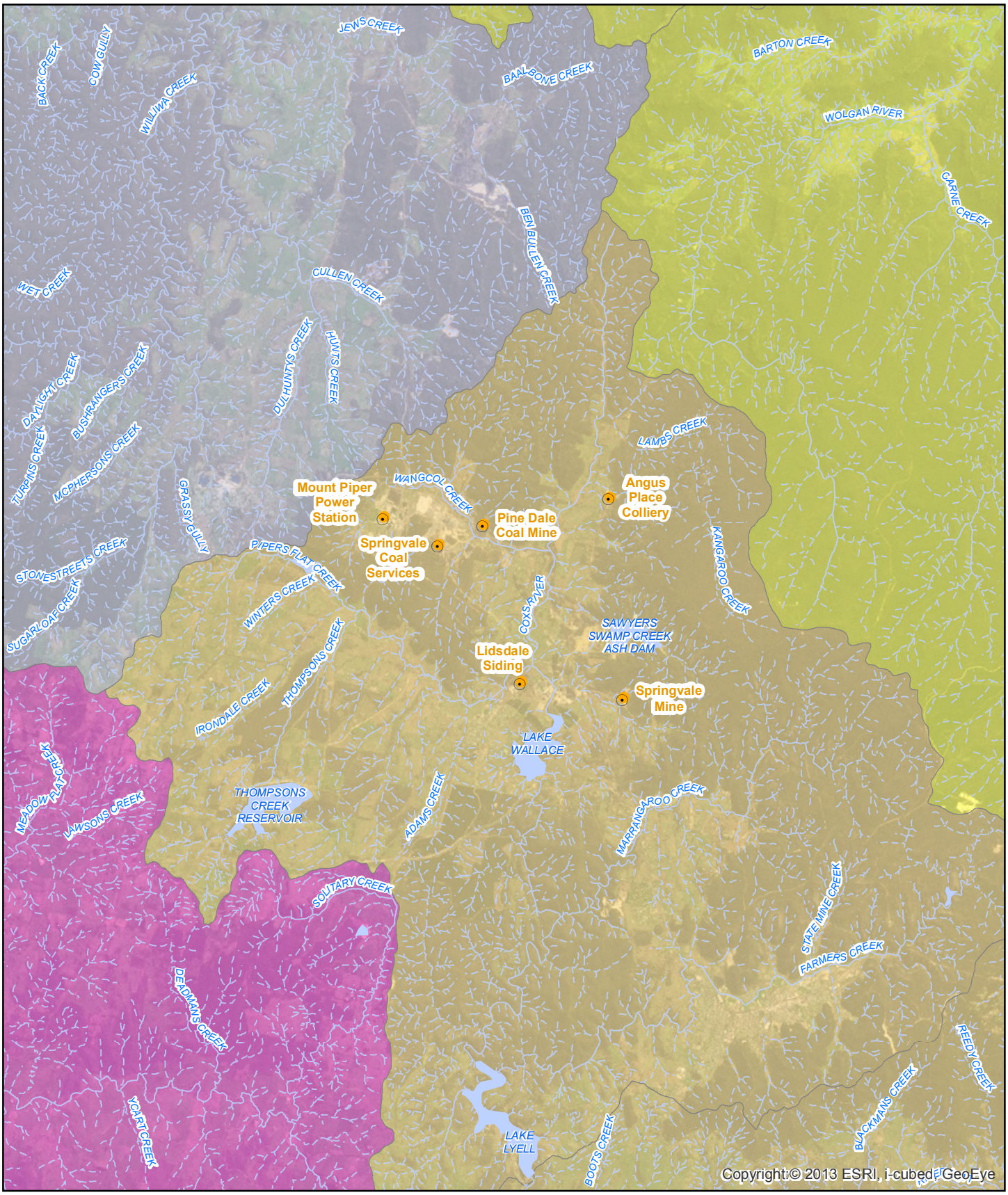
Figure 2-1 and Figure 2-2 present the WSP boundaries for surface water and groundwater respectively.

Greater Metropolitan Region Unregulated River Water Sources Water Sharing Plan

For surface water, the Project is located within the GMRU WSP, which became operational in July 2011. This WSP covers six water sources which are made up of a total of 87 management zones. The Project is located within the Wywandy Management Zone of the Upper Nepean and Upstream Warragamba Water Source.

Greater Metropolitan Region Groundwater Sources Water Sharing Plan

For groundwater, the Project is located within the GMR WSP, which became operational in July 2011. This WSP covers 13 groundwater sources on the east coast of NSW. The Project is located within the Sydney Basin Coxs River Groundwater Source.



LEGEND

- Watercourse - NonPerennial
- Watercourse - Perennial
- Waterbody

Macquarie Bogan Unregulated and Alluvial Water Sources WSP boundary

- Turon Crudine River Water Source
- Fish River Water Source

Greater Metropolitan Region Unregulated River Water Sources WSP boundary

- Hawkesbury and Lower Nepean Rivers Water Source
- Upper Nepean and Upstream Warragamba Water Source

Paper Size A4

0 700 1,400 2,800 4,200 5,600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Springvale Coal
Springvale Water Treatment Project
Water Resources Impact Assessment

Water sharing plan boundaries
Surface water

Job Number 21-25109
Revision 0
Date 10 Aug 2016

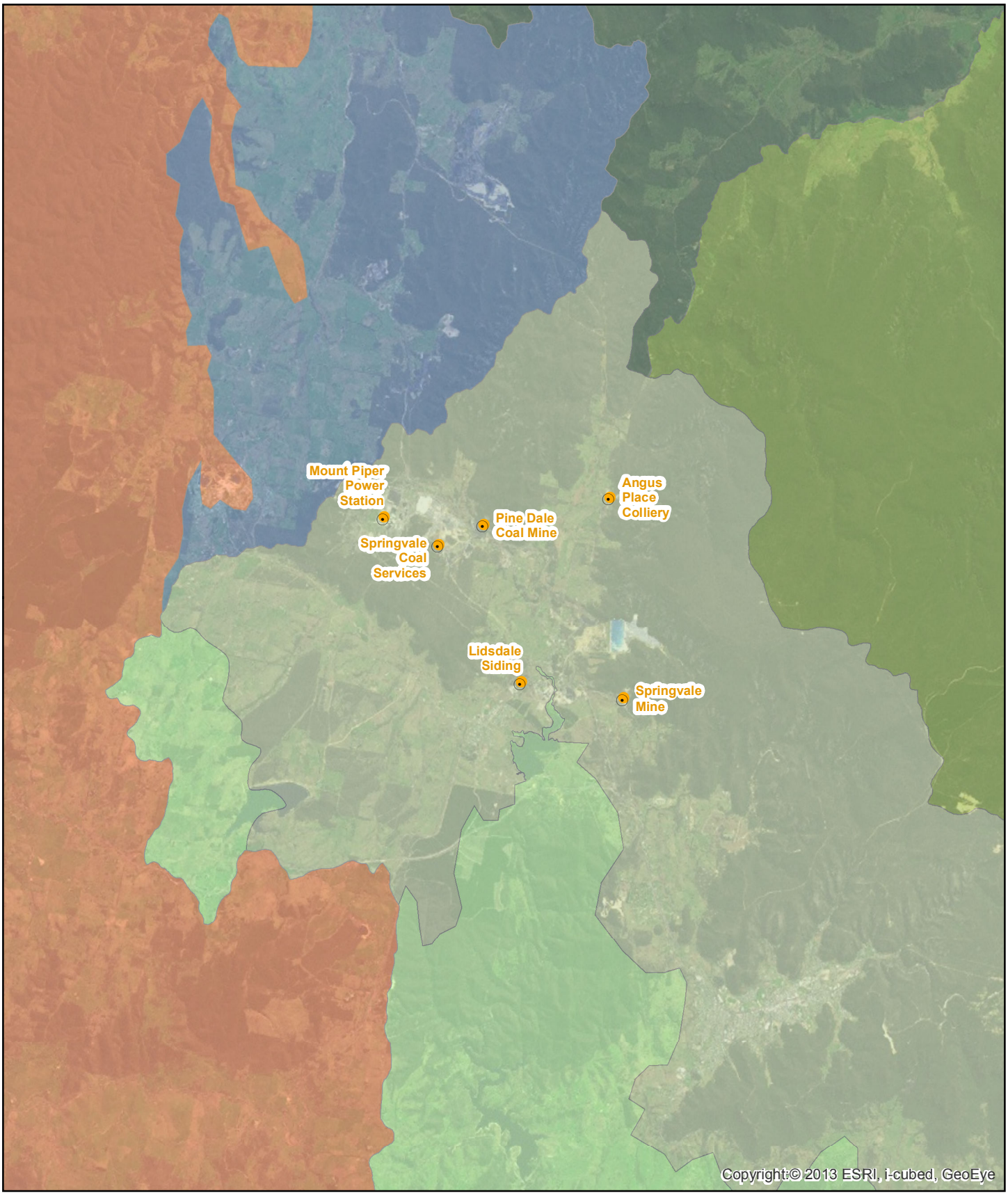
Figure 2-1

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

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Data source: © NSW Office of Water: Groundwater Data, 2013; ESRI: Aerial Imagery, 2009; Centennial: Site location, 2016. Created by: tmorton



LEGEND

Greater Metropolitan Region Groundwater Sources WSP boundary

- Coxs River Fractured Rock Groundwater Source
- Sydney Basin Coxs River Groundwater Source
- Sydney Basin Richmond Groundwater Source
- Sydney Basin North Groundwater Source

NSW Murray Darling Basin Fractured Rock Groundwater Sources WSP boundary

- Lachlan Fold Belt MDB Groundwater Source

NSW Murray Darling Basin Porous Rock Groundwater Sources WSP boundary

- Sydney Basin MDB Groundwater source

Paper Size A4

0 625 1,250 2,500 3,750 5,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Springvale Coal
Springvale Water Treatment Project
Water Resources Impact Assessment

Water sharing plan boundaries Groundwater

Job Number 21-25109
Revision 0
Date 10 Aug 2016

Figure 2-2

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Data source: © NSW Office of Water: Groundwater Data, 2013; ESRI: Aerial Imagery, 2009; Centennial: Site location, 2016. Created by: tmorton

Basic landholder rights

Under the WM Act, extraction of water for basic landholder rights is protected by allocating and prioritising water for basic landholder rights. There are three types of basic landholder rights in NSW under the WM Act:

- Domestic and stock rights.
- Native title rights.
- Harvestable rights.

Domestic and stock rights

Landholders are entitled to take water from a river, estuary or lake which fronts their land or from an aquifer which is underlying their land for domestic consumption and stock watering, without the need for a licence. However, a water supply work approval is required to construct a dam or a groundwater bore.

Native title rights

Anyone who holds native title with respect to water, as determined by the *Native Title Act 1993*, can take and use water for a range of purposes, including personal, domestic and non-commercial communal purposes. There are no native title rights in the GMRU WSP or GMR WSP and therefore this type of basic landholder rights has not been considered in the WRIA.

Harvestable rights

Landholders are entitled to collect a portion of runoff from their property and store it in one or more dams up to a certain size, known as a 'harvestable right', which is determined from the total contiguous area of land ownership. In the Central and Eastern Divisions of NSW (where the Project is located), landholders may capture and use up to 10% of the average regional rainfall runoff for their property without requiring a licence under the WM Act. The maximum harvestable right is the total volume of rainfall runoff that a landholder is entitled to use without requiring a licence. If the maximum harvestable right for a site is exceeded, licensing for the volume of water extracted from the surface water source exceeding the harvestable right is required under the WM Act.

The guidelines for determining the maximum harvestable right dam capacity (MHRDC) indicate that the following dams are exempt from the calculation of the MHRDC and do not require a licence (NOW, 2010):

- Dams for the control or prevention of soil erosion.
- Dams for the capture, containment and recirculation of drainage.
- Dams without a catchment.

The proposed surface water storages that are part of the Project all fall into one of the above categories and therefore do not require licensing under the WM Act.

Activity approvals

Any works within the defined riparian zone of a creek are to be carried out in accordance with the WM Act. Works undertaken on waterfront land (i.e. near a river, lake or estuary) require a controlled activity approval, unless defined as exempt. Controlled activity approvals are not required for projects that are defined as SSDs and as such no controlled activity approvals will be required for any aspect of the Project. However, DPI-Water may be consulted in relation to proposed activities within existing riparian corridors, such as construction works, which would provide a means of determining the suitability of engineering controls and general mitigation measures.

It is unlikely that pipeline trenching and boring activities will intercept significant groundwater volumes, however, during construction in the event that significant groundwater is intercepted, then an aquifer interference approval will be sought through DPI-Water.

Water access licences

Table 2-1 provides details for the WALs currently held by Angus Place Colliery and Springvale Mine under the WM Act, which licence the extraction of groundwater for the dewatering of underground workings.

Table 2-1 Water access licences held by Angus Place Colliery and Springvale Mine

Site	WAL number	Extraction limit (ML/year)
Angus Place Colliery	WAL 36449	2,523
	WAL 36445	2,701
	WAL 37340	329
	WAL 37343	35
Springvale Mine	WAL 36383	5,958
	WAL 36443	585
	WAL 36446	3,300

EnergyAustralia currently holds WAL 27428 under the GMRU WSP for the extraction of surface water from the Coxs River within the Upper Nepean and Upstream Warragamba Water Source up to 23,000 ML/year.

WaterNSW currently holds WAL 36230 for the Fish River water supply scheme under the Macquarie Bogan Unregulated and Alluvial Water Sources WSP. This WAL allows for the extraction of up to 15,876 ML/year from the Fish River Water Source, with up to 8,184 ML/year supplied to EnergyAustralia.

There are no proposed modifications to any WALs as part of the Project.

2.1.5 Water NSW Act 2014

The Water NSW Act 2014 defines the functions and objectives of WaterNSW, which was formed in 2015 by the merger of the Sydney Catchment Authority and State Water Corporation. WaterNSW is Australia's largest water supplier and NSW's major supplier of raw water. The Act specifically sets the objectives:

- To capture, store and release water in an efficient, effective, safe and financially responsible manner.
- To supply water in compliance with appropriate standards of quality.
- To ensure that declared catchment areas and water management works in such areas are managed and protected so as to promote water quality, the protection of public health and public safety and the protection of the environment.
- To provide for the planning, design, modelling and construction of water storages and other water management works.

- To maintain and operate the works of WaterNSW efficiently and economically and in accordance with sound commercial principles.

The functions of WaterNSW under the Act that are specific to the Project are:

- Construct, maintain and operate water management works (including providing or constructing systems or services for supplying water).
- Protect and enhance the quality and quantity of water in declared catchment areas.
- Manage and protect declared catchment areas and water management works vested in or under the control of WaterNSW that are used within or for the purposes of such areas
- Undertake flood mitigation and management.
- Undertake research on catchments generally, and in particular on the health of declared catchment areas.
- To undertake an educative role within the community.

The Project involves discharge of water within the upper Coxs River catchment, which is part of the Sydney drinking water catchment. WaterNSW, under this Act, is required to manage this catchment with respect to protection of catchment areas and water management works.

2.2 Policies

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

The State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 replaced the Drinking Water Catchments Regional Environmental Plan No. 1 and specifically requires all proposed developments in the Sydney drinking water catchment to demonstrate a neutral or beneficial effect (NorBE).

The management of the drinking water catchment is undertaken through WaterNSW, which have identified the following series of principles for managing mining impacts:

- Mining activities must not result in a reduction in the quantity of surface and groundwater inflows to storages or loss of water from storages or their catchments.
- Mining activities must not result in a reduction in the quality of surface and groundwater inflows to storages.
- Mining activities must not pose increased risks to human health as a result of using water from the drinking water catchments.
- The integrity of the WaterNSW's water supply infrastructure must not be compromised.
- The ecological integrity of the Special Areas must be maintained and protected.
- Information provided by proponents, including environmental impact assessments for proposed mining, must be detailed, thorough, scientifically robust and holistic. The potential cumulative impacts must be comprehensively addressed.

In response to the WaterNSW principles, the WRIA will detail how the Project will address potential impacts to quantity and quality of surface water. As there are no components of WaterNSW water supply infrastructure or Special Areas present within or surrounding the Project, it is unlikely that the Project will impact upon these.

2.2.2 NSW State Rivers and Estuary Policy

The NSW State Rivers and Estuary Policy (NSW Water Resource Council, 1993) recognises the need for improved management of rivers for economic and social users in the long-term through development of competent policies and river (and estuary) resource information studies. The Policy recognises the impacts of land degradation on water quality with a total catchment management approach. The Policy also provides consideration for the condition of physical and biological functions including water chemistry, geomorphology, vegetation and invertebrate and vertebrate biota.

The NSW State Rivers and Estuary Policy (NSW Water Resource Council, 1993) provides an initial set of 10 component policies (five broad ecosystem categories and five system-wide management specific policies). The component policies are developed to address improvement to and prevention of further damage or degradation to biological or physical functions. It is not intended to closely prescribe the contents of each catchment component policy, although it is important for each policy to match the specific needs for which it is being designed.

The Policy specifies responsibility is shared between government, landholders and resource users. The component policies developed by NSW Government will commit agencies to the review and modification of related regulatory and operational activities and support rehabilitation and management programs.

2.2.3 NSW Aquifer Interference Policy

The NSW Aquifer Interference Policy was finalised in September 2012 and clarifies the water licensing and approval requirements for aquifer interference activities in NSW, including the taking of water from an aquifer in the course of carrying out mining.

The Policy outlines the water licensing requirements under the *Water Act 1912* and WM Act. A water licence is required whether water is taken for consumptive use or whether it is taken incidentally by the aquifer interference activity (such as groundwater filling a void), even where that water is not being used consumptively as part of the activity's operation. Under the WM Act, a water licence gives its holder a share of the total entitlement available for extraction from the groundwater source. The WAL must hold sufficient share component and water allocation to account for the take of water from the relevant water source at all times.

Sufficient access licences must be held to account for all water taken from a groundwater or surface water source as a result of an aquifer interference activity, both for the life of the activity and after the activity has ceased. Many mining operations continue to take water from groundwater sources after operations have ceased. This take of water continues until an aquifer system reaches equilibrium and must be licensed.

The NSW Aquifer Interference Policy requires that potential impacts on groundwater sources, including their users and GDEs, be assessed against minimal impact considerations, outlined in Table 1 of the Policy. If the predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered as acceptable.

The Level 1 minimal impact considerations for less productive groundwater sources are relevant to the groundwater sources at Centennial sites and are as follows:

- *Water table*: less than or equal to 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 m from any high priority GDE or high priority culturally significant site listed in the schedule of the relevant WSP. A maximum of a 2 m decline cumulatively at any water supply work unless make good provisions should apply.

- Water pressure: a cumulative pressure head decline of not more than 40% of the 'post-water sharing plan' pressure head above the base of the water source to a maximum of a 2 m decline at any water supply work.
- Water quality: any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity. For alluvial water sources, there should be no increase of more than 1% per activity in the long-term average salinity in a highly connected surface water source at the nearest point to the activity.

It is not proposed to modify the existing groundwater extraction activities of Angus Place Colliery or Springvale Mine as part of the Project. During construction works, however, if groundwater is encountered as result of excavation or drilling, the policy would be applicable.

2.2.4 NSW State Groundwater Policy

The objective of the NSW State Groundwater Policy Framework Document (NSW Government, 1997) is to manage the State's groundwater resources so that they can sustain environmental, social and economic uses for the people of NSW. The NSW groundwater policy has three component parts:

- NSW Groundwater Quantity Management Policy.
- NSW Groundwater Quality Protection Policy.
- NSW Groundwater Dependent Ecosystems Policy.

NSW Groundwater Quantity Management Policy

The principles of this policy include:

- Maintain total groundwater use within the sustainable yield of the aquifer from which it is withdrawn.
- Groundwater extraction shall be managed to prevent unacceptable local impacts.
- All groundwater extraction for water supply is to be licensed. Transfers of licensed entitlements may be allowed depending on the physical constraints of the groundwater system.

NSW Groundwater Quality Protection Policy

The objective of this policy is the ecologically sustainable management of the State's groundwater resources so as to:

- Slow and halt, or reverse any degradation in groundwater resources.
- Direct potentially polluting activities to the most appropriate local geological setting so as to minimise the risk to groundwater.
- Establish a methodology for reviewing new developments with respect to their potential impact on water resources that will provide protection to the resource commensurate with both the threat that the development poses and the value of the resource.
- Establish triggers for the use of more advanced groundwater protection tools such as groundwater vulnerability maps or groundwater protection zones.

NSW Groundwater Dependent Ecosystems Policy

This policy was designed to protect ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependent ecosystems are maintained or restored for the benefit of present and future generations.

2.3 Guidelines

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

The National Water Quality Management Strategy (NWQMS) provides a national framework for improving water quality in Australia's waterways. 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 Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000a) is a benchmark document of the NWQMS which provides a guide for assessing and managing ambient water quality in a wide range of water resource types and according to specified environmental values, such as aquatic ecosystems, primary industries, recreation and drinking water. ANZECC (2000a) provide a framework for determining appropriate guideline values or performance criteria to evaluate the results of water quality monitoring programs.

The ANZECC (2000a) guidelines adopt a risk-based approach to assessing ambient water quality by providing the framework to tailor water quality guidelines to local environmental conditions. Guideline values provided by ANZECC (2000a) can be modified into regional, local or site-specific guideline values (SSGVs) by taking into account factors such as the variability of the particular ecosystem, soil types, rainfall and level of exposure to contaminants. It should be noted that guideline values are applied to the receiving environment at the edge of the mixing zone and do not apply to mine water discharges.

2.3.2 Australian Guidelines for Water Quality Monitoring and Reporting

The Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC, 2000b) is a benchmark document of the NWQMS that relates closely to the water quality guidelines (ANZECC, 2000a). These guidelines provide a nationally accepted framework for undertaking monitoring and reporting of water quality that applies to freshwater, marine waters and groundwater.

2.3.3 Australian Drinking Water Guidelines

The Australian Drinking Water Guidelines (ADWGs) (NHMRC, 2016) provide a framework for the appropriate management of drinking water supplies to achieve a safe and appropriate point of supply. The guidelines provide a base standard for aesthetic and health water quality levels. WaterNSW have used the ADWGs as the agreed level of service for any operation within the Sydney drinking water catchment.

Where ADWG levels are higher than the ANZECC (2000a) guideline levels, the most stringent of values between the two guidelines has been considered in the assessment. Characterisation of surface water quality has been assessed using the ANZECC (2000a) framework. Both guidelines and their application to the Project have been discussed in Section 5.5 and Section 6.5.

2.3.4 Approved Methods for the Sampling and Analysis of Water Pollutants in NSW

The document Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (EPA, 2004) lists the sampling and analysis methods to be used when acquiring water samples for compliance with environmental protection legislation, a relevant licence or relevant notice.

2.3.5 Managing Urban Stormwater: Soils and Construction

The document Managing Urban Stormwater: Soils and Construction – Volume 1 (Landcom, 2004) outlines the basic principles for the design and construction of sediment and erosion control measures. This document relates particularly to urban development sites; however, it is relevant to the Project as it provides guidance on the configuration of erosion and sedimentation controls required during construction.

Managing Urban Stormwater: Soils and Construction – Volume 2E (DECC, 2008) is a companion document to Volume 1. It provides specific guidelines, principles and minimum design standards for good management practice in erosion and sediment control during the construction and operation of mines and quarries.

The mitigation measures will use the recommendations and guidelines from both Volume 1 and Volume 2E of Managing Urban Stormwater: Soils and Construction to assess the sediment control structures for adequacy in capturing and detaining sediment-laden runoff.

2.3.6 Managing Urban Stormwater: Source Control

The intent of Managing Urban Stormwater: Source Control (EPA, 1998) is to provide guidance to local and state government agencies and developers, as well as community and business groups, on a range of source control (water quality and quantity) techniques that can be adopted to minimise impacts of works on surface water environments. It highlights the need for pollutant control using sustainable cost effective methods such as swales, wet basins, dry basins and gross pollutant traps. This document provides guidance for the Project on the selection of suitable source control measures for surface water management.

2.3.7 Managing Urban Stormwater: Treatment Techniques

The aim of Managing Urban Stormwater: Treatment Techniques (EPA, 1997) is to provide guidance to stormwater planners and designers on the selection and functional or conceptual design of a range of structural stormwater quality management practices, known as stormwater treatment measures.

The first step in design of stormwater treatment measures is to establish the site-specific objectives including water quality and ecosystem requirements. The design should consider impacts to the environment at the installation site including water quality and disruption to the ecosystem.

It is important to note that stormwater treatment measures are generally not intended to effectively treat all catchment runoff. The common goal is to provide effective treatment up to a certain flow level, with lower or negligible treatment provided for flows beyond this level. It is important that the majority of the pollutants trapped during flows less than the design level are not lost during higher flows.

2.3.8 Risk Assessment Guidelines for Groundwater Dependent Ecosystems

Risk Assessment Guidelines for Groundwater Dependent Ecosystems (NOW, 2012a) comprises four volumes and provides a conceptual framework for identifying and assessing ecosystems along with worked examples of assessments and discusses the identification of high probability GDEs and also discussed the ecological value of GDEs. The results from this assessment will be used by others to assess potential impacts of GDEs.

2.3.9 Controlled activities on waterfront land

As discussed in Section 2.1.4, works undertaken on water front land (i.e. near a river, lake or estuary) require a controlled activity approval, unless they are defined as exempt. DPI-Water has developed Guidelines for Instream Works on Waterfront Land (NOW, 2012b) and Guidelines for Riparian Corridors on Waterfront Land (NOW, 2012c), which provide recommendations for the design and construction of instream works and an indication of the width of riparian zones to be considered. The guidelines focus on the following key requirements:

- Maintaining the natural geomorphic processes through the accommodation of the existing waterway, allow for natural movement of sediment, woody debris and not allowing for an increase or the creation of scour and erosion within the existing waterway.
- Maintain the existing waterway's hydrologic function through accommodation of low flows and not altering the natural bank full or flood flows.
- The use of scour protection when required for the protection of existing banks, using placed rock.
- Visual inspections and maintenance on the waterway during the works.

2.3.10 Guidelines for Groundwater Protection in Australia

The Guidelines for Groundwater Protection in Australia (ANZECC, 1995) are part of the NWQMS. The objective of these guidelines is to provide a national framework for the protection of groundwater from contamination. The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000a) are identified as a reference for identifying water quality criteria for developing a strategy for protecting groundwater and the aquatic ecosystem to meet a desired end point.

Protection of groundwater is generally easier when the source of contamination is concentrated at a point rather than spread over a broad area. Additionally, environmental protection measures have been developed to manage and minimise pollution from production of waste. These measures for protecting groundwater include waste avoidance, waste reuse, recycling and waste treatment.

Other groundwater protection strategies can include monitoring and review of performance of protection measures.

2.3.11 Guidelines for the Assessment and Management of Groundwater Contamination

The Guidelines for the Assessment and Management of Groundwater Contamination (DEC, 2007) outline a best practice framework for assessing and managing contaminated groundwater in NSW. The guidelines adopt the approach for preliminary assessment of potential source of contamination from current activities, determining natural background water quality, assessing receptors and exposure pathways and managing groundwater contamination (if required). The guidelines refer groundwater assessment to be compared with the NWQMS.

2.3.12 NSW Government Water Quality and River Flow Objectives

The NSW Government Water Quality and River Flow Objectives (DEC, 2006) are the agreed environmental values and long-term goals for NSW's surface waters. Water quality objectives have been agreed for fresh and estuarine surface waters and are consistent with the agreed national framework for assessing water quality set out in the ANZECC (2000a) guidelines and uses these guidelines for strategic planning and assessing impacts of developments at a local level. From this assessment risks and threats to water quality can be identified and prioritised for management plans and on-ground investment to manage water quality 'hot-spots'.

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.

The water quality objectives are consistent with and complementary to the state-wide targets developed by the Natural Resources Commission and Catchment Management Authorities for managing natural resources and to work towards long-term improvement goals. The NSW Government Water Quality and River Flow Objectives (DEC, 2006) refers stakeholders to booklet summarising the components in the ANZECC (2000a) guidelines which is designed for technical practitioners applying the guidelines in NSW.

3. Site description

3.1 Land use

The Project is located on the western slopes of the north-south oriented sandstone ridgeline of the Great Dividing Range, to the west of the Wollemi and Blue Mountains national parks. The nearest large regional urban centre is Lithgow, with other nearby residential areas including Wallerawang, Portland and Cullen Bullen. The region consists primarily of undulating hills and mountain tops, with some low lying areas. These low-lying areas have been cleared of natural vegetation for agricultural, commercial and industrial purposes, including coal and shale mining, forestry and power generation. There are a number of national parks and state forests in the region, including Ben Bullen State Forest and Wolgan State Forest to the north of the Project and the Newnes State Forest to the east.

Key operations in the vicinity of the Project include:

- Angus Place Colliery (care and maintenance).
- Lidsdale Siding Rail Loading Facility (Lidsdale Siding).
- MPPS.
- Pine Dale Coal Mine (care and maintenance).
- Springvale Coal Services.
- Springvale Mine.
- Wallerawang Power Station (decommissioned).

Surrounding sites are discussed in detail with respect to their operation and their relevance to the Project within Section 3.7. The potential cumulative impact of existing sites and the proposed Project within the Wangcol Creek and Coxs River catchments is discussed within Section 7.

3.2 Topography

The topography around Springvale Mine comprises narrow gorges with high ridgelines and steep-sided slopes of sandstone cliffs. The cliffs rise above incised valleys and hilly areas with relatively flat crests and some spurs with moderately sloped ephemeral drainage lines. Rivers and streams, such as Coxs Creek and Kangaroo Creek, are found in the vicinity.

The proposed pipeline alignment is located partially within the Newnes Plateau, which forms part of the divide between the Coxs River and Wolgan River catchments with elevations ranging from 900 m Australian Height Datum (AHD) to greater than 1,175 m AHD.

The local topography at MPPS and the SCSS is on a northern aspect with elevations ranging from 900 m AHD to 985 m AHD in the south. The catchments of Lamberts Gully and Huon Gully drain through the SCSS to Wangcol Creek. MPPS similarly also has catchment from the south contributing to Wangcol Creek. The headwaters of Wangcol Creek are up to 1,060 m AHD in the south-west.

3.3 Climate

3.3.1 Rainfall

Annual rainfall

Daily rainfall data was obtained from the Scientific Information for Land Owners (SILO) database operated by the Queensland Department of Science, Information Technology and Innovation. SILO patched point data is based on historical data from a particular Bureau of Meteorology (BOM) station with missing data 'patched in' with interpolations from nearby stations.

For this assessment, SILO data was obtained for Lithgow (Birdwood St) Station (station number 63224) which is located approximately 13 km south-east of the proposed WTP site. This station was chosen based on the length and quality of the data record and proximity to the Project.

The period of rainfall data extended from January 1889 to December 2015 and is summarised as annual totals in Figure 3-1. The statistics for this rainfall set are:

- Minimum annual rainfall – 447 mm in 1944.
- Average annual rainfall – 862 mm.
- Median annual rainfall – 853 mm.
- Maximum annual rainfall – 1,683 mm in 1950.

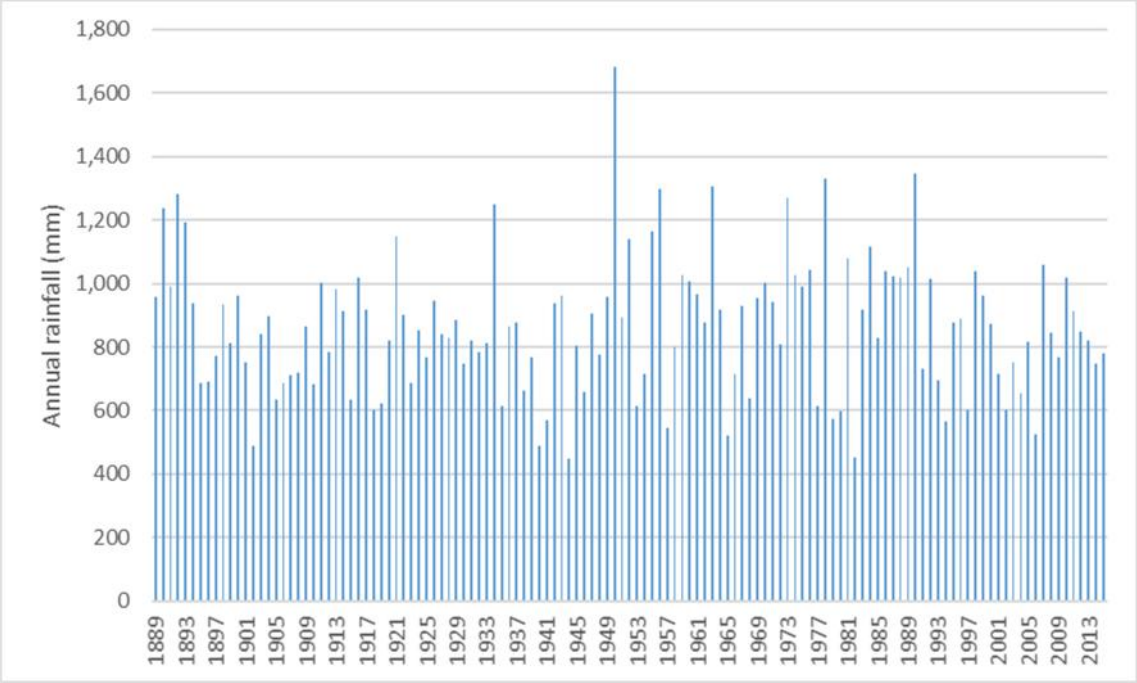


Figure 3-1 Annual rainfall recorded at Lithgow (Birdwood St) Station

Monthly rainfall

The monthly rainfall statistics were also determined for the period of record from the Lithgow (Birdwood St) station and are provided in Figure 3-2. The average monthly rainfall was observed to vary from a low of approximately 57 mm in September to a high of approximately 93 mm in January. Figure 3-2 shows a significant variation in the maximum recorded monthly rainfall with the maximum monthly value being approximately 374 mm in August and the lowest monthly value being approximately 196 mm in September. The minimum monthly rainfall is less than 10 mm for all months.

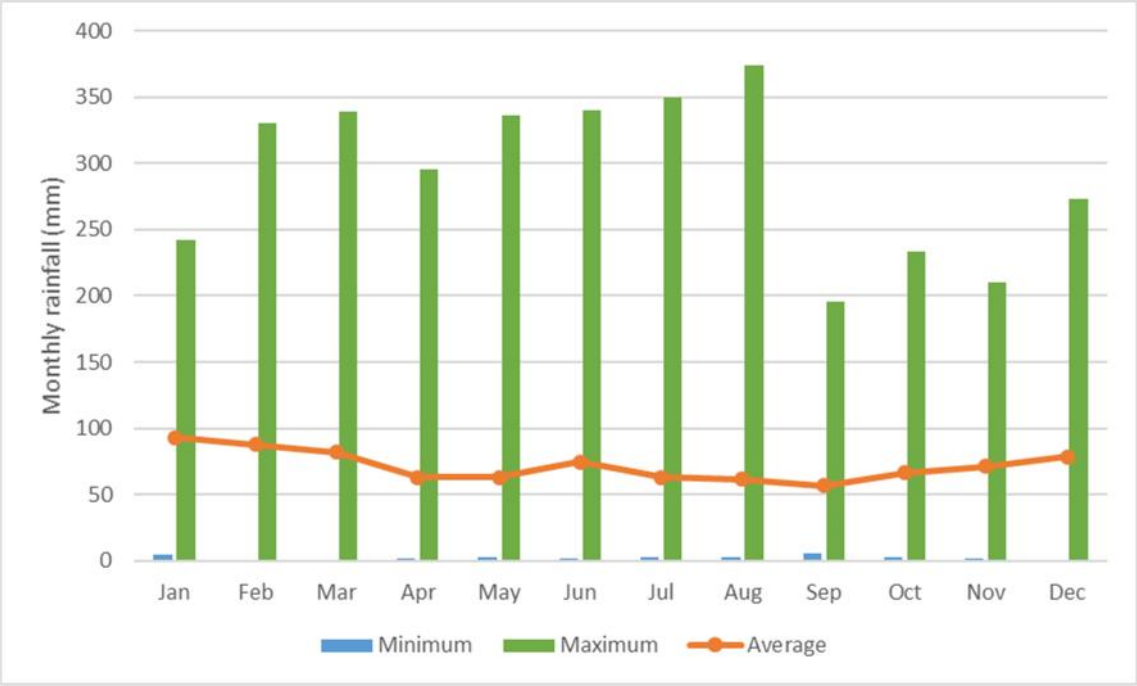


Figure 3-2 Monthly rainfall statistics for Lithgow (Birdwood St) Station

Cumulative rainfall departure

The SILO patched point data from the Lithgow (Birdwood St) Station was also used to generate a cumulative rainfall departure (CRD) curve over the period from 1889 to 2015, presented in Figure 3-3. A CRD curve is a monthly accumulation of the difference between the observed monthly rainfall and long-term average monthly rainfall. Any increase in the CRD curve reflects above average rainfall while a decrease in CRD curve reflects below average rainfall. The CRD curve only deviates from zero due to atypical (above and below average) rainfall.



Figure 3-3 Cumulative rainfall departure curve

As shown in Figure 3-3, the CRD curve indicates a period of approximately 15 years of above average rainfall between 1990 and 2005. From 2006 through to present, monthly rainfall has been less than average, with a relatively low rainfall period in 2007.

The relationship presented in the CRD curve is important to consider with respect to water quality and streamflow results. Water quality within Wangcol Creek has been known to vary in response to water level within the creek affecting the health of the aquatic ecology. Typically, Wangcol Creek operates such that as runoff derived flow reduces, groundwater contribution to the creek will increase. This subsequently introduces groundwater quality characteristics which include increased dissolved metals and EC.

3.3.2 Evaporation

Information provided at the closest BOM station which records evaporation, Bathurst Agricultural Station (station number 63005), was reviewed and average monthly evaporation rates were determined. The average daily evaporation is presented in Figure 3-4, based on 44 years of data from 1966 to 2016.

The total average annual evaporation is approximately 1,350 mm, compared to the annual average rainfall total of approximately 862 mm. This gives an annual deficit (difference between annual rainfall and annual evaporation) of approximately 488 mm.

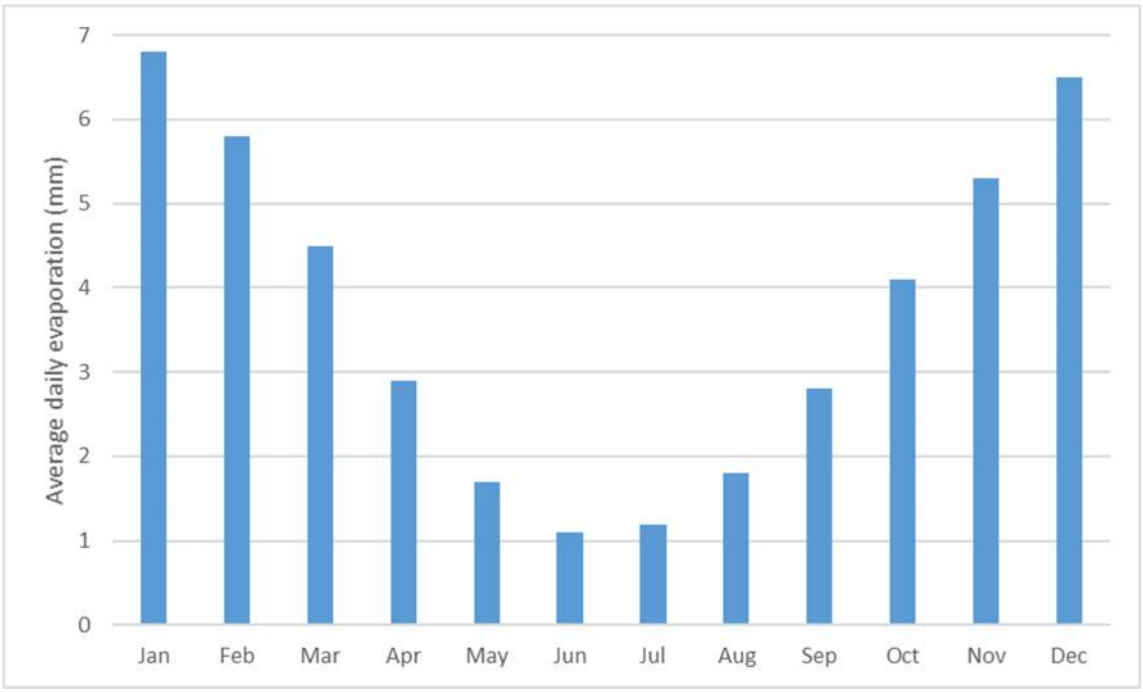


Figure 3-4 Average daily evaporation from Bathurst Agricultural Station

3.4 Soils and geology

3.4.1 Soils

Soil landscapes have been reviewed as part of previous assessments for Centennial Coal Pty Limited (Centennial Coal) projects in the vicinity of the Project, including for the Lidsdale Siding Upgrade Project (GSS Environmental, 2012), Springvale Mine Extension Project (GSS Environmental, 2013) and the Western Coal Services Project (SLR, 2013). A summary of the soil landscapes present in the area of the proposed pipeline alignment and WTP site is provided in Table 3-1, with a description of the chemical and physical limitations of each landscape. The area of each soil landscape is presented on Figure 3-5.

Table 3-1 Soil landscape characteristics

Site component	Soil landscape	Chemical and physical limitations
Pipeline	Cullen Bullen	Dispersibility, erodibility, hard setting surface, acidity, low fertility, low wet bearing strength.
	Deanes Creek	High water tables, permanent waterlogging, acid soils and low fertility, high run-on.
	Hassans Walls	Rock fall hazard, steep slopes, extreme water erosion, mass movement, localised shallow soils, high run-on, non-cohesive soils.
	Lithgow	Hard setting surface, acidity, aluminium toxicity, low fertility.
	Long Swamp	High run-on, permanent high water table, waterlogging, foundation hazard, acidity, low fertility.
	Mount Sinai	Extreme water erosion, rock outcrop, steep slopes, acidity, highly permeable soils, low fertility.
	Newnes Plateau	Acidity, high permeability, low fertility, aluminium toxicity, localised shallow soils.
	Pipers Flat	Low organic matter, erodibility, hard setting surface, low permeability, acidity, aluminium toxicity, low fertility, low wet bearing strength.
Water treatment plant	Cullen Bullen	Dispersibility, erodibility, hard setting surface, acidity, low fertility, low wet bearing strength.
	Lithgow	Hard setting surface, acidity, aluminium toxicity, low fertility.

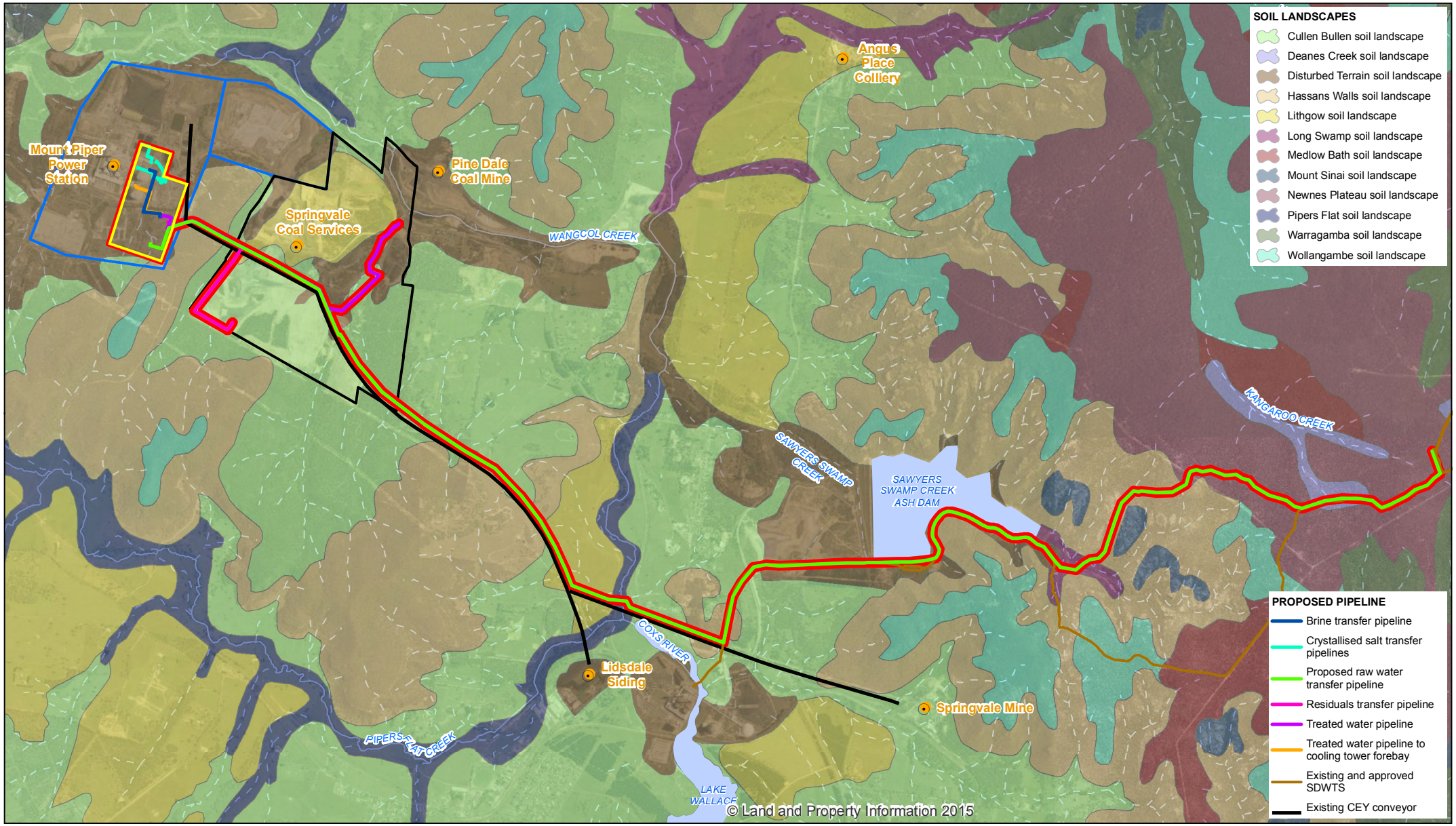
3.4.1 Geology

The Project is located in the southern part of the Western Coalfield and on the western edge of the Sydney Basin. The stratigraphy of the region consists of material from the Tertiary, Triassic and Permian periods.

The Sydney Basin is characterised by coal, shale and sandstone sedimentary beds of Permo-Carboniferous age. These form the gently dipping beds of the Illawarra Coal Measures, capped by shale and sandstone from the Wiannamatta and Narrabeen Group (Triassic Period) and Basalt from the Tertiary period.

Directly below the Illawarra Coal Measures lies the silty, coaly sedimentary rocks of the Nile Subgroup and sandy siltstone of the Berry Siltstone.

Basement rocks of Western Sydney are folded Palaeozoic metamorphosed rocks of the Lachlan Fold Belt, Late Carboniferous granites and Early Permian Rylstone Volcanics.



Paper Size A4

0 0.2 0.4 0.8 1.2 1.6

Kilometers

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

N

LEGEND

- Project application area
- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- Waterbody
- Watercourse - Non Perennial
- Watercourse - Perennial

Springvale Coal
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Soil landscapes

Figure 3-5

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Data source: LPI: DTDB/Imagery, 2012, 2015. DECC: Soil landscapes, 2016. Centennial: Site location; boundaries; pipeline, 2016. Created by: tmorton

There are seven identified coal seams within this region, listed in descending stratigraphical order as follows:

- Katoomba Seam.
- Middle River Seam.
- Moolarben Seam.
- Upper Irondale Seam.
- Irondale Seam.
- Lidsdale Seam.
- Lithgow Seam.

Seismic activity has been noted along the Coxs River Lineament Fault Zone, a 250 m wide, north-south trending graben structure which follows the valley of Coxs River.

The regional stratigraphy of the Project is summarised in Table 3-2.

3.5 Surface water environment

Watercourses in the vicinity of the Project are presented on Figure 3-6. The Project is located within the upper Hawkesbury River catchment, which includes the greater Warragamba Dam catchment and the upper Coxs River sub-catchment. The Coxs River is a perennial river that drains a catchment area of approximately 1,700 km^2 and is part of the greater Hawkesbury/Nepean catchment. The river rises within the Ben Bullen State Forest east of Cullen Bullen and flows generally in a south-east direction into Lake Burragorang (impounded by Warragamba Dam), which is the primary reservoir for drinking water supply to Sydney. The flow in Coxs River is regulated by three reservoirs, Lake Wallace, Thompsons Creek Reservoir and Lake Lyell, which are used to supply water for power generation activities at MPPS.

The Springvale Mine and Angus Place Colliery underground mining operations both traverse the catchment divide of the Coxs River and the Wolgan River. The surface facilities of both operations lie wholly within the Coxs River catchment. Springvale Mine's LDP009 currently discharges into Sawyers Swamp Creek, which is a stream located to the east of the Coxs River, downstream of the Sawyers Swamp Creek Ash Dam. Sawyers Swamp Creek drains to the Coxs River approximately 2 km west of LDP009. Sawyers Swamp Creek has been diverted a number of times due to modifications in ash emplacement areas.

SCSS and MPPS are located within the Wangcol Creek catchment. This creek is a highly modified stream that drains into the Coxs River approximately 3 km to the east of SCSS and MPPS. Wangcol Creek has also been diverted to assist in mining land uses historically.

3.6 Groundwater environment

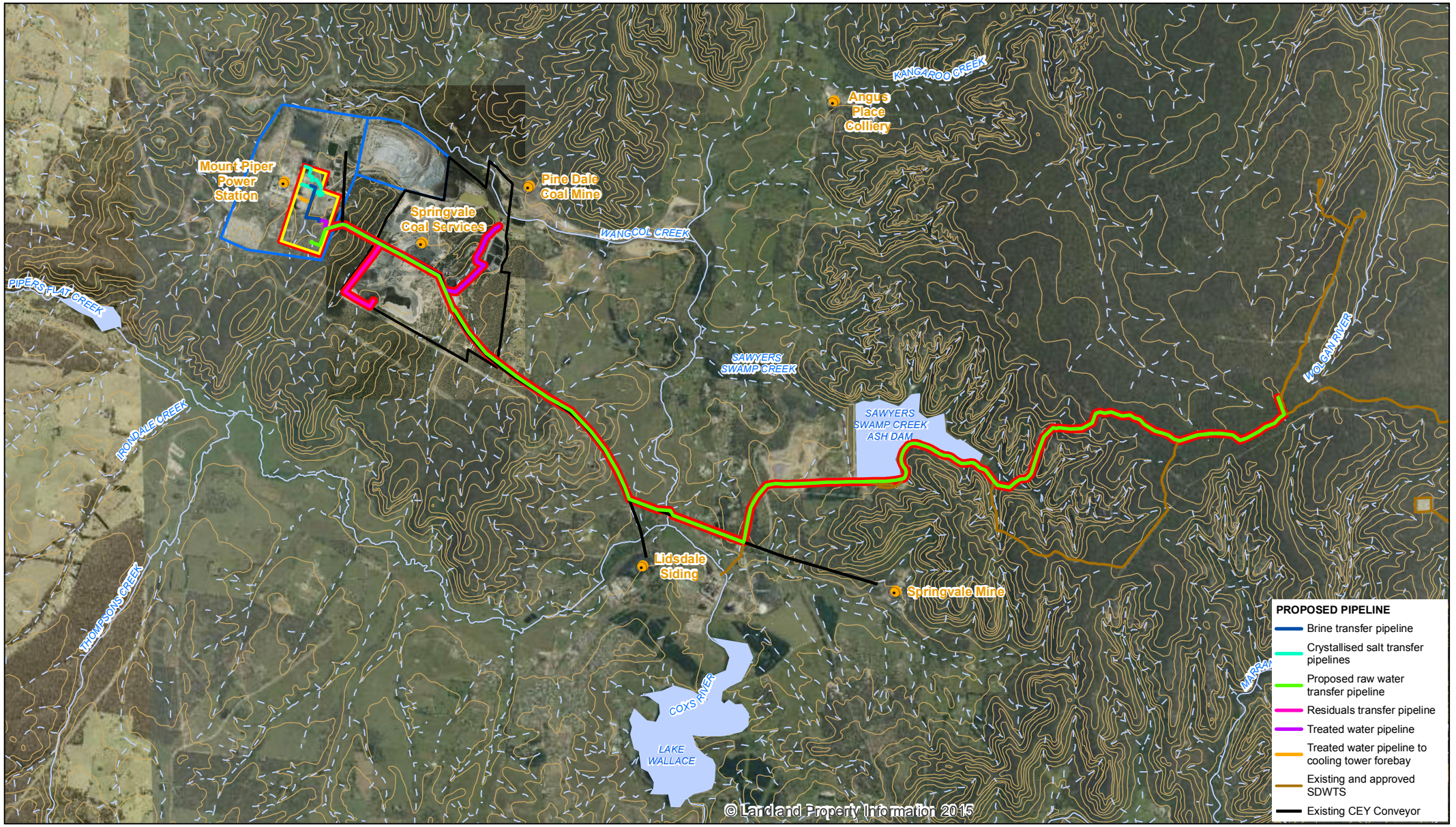
The geological conditions present within the vicinity of the Project are expected to create a range of aquifer systems associated with higher permeability sandstones and coal seams. These are likely to be separated by lower permeability aquitards associated with mudstones, claystones and shale layers.

Shallow sandstone aquifers are predominant across the site and are expected to be associated with the Gap and Ivanhoe sandstone units. These aquifers are likely to be weathered in their near-surface profile resulting in relatively high permeability with potential for significant hydraulic connection with surface water features, including Wangcol Creek.

Table 3-2 Regional geology

Period	Stratigraphy			Unit/lithology	Approximate elevation	Approximate thickness
	Group	Subgroup	Formation			
Quaternary	–	–	–	Alluvium	At ground surface	–
Triassic	Narrabeen	Grose	Bankswall Sandstone	Sandstone, shale, tuff	>950 m AHD	–
Permian	Illawarra Coal Measures	Wallerawang	Gap Sandstone	Predominantly sandstone (fine to coarse grained) with interbedded mudstones, tuff and chert	>909 m AHD	0 m in areas of low relief but >25 m in northern elevated areas.
		Charbon	Denman Formation Glen Davis Formation Newnes Formation Ivanhoe Sandstone			
			Irondale Seam	Coal	909–929 m AHD	1.4–1.6 m
			Long Swamp Formation	Predominantly sandstone (fine to coarse grained) and mudstone with isolated tuff and chert beds	–	13–19 m
			Lidsdale Seam	Coal	889–912 m AHD	1.4–4 m

Period	Stratigraphy			Unit/lithology	Approximate elevation	Approximate thickness
	Group	Subgroup	Formation			
		Cullen Bullen	Blackmans Flat Formation	Sandstone, shale or absent	–	0–4 m
			Lithgow Seam	Coal	886–907 m AHD	1.1 m (southern areas) to 3.7 m (northern areas)
			Marrangaroo Formation	Sandstones and siltstones	–	10 m
	Shoalhaven	–	Berry Siltstone Formation	Shale, sandstone, conglomerate and chert with coal, torbanite seams	<880 m AHD	Unknown
Carboniferous	Bathurst Batholith		Tarana Granite	Adamellite, granite and granodiorite	Estimated to be <800 m AHD. Based on outcrop in Wolgan River Valley.	Unknown
			Turondale, Waterbeach and Merrions	Feldspathic Volcaniclastics, grewacke, slate	Estimated to be <800 m AHD. Based on outcrop in Wolgan River Valley.	Unknown
Devonian	Crudine			Feldspathic siltstone and sandstone, limestone, conglomerate	Unknown	Unknown



Paper Size A4

0 0.25 0.5 1 1.5 2

Kilometers

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

N

LEGEND

- Site location
- Project application area
- Proposed water treatment site
- 20m Contour
- Waterbody
- Watercourse - Non Perennial
- Watercourse - Perennial

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Waterways

Figure 3-6

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Data source: LPI: DTDB/Imagery, 2012, 2015; Centennial: Site location, boundaries, alignment, imagery, 2016. Created by: tmorton

Surrounding the MPPS and the SCSS operational areas, groundwater is connected to remnant open cut areas, some of which have been backfilled while others remain open. SKM (2010) indicate that following mining (pillar extraction), the connectivity between surface water and groundwater can increase up to three times due to changes in permeability and storage capacities above the mine. This is supported by observations at the SCSS where a number of groundwater recharge areas exist, which maintain an influencing factor over discharge volume and quality currently.

The mudstone and siltstone units that are present between the primary coals seams (the Lidsdale and Lithgow seams) and sandstones throughout the profile significantly retard vertical flow between aquifer units. Much of this material has been extracted through mining activities.

The groundwater environment present along the proposed pipeline route is likely to either perched or shallow aquifer systems as the alignment will be typically elevated compared to that of the waterways present and within the geology of the Narrabeen group, which is comprised of sandstone.

Regionally, the typical use of groundwater has been limited to stock use due to the low bore yields and water quality that is not potable (SKM, 2010).

The primary hydrogeological units identified as part of the MPPS Ash Placement Project (SKM, 2010) and the Western Coal Services Project (RPS, 2013a) are summarised in Table 3-3. Note that the Permian Illawarra Coal Measures outcrops at the proposed WTP site.

Table 3-3 Hydrogeological units surrounding the WTP

Unit	Comments
Quaternary alluvium	Isolated to Wangcol Creek, very little presence within MPPS site and the SCSS.
Triassic sandstone	Areas of fracturing due to historical underground mining.
Permian Illawarra Coal Measures	Areas of Lidsdale and Lithgow seam have been mined historically.
Marrangaroo conglomerate	Outcrops to the south.
Basal unit comprising the Shoalhaven Group	Outcrops to the south with a high porosity but low permeability.

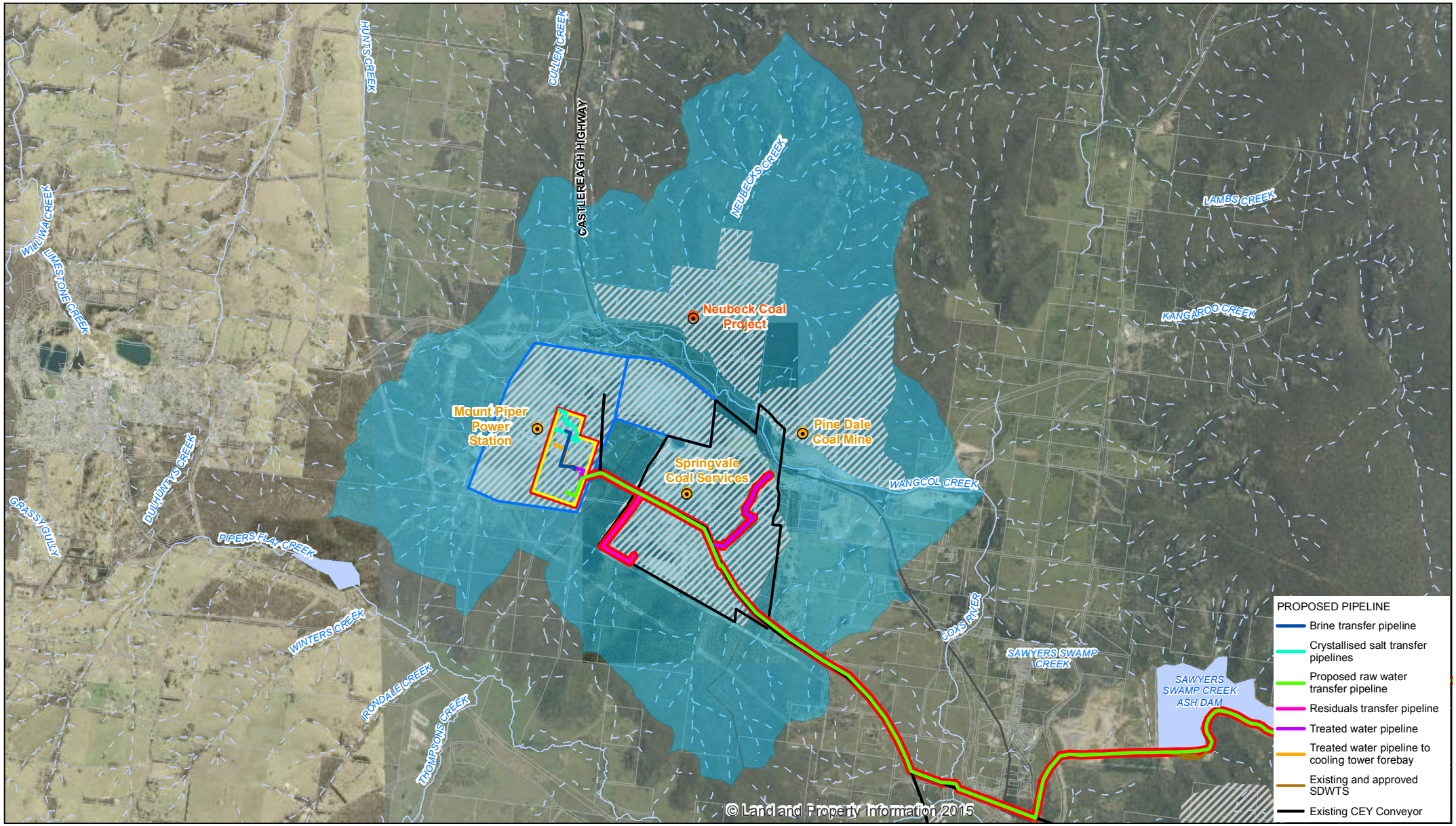
No GDEs have been identified as part of the Western Coal Services Project (RPS, 2013a) for the SCSS. Further discussion on the presence of GDEs has been provided in the Aquatic Ecology Impact Assessment (GHD, 2016a) for the Project.

In accordance with the NSW Aquifer Interference Policy and the GMR WSP, the existing aquifer systems within the vicinity of the Project are expected to form less productive porous rock aquifer systems associated with the Sydney Basin Coxs River groundwater source.

3.7 Regional setting

3.7.1 Wangcol Creek catchment

The operations that contribute to Wangcol Creek are MPPS and the SCSS. Prior to 2014, Pine Dale Coal Mine also contributed to Wangcol Creek, however the mine is now under care and maintenance. A brief overview of these operations is provided below, along with a description of the proposed Neubeck Coal Project. The location of these sites is presented in Figure 3-7.



Paper Size A4

0 0.25 0.5 1 1.5 2

Kilometers

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

N

LEGEND

- Project application area
- Proposed water treatment site
- Wangol Creek catchment
- Existing site locations
- Proposed site locations
- Operational Areas
- Principal Road
- Cadastre
- Waterbody
- Watercourse - Non Perennial
- Watercourse - Perennial

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Regional setting
Wangcol Creek catchment

Figure 3-7

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Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial: Site location, boundaries, imagery, 2016. Created by: tmorton

Mount Piper Power Station

As discussed, MPPS is owned and operated by EnergyAustralia (acquired from Delta Electricity in September 2013). The power station was commissioned in 1993 and currently comprises two coal-fired generating units. MPPS is the greatest surface water user within the region, due to the significant demand for water required in the cooling process that is subsequently lost to evaporation. Water required for the operation of MPPS is supplied from the Coxs River and is supplemented by the Fish River water supply scheme. Surface water runoff from contributing catchments within the MPPS site is directed through an LDP into Wangcol Creek.

Neubeck Coal Project

The Neubeck Coal Project is a proposed open cut mine within the Wangcol Creek catchment. Centennial Angus Place Pty is currently seeking approval to develop the Neubeck Coal Project. It is proposed to extract coal using open cut mining methods to produce up to 1.2 million tonnes per annum (Mtpa) of run of mine (ROM) coal. All coal is proposed to be transported to MPPS or to SCSS using the private haul road network.

Water for the Neubeck Coal Project required for dust suppression and washdown is proposed to be supplied by surface water storages. Groundwater extraction is proposed from old adjacent underground workings and via groundwater inflows into the open pit. One LDP is proposed to be established, located on Wangcol Creek.

Pine Dale Coal Mine

Pine Dale Coal Mine is an open cut coal mine owned and operated by Enhance Place Pty Ltd, which is owned by EnergyAustralia. Coal production commenced at Pine Dale Coal Mine in 2006 and establishment works within the Yarraboldy Extension Area adjacent to the Project commenced in 2011. Pine Dale Coal Mine had approval to extract 0.35 Mtpa of ROM coal using open cut mining methods until 31 December 2014. The site moved to a care and maintenance phase in April 2014, during which mining operations have ceased but environmental management of the site is ongoing. Enhance Place currently has a Project with the NSW DPE seeking approval to extend mining operations and increase coal extraction to 2 Mtpa of ROM coal, however this has not progressed since 2012.

Water required for the operation of the Pine Dale Coal Mine site is supplied by surface water storages on site. Currently, excess water not utilised on site is stored in underground mine workings as necessary, mitigating the need for discharge into Wangcol Creek. Open cut mining is proposed as part of Stage 2 of the Yarraboldy Extension, with excess water transferred to MPPS or discharged through an LDP into Wangcol Creek.

Springvale Coal Services site

The SCSS is a coal processing facility that currently receives coal from Springvale Mine by overland conveyor and provides coal storage, handling and processing functions. ROM coal from Springvale Mine is transported to MPPS via the overland conveyor system. Beneficiated (washed) coal is transferred by overland conveyor to Lidsdale Siding for export. The site has a long history of mining and includes the Lamberts Gully open cut mine.

The Western Coal Services Project was granted development consent SSD-5579 in April 2014, which involves an upgrade to the existing facilities at the SCSS and the management of the coal transport and handling logistics of the source mines, Angus Place Colliery and Springvale Mine. The project will also increase the total coal handling capacity of the site to up to 9.5 Mtpa of ROM coal.

Water required for the operation of the SCSS is sourced from surface water storages on site. Treated excess water is discharged through a single LDP into Wangcol Creek. There is minor groundwater extraction due to incidental flows of water from the old Western Main workings into surface storages.

3.7.2 Coxs River catchment

The existing operations that contribute to Coxs River are Angus Place Colliery upstream of the confluence with Wangcol Creek, and Lidsdale Siding and Springvale Mine downstream of Wangcol Creek. Wallerawang Power Station is also located downstream of the confluence of Wangcol Creek and Coxs River, however it is currently in care and maintenance while the power station is decommissioned. The locations of these sites is presented in Figure 3-8.

Angus Place Colliery

As discussed, Angus Place Colliery is an underground coal mine that commenced operations in 1979 and currently has approval to produce up to 4 Mtpa of ROM coal. The colliery moved to care and maintenance in March 2015, during which mining operations have ceased but environmental management of the site, including dewatering of the underground workings, is ongoing.

Angus Place Colliery is currently seeking approval for the continuation of longwall mining to the east of the current workings. The construction and operation of a new private haul road, linking the SCSS to the Mount Piper Haul Road, has been approved as part of the Western Coal Services Project. This haul road will enable coal from Angus Place Colliery to be transported to the SCSS for processing and distribution.

Water is required at Angus Place Colliery for dust suppression and washdown and is supplied by surface water storages. There is groundwater extraction into the underground workings by incidental inflow due to aquifer interference. This water transferred from the underground workings to the SDWTS operated by Springvale Mine. Excess water from Angus Place Colliery is discharged through LDPs into the Coxs River catchment.

Lidsdale Siding Rail Loading Facility

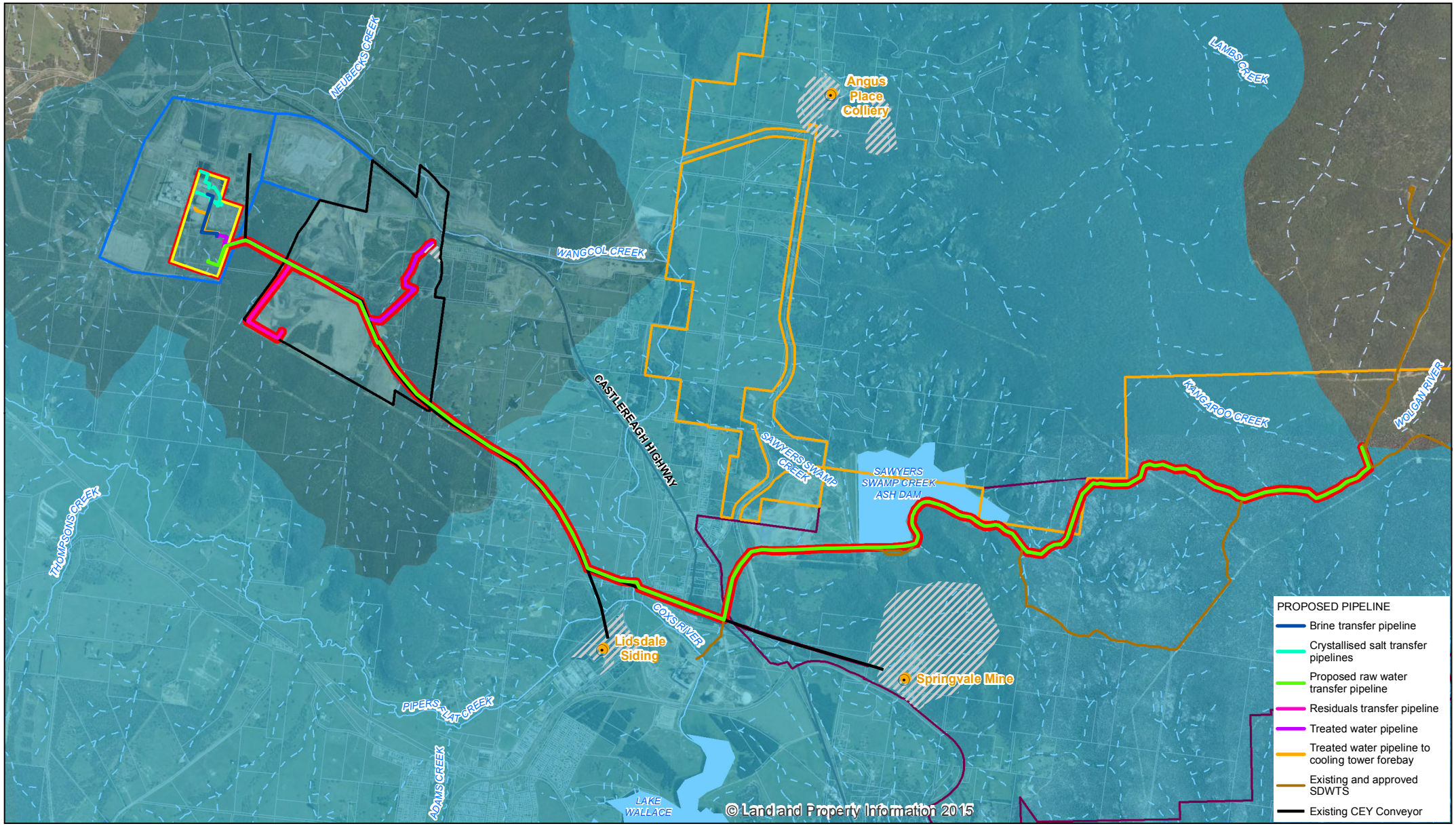
Lidsdale Siding is a coal storage and rail loading facility owned and operated by Ivanhoe Coal Pty Ltd. Coal is delivered by overland conveyor from Springvale Mine via SCSS and transported by rail to Port Kembla or Port of Newcastle for export. Lidsdale Siding was upgraded in 2014 to improve operational efficiency with an automated train loading process and increase throughput capacity to approximately 6.3 Mtpa of product coal.

Water is required at Lidsdale Siding for dust suppression and washdown and is supplied by surface water storages and supplemented by a production bore. Discharges through the single LDP into Pipers Flat Creek, a tributary of Coxs River, are expected to be minimal.

Springvale Mine

As discussed, Springvale Colliery is an underground coal mine that commenced mining operations in 1995 and currently has approval to extract up to 4.5 Mtpa of ROM coal. Coal is delivered by overland conveyor to MPPS or to SCSS for further processing and stockpiling.

Water is required at Springvale Mine for underground mining activities, dust suppression and washdown and is supplied by surface water storages. There is groundwater extraction into the underground workings by incidental inflow due to aquifer interference. This water is transferred from the underground workings to the SDWTS, which currently discharges to Coxs River via LDP009.



Paper Size A4

0 0.2 0.4 0.8 1.2 1.6

Kilometers

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

N

LEGEND

- Project application area
- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- Principal Road
- Angus Place Colliery boundary
- Springvale Mining lease boundary
- Coxs River catchment
- Wangol Creek catchment
- Operational Areas
- Cadastre
- Waterbody
- Watercourse - Non Perennial
- Watercourse - Perennial

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Regional setting
Coxs River catchment

Figure 3-8

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Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial: Site location, boundaries, 2016. Created by: tmorton

3.7.3 Environment protection licences

Figure 3-9 shows the location of each existing LDP associated with Angus Place Colliery, Lidsdale Siding, MPPS, Pine Dale Coal Mine, the SCSS and Springvale Mine. Note points for ambient water monitoring and discharges to utilisation areas have not been shown in Figure 3-9. Table 3-4 below summarises the licence conditions for LDPs at each site.

3.8 Sensitive receptors

The following sensitive surface and groundwater receptors have been identified:

- GDEs located along Wangcol Creek and in the vicinity of MPPS and SCSS.
- Aquatic ecology maintained in local waterbodies, including macroinvertebrate fauna, frogs, macrophytes and algae, fish, semi-aquatic invertebrate species and semi-aquatic mammals.
- Waterways described in Section 3.5, including Wangcol Creek and Coxs River.
- The drinking water catchment for Warragamba Dam, which receives inflows from a number of waterways including Coxs River.
- Users of surface water and groundwater downstream of the Project, including licensed water users and basic landholder rights.

3.8.1 Aquatic ecology

Instream aquatic ecology has been monitored since 2010 by Centennial Angus Place and Springvale Coal within the catchments of Wangcol Creek and the Coxs River. GDEs and stygofauna (groundwater fauna) have been monitored for since 2013. Instream aquatic ecology monitoring has been undertaken in conjunction with Angus Place Colliery, the SCSS and Springvale Mine, referred to as the Centennial West aquatic ecology monitoring program. The monitoring program considers other catchment and creek systems in the region which include Wolgan Creek and the shrub swamp systems within the Newnes Plateau.

The existing condition of aquatic ecology of Wangcol Creek, Sawyers Swamp Creek and Coxs River was assessed within the Aquatic Ecology Impact Assessment (GHD, 2016a) for the Project and is summarised below. The locations of the sample sites discussed within this section are provided in Figure 3-10.

The potential impact on GDEs and aquatic ecology has been discussed within the Aquatic Ecology Impact Assessment (GHD, 2016a) for the Project.

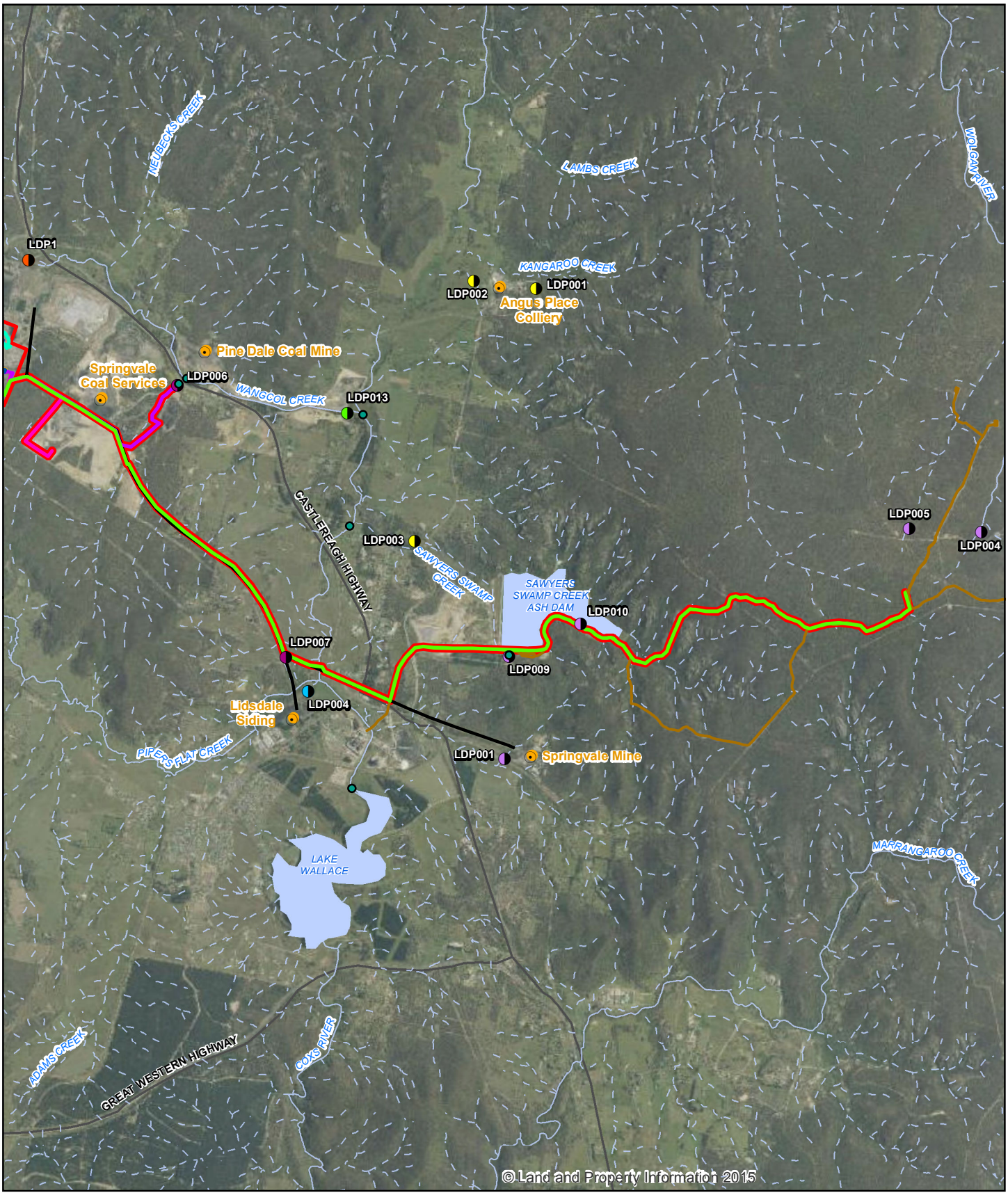
Wangcol Creek

Macroinvertebrates

Sampling of four sites distributed along Wangcol Creek over the past four years has indicated significant variation. Recent sampling found more taxa in the two upstream and further downstream sites. Results indicate that site WC2 is located within a mixing zone of the one of the existing operations' daily discharges.

Vegetation

The vegetation health of Wangcol Creek was determined to be of a moderate level, with some degradation and incompleteness in riparian vegetation extent. Historical sampling of the site has found that the health of Wangcol Creek has improved with bank stabilisation works. Previous development and current mining land uses have degraded some reaches of Wangcol Creek.



LEGEND

- Project application area
- Angus Place LDP
- Lisdale LDP
- Mt Piper Power Station LDP
- Pine Dale LDP
- Springvale LDP
- Springvale Coal Services LDP
- Brine transfer pipeline
- Crystallised salt transfer pipelines
- Proposed raw water transfer pipeline
- Residuals transfer pipeline
- Treated water pipeline
- Treated water pipeline to cooling tower forebay
- Existing and approved SDWTS
- Principal Road
- Watercourse - Non Perennial
- Watercourse - Perennial
- Waterbody

Paper Size A4

0 230 460 920 1,380 1,840

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

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Current LDP locations

Figure 3-9

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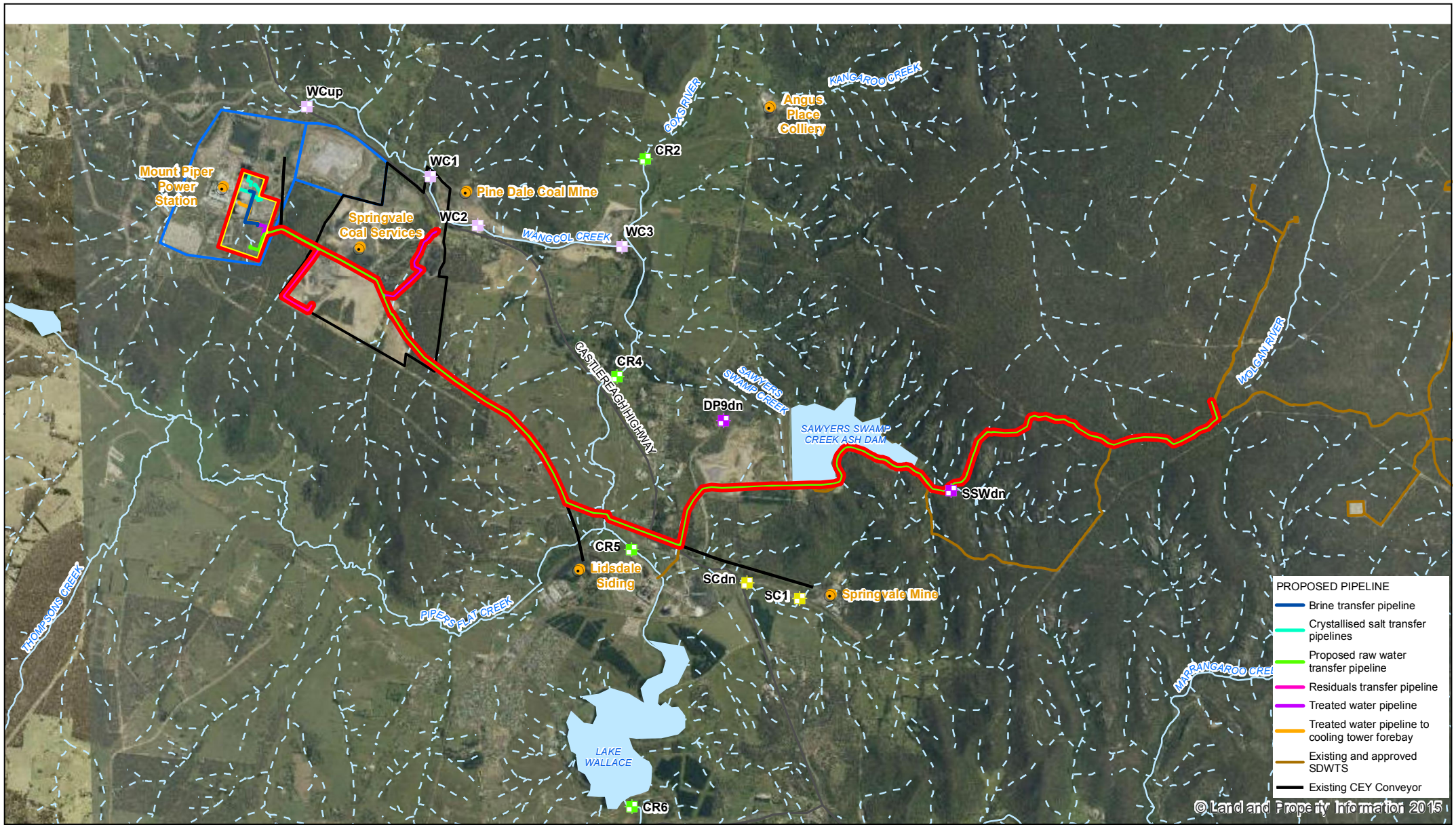
Data source: © NSW Office of Water: Groundwater Data, 2013; ESRI: Aerial Imagery, 2009. Created by: tmorton

Table 3-4 Environment protection licence details

Site	EPL	EPA ID	Site ID	Catchment	Type of point	Monitoring requirements	Discharge limits
Angus Place Colliery	467	1	LDP001	Kangaroo Creek	Discharge to waters Discharge quality monitoring Volume monitoring	Water quality Volume	Water quality Volume
		2	LDP002	Coxs River	Discharge to waters Discharge quality monitoring Volume monitoring	Water quality	Water quality
		3	LDP003		Discharge to waters Discharge quality monitoring	Water quality	Water quality
		5	LDP005		Discharge to utilisation area	Volume	None
Lidsdale Siding	5129	4	LDP004	Pipers Flat Creek	Discharge to waters Discharge quality monitoring	Water quality	Water quality
Mount Piper Power Station	13007	1	LDP1	Wangcol Creek	Discharge to waters Discharge quality and total volume monitoring	Water quality Volume	None
Pine Dale Coal Mine	4911	2	Point 2	Wangcol Creek	Ambient water monitoring	Water quality	None
		3	Point 3		Ambient water monitoring	Water quality	None
		13	LDP13		Discharge to waters Discharge quality monitoring Volume monitoring	Water quality Volume	Water quality
		14	Point 14	Coxs River	Ambient water monitoring	Water quality	None

Site	EPL	EPA ID	Site ID	Catchment	Type of point	Monitoring requirements	Discharge limits
Springvale Mine	3607	1	LDP001	Springvale Creek	Discharge to waters Discharge quality monitoring Volume monitoring	Water quality Volume	Water quality Volume
		2	LDP002	Coxs River	Discharge to utilisation area	Volume	None
		4	LDP004	Wolgan River	Discharge to waters Discharge quality monitoring Volume monitoring	Water quality Volume	Volume
		5	LDP005		Discharge to waters Discharge quality monitoring Volume monitoring	Water quality Volume	Volume
		6*	LDP006	Wangcol Creek	Discharge to waters Discharge quality monitoring Volume monitoring	Water quality	Water quality
		7*	LDP007	Coxs River	Discharge to waters Discharge quality monitoring	Water quality Volume	Water quality
		9	LDP009	Sawyers Swamp Creek	Discharge to waters Discharge quality monitoring Volume monitoring	Water quality Volume	Water quality Volume
		10	LDP010		Discharge to waters Discharge quality monitoring Volume monitoring	Water quality Volume	Water quality

* LDP006 and LDP007 are located at the SCSS and form part of Springvale Mine's EPL 3607.



Paper Size A4

0 0.25 0.5 1 1.5 2

Kilometers

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

N

LEGEND

- Coxs River
- Sawyers Swamp Creek
- Springvale Creek
- Wangcol Creek
- Principal Road
- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- Waterbody
- Watercourse - Non Perennial
- Watercourse - Perennia
- Project application area

Springvale Coal
Springvale Water Treatment Project
Water Resources Impact Assessment

Job Number 21-25109
Revision 0
Date 10 Aug 2016

Aquatic ecology monitoring locations

Figure 3-10

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Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

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Data source: LPI: DTDB/Imagery, 2012, 2015; Centennial: Site location, boundaries, monitoring, alignment, imagery, 2016. Created by: tmorton

Coxs River

Macroinvertebrates

Over the historical sampling undertaken at sites on the Coxs River, macroinvertebrate communities have remained consistent with the highest taxa richness found in spring 2012. In the most recent sampling, a total of 17 (CR2), 18 (CR4) and 27 (CR5) taxa were collected from the sites on the Coxs River. Results indicated slight impacts with fewer families collected than expected. Recent sampling and assessment had concluded that there were existing impacts on water quality and/or habitat quality (GHD, 2014c).

Vegetation

The sites assessed for the Coxs River indicated that the current environment has been severely degraded. This was potentially associated with a lack of riparian vegetation and high erosion potential. In past surveys, the vegetation species observed within the Coxs River have been significant enough to warrant a good condition, as was the case in 2011.

Sawyers Swamp Creek

Macroinvertebrates

Sites upstream from discharge point LDP009 (SSWdn/SSCup) indicate that a more diverse macroinvertebrate community exists when water is present. Macroinvertebrate data from sites below LDP009 indicated a creek condition with very low to moderate diversity but there were consistent with SIGNAL 2 scores which were indicative of moderately degraded water quality.

Vegetation

Above the Sawyers Swamp Ash Dam, the macrophytes present included Jointed Rush and Swamp Clubrush. Substrate was composed of muddy sand and gravel/pebble. Small amounts of filamentous algae were observed.

Downstream of LDP009 discharges the vegetation consisted of dense stands of emergent spike and jointed rushes, grasses (Carex sp), Pampas grass (Cortaderia sp) and Cumbungi at the channel edges.

4. Assessment methodology

4.1 Criteria for undertaking the assessment

The objective of the WRIA is to determine the potential impact of the Project on the surface water and groundwater environments. The identification of potential impacts will enable the development of measures to avoid or mitigate impacts or provide the framework of monitoring programs that may be required for the Project. The following potential impacts to surface water and groundwater systems were identified through a preliminary environmental risk assessment:

- Changes to the local water cycle.
- Changes to regional catchment flows.
- Changes to geomorphological condition of waterways.
- Erosion and sedimentation resulting from the disturbance area.
- Altered surface water and groundwater quality downstream of the Project.
- Altered availability of surface water and groundwater to downstream of the Project.
- Cumulative impacts of the Project in association with other projects in the Wangcol Creek and Coxs River catchments.

The methodology for each of these assessments categories is detailed further in Section 4.2 to Section 4.9.

4.2 Water and salt balance assessment

To assess changes in the local and regional water and salt cycle and to quantify potential impacts of the Project, a water and salt balance model was prepared.

The modelling software used to represent the water and salt balance was GoldSim (Version 11.1). This software is a graphical object orientated system for simulating either static or dynamic systems. It is like a 'visual spreadsheet' that allows the visual creation and manipulation of data and equations representing system behaviour.

Simulation, in this context, is defined as a process of creating a model of an existing or proposed system (such as a mine water management system) in order to identify and understand the factors that control the system performance or predict (forecast) the future behaviour of the system under varying input conditions and operational decisions.

The model was created by representing the water and salt cycle as a series of elements, each containing pre-set rules and data, that were linked together to simulate the interaction of these elements within the water and salt cycle. The water and salt cycle was simulated over time in GoldSim and selected outputs from the modelled system were statistically summarised.

4.2.1 Time steps and simulation timeline

The GoldSim model simulated the water and salt cycle from current conditions in 2016 to 2035 using daily time steps. Daily time steps were used for the modelling as daily rainfall data was the shortest period of data available and changes in operational conditions are typically made on a daily (or shorter) basis.

4.2.2 Probabilistic modelling

To assess the impact of rainfall on the water and salt balance, the modelling was completed by applying 127 different rainfall patterns over the simulation timeline. To complete this, the simulation timeline was modelled for 127 'realisations', where each realisation represented a single model run from 2016 to 2035. The only variation between realisations was that each realisation modelled a different continuous historical rainfall pattern.

The 127 realisations were applied as the historical rainfall dataset extended from January 1889 to December 2015 (refer Section 3.3.1), which represents 127 years of complete rainfall data available. The 127 years of rainfall data provides 127 rainfall patterns as the seasonality in rainfall is maintained for each model run, e.g. the 1st January in the model was simulated with 1st January historical rainfall data. For each realisation, a continuous pattern of historical rainfall was applied over the simulation timeline. Where the end of the continuous historical rainfall record was reached in a realisation, the rainfall looped back to the start of the rainfall record.

The above repetition process provided 127 values for each simulated element in the model, for each day of the simulation timeline. Each transfer was then statistically assessed to provide estimates of the average, 10th percentile and 90th percentile annual totals for each year over the simulation timeline.

4.2.3 GoldSim representation

Project water and salt balance

The water cycle for existing conditions was modelled in GoldSim based on site conditions in the year 2016. To undertake the modelling in GoldSim, the following simplifications were incorporated:

- Transfer rates were modelled using daily time steps. In reality, transfer rates are determined during the day on an 'as needs basis' and may apply over periods smaller than a day.
- Operating rules/conditions were established within the model in accordance with advice from site personnel.
- Rainfall and runoff are represented in daily time steps and therefore short duration, high intensity events are not accurately modelled. In reality, more overflows from surface water storages may occur than represented in the model.

The GoldSim water and salt balance model developed for existing conditions was modified to represent the proposed conditions for the water cycle as a result of the Project. The Project was assumed to commence on 30 June 2017 (as per consent conditions within SSD-5594). Amendments to the model to represent the proposed conditions were associated with:

- Transfer of up to 36 ML/day of dewatered mine water from Angus Place Colliery and Springvale Mine to the WTP for treatment prior to transfer to the MPPS cooling water system.
- Discharge of any excess water not able to be reused within the MPPS cooling water system to Wangcol Creek at a new discharge point adjacent to SCSS's LDP006.
- Transfer of residual material from the pre-treatment process to the existing REA at the SCSS.
- Transfer of the brine from the WTP to the existing MPPS blowdown system.

Coxs River catchment water and salt balance

An assessment of the water and salt balance of the Coxs River catchment was undertaken to predict the flows and salt loads in the Coxs River. Relevant results for Angus Place Colliery, Lidsdale Siding, Springvale Mine and SCSS were incorporated into the GoldSim model. Figure 4-1 indicates the location of the operations and licensed discharges within the Coxs River catchment included in the GoldSim model.

GHD has previously developed detailed site water and salt balances in GoldSim for all Centennial sites in the Coxs River catchment, as discussed in the following documents:

- Angus Place Mine Extension Project: Water and Salt Balance Assessment (GHD, 2013a).
- Lidsdale Siding Rail Loading Facility: Water and Salt Balance Assessment (draft; GHD, 2016b).
- Springvale Mine Modification 1 Project: Water and Salt Balance Assessment (GHD, 2016c).
- Western Coal Services: Site Water and Salt Balance Assessment (draft GHD, 2016d).

The detailed water and salt balance models for each of these sites were directly incorporated into the GoldSim model for the Project.

It should be noted that the Neubeck Coal Project and Pine Dale Coal Mine within the Wangcol Creek catchment were not included in the water and salt balance model due to the undetermined status of their respective proposed operations. Only catchment runoff contributing to Neubecks Creek and Wangcol Creek from the proposed Neubeck Coal Project and Pine Dale Coal Mine respectively was modelled.

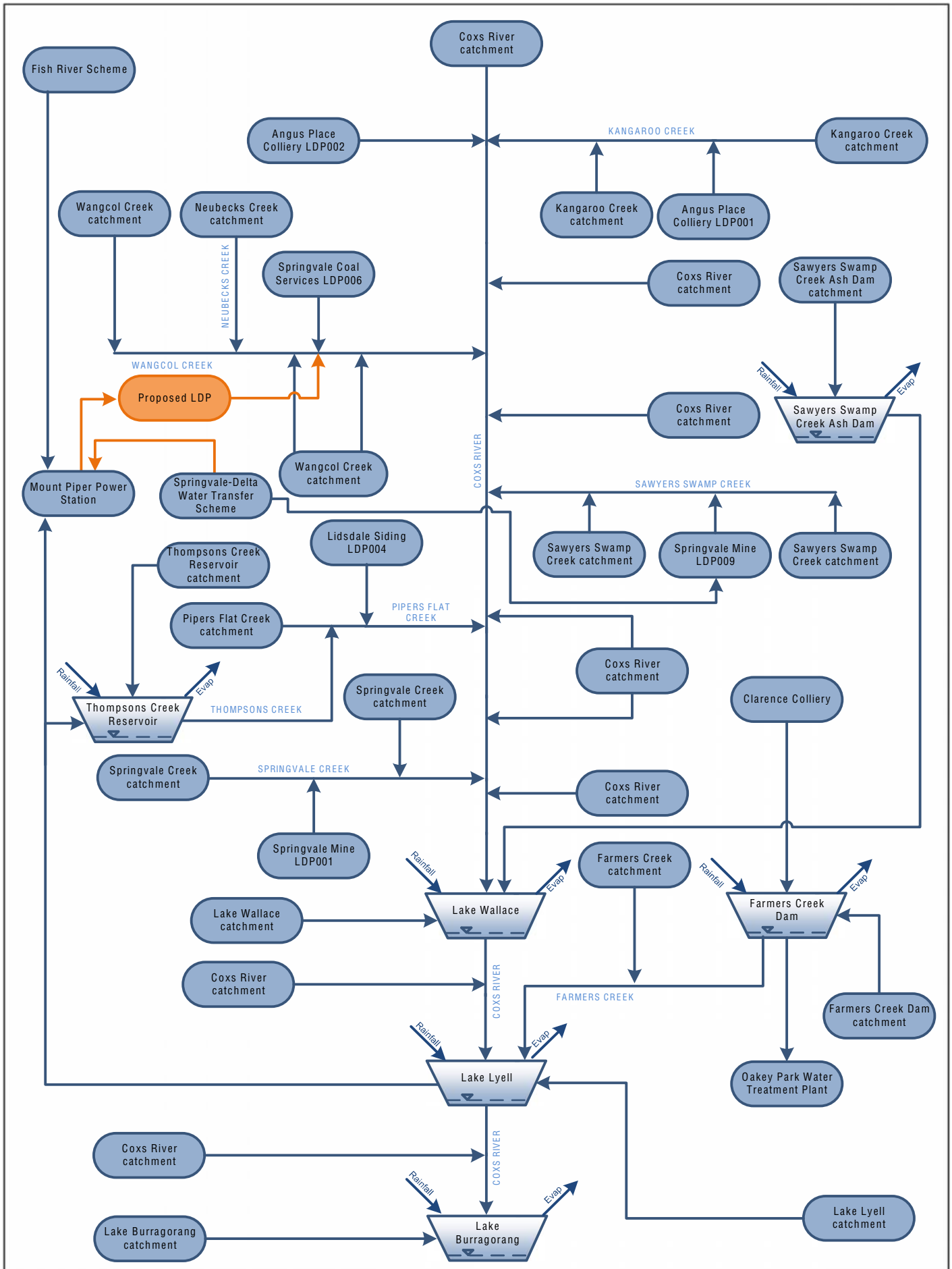
A timeline of each modelled operation has been presented in Appendix B.

4.2.4 Catchment modelling

In addition to modelling the site-specific water and salt balance, the surface water runoff from all catchments contributing to Lake Burragorang was also modelled. Sub-catchments were delineated and are summarised in Appendix B. The development footprint of each assessed site was excluded from the corresponding sub-catchment area. An estimate of the runoff volume from each catchment was determined using the Australian Water Balance Model (AWBM), which is a catchment water balance model that calculated runoff from rainfall. Hydrologic modelling with the AWBM is discussed further in Section 4.2.5.

4.2.5 Hydrologic model

To estimate catchment runoff from rainfall, the AWBM was incorporated into the wider water balance model. The AWBM was adopted as the most suitable model as it is widely used throughout Australia, has been verified through comparison with large amounts of recorded streamflow data and literature is available to assist in estimating input parameters based on recorded streamflow data (Boughton and Chiew, 2003). Another advantage of the AWBM is the consideration of soil moisture retention when determining runoff.



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LOCATION	Coxs River
SEAM	NA
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

Springvale Water Treatment Project
Water Resources Impact Assessment

Water cycle schematic

Centennial Coal
EnergyAustralia

DATE Jul 2016

Figure 4-1

The AWBM is a catchment water balance model that calculates runoff from rainfall after allowing for relevant losses and storage. The model consists of three storage elements (with surface areas A_1, A_2 and A_3) representing elements such as infiltration into the soil. Rainfall initially enters these storages and once a storage element is full, any additional rainfall is considered to be excess rainfall. Of this excess rainfall, a proportion is routed to the groundwater/baseflow storage while the remainder is routed to the surface storage. The discharge from the groundwater storage and surface storage is estimated as a proportion of the volume of the storages at the end of each day. The total daily runoff is equal to the combined volume of water discharged from these two storages.

The definition of AWBM parameters is provided in Table 4-1. Figure 4-2 provides a schematic representation of the AWBM.

Table 4-1 Description of AWBM parameters

Parameter	Description
A_1, A_2, A_3	The partial areas of the overall catchment contributing to storages 1, 2 and 3 respectively.
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.
Excess	Excess from storages C_1, C_2 and C_3
SS	Surface storage recharge.
BS	Baseflow storage recharge.
Kb	The proportion of the volume of the baseflow storage remaining in the storage at the end of each day. Not applicable for these catchments as there is no baseflow component.
Ks	The proportion of the surface flow storage remaining in the storage at the end of each day.

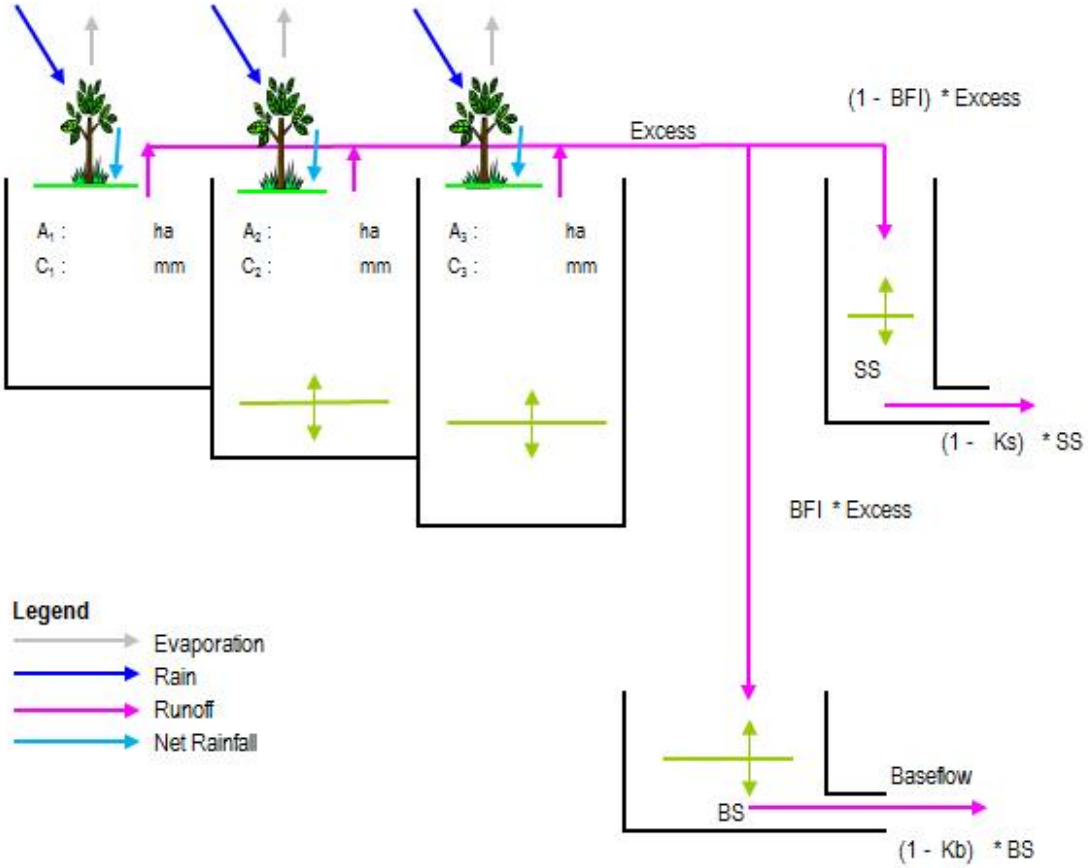


Figure 4-2 Australian Water Balance Model representation

4.2.6 Salt balance

The salt balance was developed as an extension of the water balance within GoldSim. The structure of the model remained unchanged, with expected concentrations of salt applied to inputs within the model. The salt balance provides the expected salt loads and concentration of salt associated with each water transfer within the water balance. Chemical reactions have not been incorporated into the salt balance modelling. Salt transfers were simulated in parallel with the water balance model.

Inputs to the water and salt balance model were assigned a specific concentration of salt depending on the source of water. Salt concentrations were based upon recorded water quality data and typical concentration values for similar sites, usually provided in units of µS/cm. A conversion factor of 0.67 was used to convert salinity data in µS/cm to mg/L as recommended by the Queensland Department of Natural Resources and Water (DNRW, 2007).

4.2.7 Modelling scenarios

As discussed, the GoldSim water and salt balance model simulated the proposed water cycle from current conditions to the end of 2035 using daily time steps. Due to the variability associated with power generation requirements and water demand at MPPS, a number of scenarios were modelled. Results for the following operational scenarios are presented:

- Existing conditions – based on site conditions in the year 2016, with a 50% power generation requirement at MPPS.

- Proposed conditions:
  - Scenario 1 – assumed a 0% power generation requirement at MPPS.
  - Scenario 2 – assumed a 25% power generation requirement at MPPS.
  - Scenario 3 – assumed a 50% power generation requirement at MPPS.
  - Scenario 4 – assumed a 75% power generation requirement at MPPS.
  - Scenario 5 – assumed a 100% power generation requirement at MPPS.
  - Do nothing – assumed that the Project will not be developed, with a 50% power generation requirement at MPPS and flows from the SDWTS discharged through LDP009 into Sawyers Swamp Creek.

Within the WRIA, a 50% power generation requirement was used to present the results for the modelling, for the existing conditions, do nothing scenario and Scenario 3. The 50% power generation requirement was considered as it correlated to recent historical trends and corresponds to the approximate volume of water available from the SDWTS. All detailed model results for scenarios 1, 2, 4 and 5 is provided in Appendix B

4.2.8 Data

Project operational data

The sources of data and the operational data used to develop the water and salt balance model for the Project is provided in Appendix B.

Groundwater inflows

The groundwater inflows into the active underground workings of Angus Place Colliery and Springvale Mine provided by CSIRO (2015) and incorporated into the water and salt balance model are provided in Figure 4-3. The combined inflow into the underground workings of both Springvale Mine and Angus Place Colliery are predicted to peak in December 2029 at approximately 36.1 ML/day. The transfer of mine water-make dewatered from the underground workings is currently transferred to the SDWTS via dewatering bores prior to being discharged to Sawyers Swamp Creek through Springvale Mine's LDP009. As part of the Project, the mine water-make is proposed to be transferred to the MPPS cooling water system via the WTP, with excess water discharged to Wangcol Creek.

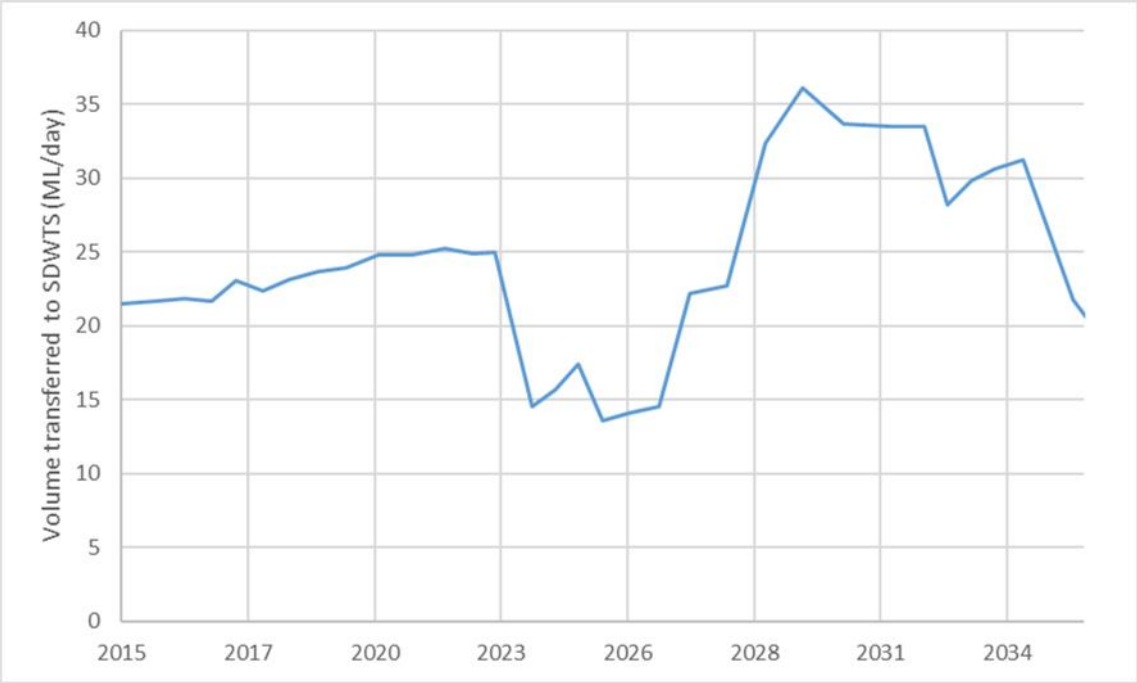


Figure 4-3 Predicted groundwater inflows into Angus Place Colliery and Springvale Mine (CSIRO, 2015)

Climate data

Daily rainfall data from the Lithgow (Birdwood St) Station obtained from the SILO database, as discussed in Section 3.3.1, and the average daily evaporation data from the Bathurst Agricultural Station, as discussed in Section 3.3.2, was incorporated into the water and salt balance model. A pan factor of 0.9 was adopted to the daily evaporation rates to simulate the evaporation of water from surface water storages. Evapotranspiration factors were applied in the hydrologic model to simulate evapotranspiration losses from catchments.

Hydrologic model

Catchments were divided into three areas representing bushland/vegetation, impervious and disturbed areas. The three areas were modelled with a different set of AWBM parameters. The AWBM parameters adopted for the water and salt balance model are presented in Table 4-2.

The parameters for bushland/vegetated areas were determined based on available literature where historical streamflow data had been used to provide recommendations on parameter selection. The nearest location for which AWBM model parameters had been determined by Boughton and Chiew (2003) was Coxs River, located downstream approximately 74 km south-east of MPPS. The recommended parameters relating to baseflow were adjusted to reflect the ephemeral nature of drainage lines adjacent to the sites.

The impervious areas were modelled without infiltration into the soil and without surface storage or baseflow storage. Only one storage was assigned a non-zero capacity. This storage represents depression storage of 5 mm for impervious areas. The baseflow parameters were adjusted to reflect no baseflow.

The parameters for disturbed areas are typical hydrologic parameters for such land use types. The soil storage parameters were calibrated to the average annual runoff depth.

The runoff parameters adopted were considered reasonable given the lack of site-specific flow gauging data and significant variability in catchment runoff characteristics that can occur.

Table 4-2 AWBM parameters adopted

Parameter	Bushland/vegetation areas	Impervious areas	Disturbed areas
A_1, A_2, A_3	0.134, 0.433, 0.433	1.0, 0.0, 0.0	0.134, 0.433, 0.433
C_1, C_2, C_3	8.1, 82.3, 164.6	7.0, 0., 0.	8.1, 82.3, 164.6
BFI	0.4	0.0	0.4
Excess	Calculated	Calculated	Calculated
SS	(1-BFI) x Excess	(1-BFI) x Excess	(1-BFI) x Excess
BS	BFI x Excess	BFI x Excess	BFI x Excess
Kb	0.9	N/A	0.9
Ks	0.5	0.0	0.5

Salinity data

A summary of the salinity data incorporated into the water and salt balance model is provided in Appendix B. Data was sourced from available information, typically water quality monitoring data and the predicted salinity of the outflows from the WTP and cooling water system at MPPS. Generally, average values were applied; however maximum values were used on occasion where deemed appropriate.

Site-specific data

Angus Place Colliery

Angus Place Colliery is currently seeking approval for the continuation of longwall mining to the east of the current workings. Extraction of longwalls in the proposed Angus Place East mining area is expected to commence in 2024 following the completion of mining at Springvale Mine. This expansion would extend the mine life by up to 25 years. The site is currently in care and maintenance, with environmental management of the site ongoing.

GHD has developed a detailed site water and salt balance for Angus Place Colliery in GoldSim which simulated the complete water and salt cycles at the site (GHD, 2013a). The entire detailed water and salt balance was incorporated into the GoldSim model for the Project. Groundwater inflows into the underground workings incorporated into the water and salt balance model were predicted by CSIRO (2015) using a COSFLOW geomechanical/ hydrogeological model.

The water and salt balance model was based on site conditions assuming maximum extraction of 4 Mtpa of ROM coal. Discharge from Angus Place Colliery to surface water sources were modelled to occur through LDP001 at a minimum of 2 ML/day plus rainfall-based flows to Kangaroo Creek as well as overflows from a surface water storage through LDP002 to a tributary of Coxs River. The majority of groundwater inflows into the underground workings were assumed to be transferred to the SDWTS with flows from Springvale Mine for discharge at LDP009 at Springvale Mine under existing conditions and to MPPS via the WTP under proposed conditions.

Lidsdale Siding

Lidsdale Siding is a coal storage and rail loading facility. Coal is delivered by overland conveyor from Springvale Mine via the SCSS and transported by rail to Port Kembla or Port of Newcastle for export. Lidsdale Siding was upgraded in 2014 to improve operational efficiency with an automated train loading process and increase throughput capacity to approximately 6.3 Mtpa of product coal.

GHD has developed a detailed site water and salt balance for Lidsdale Siding in GoldSim, which simulated to complete water and salt cycle at the site (draft; GHD, 2016b). Groundwater extraction at Lidsdale Siding was modelled to occur via a production bore to supplement water supply. Rainfall-based surface water discharges through an LDP into Pipers Flat Creek are minimal.

Mount Piper Power Station

The inputs to and outputs from the water management system at MPPS were modelled in the GoldSim water and salt balance model.

Water required for the operation of MPPS was modelled to be supplied from the following sources in order of priority:

- Mine water-make via the water transfer and treatment system proposed as part of the Project (under proposed conditions only).
- Water from the Coxs River extracted from Lake Lyell. Water extracted from Lake Lyell that is not required by MPPS is stored in Thompsons Creek Reservoir.
- Water from the Fish River water supply scheme.

Outputs from the MPPS water management system were modelled as the discharge of any excess treated water not able to be reused within the MPPS cooling water system to Wangcol Creek and the transfer of residual material to the SCSS for placement within the existing REA. As there is no discharge of water associated with the cooling water system or water treatment process, the cooling water system at MPPS was not modelled.

Springvale Coal Services site

The SCSS is a coal processing facility that receives coal from Springvale Mine by overland conveyor and provides coal storage, handling and processing functions. ROM coal is transferred directly from Springvale Mine to MPPS or following stockpiling at SCSS using the overland conveyor system. Product coal is transferred from the SCSS by overland conveyor to Lidsdale Siding for export.

GHD has developed a detailed site water and salt balance for SCSS in GoldSim, which simulated the complete water and salt cycle at the site (GHD, 2016d). There is minor groundwater extraction due to incidental flows of water from the old Western Main Workings into surface storage dams. Rainfall-based surface water discharges through an LDP into Wangcol Creek are minimal.

Springvale Mine

Springvale Mine currently has approval to extract up to 4.5 Mtpa of ROM coal, which is delivered by overland conveyor to SCSS for further processing or directly to Lidsdale Siding or MPPS. The Springvale Mine Extension Project was approved on 21 September 2015 and is expected to extend the mine life by up to 13 years.

GHD has developed a detailed site water and salt balance for Springvale Mine in GoldSim which simulated the complete water and salt cycles at the site (GHD, 2016c). Groundwater inflows into the underground workings incorporated into the water and salt balance model were predicted by CSIRO (2015) using a COSFLOW geomechanical/hydrogeological model.

The water and salt balance model was based on site conditions assuming maximum extraction of 4.5 Mtpa of ROM coal. Under existing conditions, groundwater inflows into Springvale Mine were modelled to be transferred to the SDWTS for discharge through LDP009 into Sawyers Swamp Creek, along with transfers of groundwater from Angus Place Colliery. For the proposed conditions, groundwater was modelled to be transferred to MPPS via the WTP as part of the Project. Discharge from Springvale Mine also occurs through LDP001 into Springvale Creek due to overflows from surface water storages under both existing and proposed conditions.

Water supply storages

EnergyAustralia currently holds WAL 27428, which allows for the extraction of surface water up to 23,000 ML/year from the Coxs River. The Statement of Approval (approval number 10CA117220) issued to EnergyAustralia on 28 February 2014 states conditions for environmental management of the Coxs River. The following rules were incorporated into the water and salt balance model for environmental flow releases from Lake Wallace, Lake Lyell and Thompsons Creek Reservoir:

- The daily release of water from Lake Wallace is equal to or greater than 0.7 ML/day.
- When the total storage of Lake Wallace, Lake Lyell and Thompsons Creek Reservoir is greater than or equal to 50,000 ML:
  - If daily inflows to Lake Lyell are less than or equal to 13.6 ML/day, the daily release of water from Lake Lyell is equal to the daily inflows.
  - If daily inflows to Lake Lyell are greater than 13.6 ML/day, the daily release of water from Lake Lyell is equal to 13.6 ML/day plus 25% of the daily inflow volume above 13.6 ML/day.
- When the total storage of Lake Wallace, Lake Lyell and Thompsons Creek Reservoir is less than 50,000 ML:
  - If the total storage in Lake Wallace, Lake Lyell and Thompsons Creek Reservoir has been less than 50,000 ML continuously for less than six months, the daily release of water from Lake Lyell is equal to the lesser of the daily inflows to Lake Lyell and 9 ML/day.
  - If the total storage in Lake Wallace, Lake Lyell and Thompsons Creek Reservoir has been less than 50,000 ML continuously for six months or more, the daily release of water from Lake Lyell is equal to the lesser of the daily inflows to Lake Lyell and 5 ML/day.
- The daily release of water from Thompsons Creek Reservoir is equal to or greater than 0.8 ML/day between 1 September and 30 April and equal to or greater than 0.3 ML/day between 1 May and 31 August.

The Statement of Approval also includes conditions for annual channel maintenance flow releases and banked environment flow rules for Lake Lyell which were not incorporated into the water and salt balance model.

4.2.9 Modelling qualifications on predictions

GHD has developed the water and salt balance models for the Project based on information supplied by Centennial Springvale Pty Ltd, EnergyAustralia, Jacobs (2015) and external data sources. Where data was not available, GHD has made assumptions as appropriate.

Data used to develop the models are categorised as follows:

- Relatively reliable data:
  - SILO rainfall data.
  - BOM evaporation data.
  - Surface catchment areas based on topographic maps.
  - Water infrastructure data.
- Less reliable data:
  - Runoff rates from impervious and naturally vegetated catchments.
  - Operational precedences for transfers between storages.
  - Reactive chemistry of water.
  - Operational conditions (including day to day decisions).

The consequence of the items listed within the 'less reliable data' category is there is likely to be a risk that the model predictions are somewhat inaccurate. Model predictions based on the above information should be considered to have an accuracy of ±30%. The accuracy is expected to improve once more site data is gathered during the life of the Project. This additional data will allow refinement of the model input and hence increase the reliability of the model predictions. A review of the model is likely to be undertaken as part of the commissioning phase of the Project.

In developing the regional water and salt balance, information and data relating to the water cycle at MPPS have resulted in the system being treated as a closed system with only the broad inflows and outflows considered. In relation to the operation of reservoirs, data has been interpreted from available WAL conditions. Centennial Coal operated sites are all modelled to a detailed site level.

Where publically available information has been used, GHD has endeavoured to interpret the information presented from these sources as accurately as possible in the modelling undertaken, however cannot be held responsible for inaccuracies due to misleading or absent information in the reports reviewed.

The commencement and cessation of operations have a significant impact on the assessment undertaken. If project timelines change from the timelines assumed for the water and salt balance assessment, model predictions may be impacted.

It should also be noted that the adoption of historical rainfall and evaporation data within the detailed models does not take into account the potential impacts of climate change.

4.3 Catchment hydrology and hydraulics

4.3.1 Hydrology

XPRAFTS modelling

To assess the changes to catchment hydrology due to the Project, an XPRAFTS (Version 2013) model was developed for the existing conditions and modified to represent the development of the Project. Potential impacts on catchment hydrology were assessed for:

- Development of the catchment at the site of the proposed WTP.
- Discharges from the proposed LDP to Wangcol Creek.

The impact of the development of the catchment at the proposed WTP site was assessed for the 10-year annual recurrence interval (ARI) design event.

The hydrological condition of Wangcol Creek was assessed for the 1, 10, and 100 year ARI design events. To assess the effects of climate change on waterway flooding, the consideration of a 200 and 500 year ARI event was used to assess sensitivity to an increase rainfall intensity. These 'rare rainfall' scenarios were developed using empirical methodologies outlined within Australian Rainfall and Runoff (ARR) (Institute of Engineers, 1987). An extreme event was also considered, which was modelled as what is effectively a three times a 100 year ARI event.

Input parameters

Wangcol Creek was hydrologically modelled in XPRAFTS considering land use characteristics, current topographic information available through Centennial aerial surveys from 2015 as well as broad scale historical topographic information for the catchment.

Catchment area

Wangcol Creek catchment was considered down to its confluence with the Coxs River, as it enters the waterbody formed from the open cut voids of the abandoned Commonwealth Mine. The total catchment at this point is estimated at 2,790 ha. Approximately 119 ha of catchment from the Huon Gully was excluded from the model as there is no clear flow path for this catchment to contribute to Wangcol Creek.

Catchment land use

In determining the percentage impervious for sub-catchments, a review of broad scale aerial imagery of the catchment was undertaken. The areas of MPPS, the Castlereagh Highway and Mount Piper Haul Road and the operational hardstand areas of Pine Dale Coal Mine and the SCSS site were all included to identify the percentage of impervious area over the catchment. Across the assessed catchment this averaged a total of 10%.

Intensity-frequency-duration data

A range of design storm events were considered in the hydrological assessment. Design storm events were generated from ARR (Institute of Engineers, 1987) intensity-frequency-duration design rainfall data for the Project site obtained from the BOM. The data used in the assessment is provided in Appendix C.

Lag time

The lag (or travel) time between sub-catchments was determined from a length-slope relationship for input into the XPRAFTS model. The lag time between sub-catchments was determined based on typical flow cross-sectional area, stream slope and average stream velocities, which were evaluated using open channel Manning's equation calculations. The catchment lag velocity input into the model varied between 0 m/s and 3 m/s based on flow path slope.

Catchment loss

The hydrological model adopted an initial loss of 10 mm and a continuing loss of 2.5 mm/hr. The catchment loss parameters were based on previous hydrological assessments and calibration to recorded data, discussed further in Section 5.3.1.

Catchment roughness

Catchment roughness parameters have been determined based on values discussed by Chow (1959). The majority of the catchment has been identified as being typical of pasture, with elevated areas of the Neubecks Creek sub-catchment identified as forested. These areas have been modelled with a Manning's n value of 0.05. Areas with existing infrastructure have been considered with a Manning's n value of 0.015 which is the typical roughness of concrete with straight uniform channels.

4.3.2 Hydraulics

As a result of the Project, the flow regime of Wangcol Creek may potentially be modified due to changes in hydrologic conditions of existing waterways. The potential hydraulic changes to these waterways were assessed using the one-dimensional hydraulic modelling software HEC-RAS (Version 5.0). Hydraulic models were developed for the length of Wangcol Creek downstream of the proposed discharge location.

Changes in flow depth, velocity and inundation patterns were assessed for the 1, 10 and 100 year ARI events. The assessment of hydraulic performance for climate change or extreme events was not undertaken due to its relevance in assessing Project impact. The proposed discharge volume is unlikely to influence these events due to its volumetric significance.

As site observations of Wangcol Creek indicated a dry weather baseflow component within the creek, the assessment of an existing baseflow and baseflow combined with proposed discharges was considered. Baseflow volume to be considered was determined through the low flow analysis undertaken on the stream gauge located on Wangcol Creek.

To consider the specific hydraulic response of the open channel areas specific to the discharge location, an open channel, Manning's equation approach was considered for hydraulics considering changes to flow depth and velocity. With respect to existing crossing structures, such as the culvert on Castlereagh Highway, the assessment of changes in hydraulic performance were also considered separately to the one-dimensional model for the creek, using a Manning's equation approach.

4.4 Waterway geomorphology

The assessment of waterway geomorphology involved the completion of the following tasks:

- Desktop assessment of available information.
- Site investigation and waterway condition assessment.
- Interpretation of outputs from hydrologic and hydraulic studies undertaken as part of the catchment hydrology and hydraulics components.
- Development of control structures.

The methodologies employed for the above tasks are detailed further in the following sections.

4.4.1 Desktop assessment

A desktop assessment of existing information (GIS data and aerial imagery) was undertaken to identify and preliminarily map in GIS the waterway types (river style), geomorphic condition and stream order of waterways potentially impacted by the Project.

Stream ordering followed the Strahler stream classification system where waterways are given an 'order' according to the number of additional tributaries associated with each waterway (Strahler, 1952). Figure 4-4 indicates the Strahler stream ordering process for a generic catchment. Numbering begins at the top of a catchment with headwater ('new') flow paths being assigned the number one. Where two flow paths of order one join, the section downstream of the junction is referred to as a second order stream. Where two second order streams join, the waterway downstream of the junction is referred to as a third order stream, and so on. Where a lower order stream (e.g. first order) joins a higher order stream (e.g. third order), the area downstream of the junction will retain the higher stream order.

The assessment of stream physical form and function is broadly based on the methods and principles of the River Styles® framework (Brierley and Fryirs, 2005). This is the primary framework used in NSW for the geomorphic characterisation of waterways.

Determination of stream types is largely based on the following parameters:

- Degree of valley confinement and bedrock influences.
- Presence and continuity of a channel.
- Channel planform (number of channels, sinuosity).
- Channel and floodplain geomorphic features.
- Nature of channel and floodplain sediments.

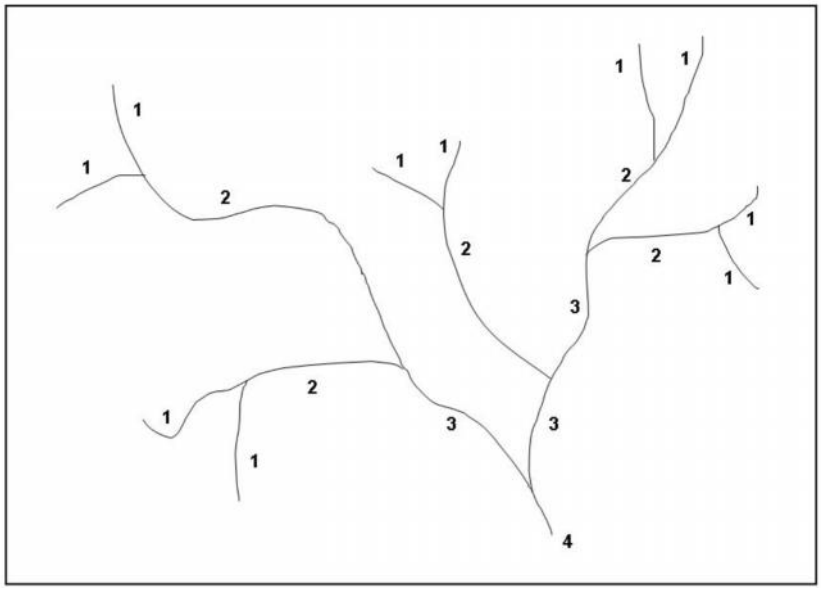


Figure 4-4 Stream order for a generic catchment using Strahler (1952) method

4.4.2 Site investigation

A site investigation was undertaken on the 10 May 2016 to identify the current physical characteristics of the waterways potentially impacted by the Project. The investigation focussed on assessing the higher Strahler order waterways. Information recorded during the field investigation included:

- Geomorphic type and condition of waterways.
- Nature, location and extent of existing waterway instabilities.
- Nature and location of waterway controls (e.g. bedrock, logs).
- Nature of channel and bedload materials.

General site data was recorded using a hand held GPS with other measurements being undertaken including valley widths and channel widths and depths during the site investigation.

4.4.3 Condition assessment

The assessment of geomorphic condition was based on Outhet and Cook (2004) who describe a rapid method of condition assessment that frames geomorphic condition in the context of natural and human induced variability. The characteristics of each condition category are described in Table 4-3. These categories provide an indication of the degree of alteration a reach has experienced from its expected natural form.

Table 4-3 Geomorphic condition categories

Indicative geomorphic condition	Characteristics
Good	Geomorphic structure is largely unchanged from the pre-disturbance state such that only minor cases of localised instability occur. Relatively intact and effective vegetation coverage dominated by native species, giving resistance to natural disturbance and accelerated erosion. There is minimal alteration to catchment controls such as sediment supply and the hydrological regime allowing fast recovery from natural disturbance. There is also a high potential for ecological diversity.
Moderate	Geomorphic structure is moderately altered such that a reduced diversity of river features exists and floodplain connectivity is somewhat limited. Localised degradation of river character and behaviour, typically marked by modified patterns of geomorphic units. Patchy effective vegetation coverage allowing some localised accelerated erosion. The river has not fully adjusted to prevailing conditions and is experiencing ongoing changes.
Poor	Considerable geomorphic alteration to the functioning and structure of the system when compared with the pre-disturbance condition. Type, extent and rate of processes are radically altered. Floodplain connectivity may be significantly altered. Abnormal or accelerated geomorphic instability (reaches are prone to accelerated and/or inappropriate patterns or rates of planform change and/or bank and bed erosion). Excessively high volumes of sediment inputs which blanket the bed, reducing flow diversity. Absent or geomorphologically ineffective coverage by vegetation (allowing most locations to have accelerated rates of erosion).

4.5 Erosion and sediment control

Erosion and sediment control is critical to the mitigation of excessive soil loss from activities that require disturbance of existing groundcover. The assessment included a review of the erosion risk based on the soil landscape present in the area of the proposed pipeline alignment and WTP site and an assessment of potential impacts due to the Project.

4.6 Surface water quality

4.6.1 ANZECC water quality assessment

A detailed water quality assessment was undertaken for the current existing site conditions in order to establish baseline water quality for receiving watercourses. This water quality assessment has been undertaken in accordance with the assessment framework and methodologies outlined by ANZECC (2000a). Consideration has also been given to the ADWGs (NHMRC, 2016) in the assessment methodology for water quality in accordance with the requirements of State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 (refer Section 2.2.1).

Data requirements

ANZECC (2000a) recommend that, for the purpose of deriving ambient concentrations and SSGVs, a sufficient amount of data needs to be collected and that it should characterise seasonal variations:

"A minimum of two years of continuous monthly data at the reference site is required before a valid trigger value can be established."

The datasets currently available for the Project span over two years of monthly monitoring results.

Guideline values

To characterise the existing waterway quality, threshold guideline values may be derived from:

- ANZECC (2000a) default values (consistent with water quality objectives).
- Limits specified in relevant EPLs and development consents.
- SSGVs derived or recommended using site-specific water quality monitoring data.
- Local ecotoxicity testing.

ANZECC (2000a) define guideline values as:

"…the concentrations (or loads) of the key performance indicators measured for the ecosystem, below which there exists a low risk that adverse biological (ecological) effects will occur. They indicate a risk of impact if exceeded and should 'trigger' some action, either further ecosystem specific investigations or implementation of management/remedial actions."

Water quality objectives

Environmental values associated with the waterways and water sources within the area surrounding the Project include primary industry, aquatic ecosystems, recreational users, irrigation and stock watering. In this assessment, the guideline values from the ANZECC (2000a) guidelines for the protection of 95% of aquatic species have been used, as they are considered to be the most sensitive and, regardless of the current water quality present within the receiving environment, foster an improved water quality standard in the future.

The Hawkesbury Nepean River Health Strategy (HNCMA, 2010) indicates planned assisted revegetation works for a majority of the Coxs River with more significant revegetation works locally around the confluence with Pipers Flat Creek. Water quantity and flow management as well as riparian wetland management has been outlined in reach management works for the Coxs River within the areas around the confluence with Wangcol Creek.

The Healthy Rivers Commission Inquiry (Healthy Rivers Commission, 1998) conducted an assessment of NSW catchments in relation to setting water quality objectives for community environmental values. Within the assessment, water quality objectives for the Hawkesbury-Nepean catchment were not adopted. However, due to the catchment's significance to the Sydney drinking water catchment, nutrient loads were identified as an issue with recommended guideline values derived for total nitrogen of 0.7 mg/L and for total phosphorus for 0.035 mg/L (NSW Government, 2001; Table 2, p. 22). These guideline levels are noted to be greater than the ANZECC (2000a) values for upland rivers in NSW.

Ecosystem condition

The ANZECC (2000a; Section 3.1.3.1) guidelines recognise the following three categories of ecosystem condition, with a level of protection assigned to each:

- High conservation/ecological value systems.
- Slightly to moderately disturbed systems.
- Highly disturbed systems.

Wangcol Creek is considered to be a 'slightly to moderately disturbed' system, as the waterway has been adversely affected by human activities by a small to measureable degree. This is predominately due to the diversion of Wangcol Creek within its lower reaches and a lack of suitable riparian vegetation.

Reference site

Monitoring site SW1 on Neubecks Creek has been selected as the most appropriate reference site to provide background data to derive SSGVs. This site is located within the Wangcol Creek catchment and is not measurably impacted by mining or power generation activities.

Default guideline values

Guideline values for many parameters are recommended by ANZECC (2000a), which are usually derived from background assessments (physicochemical parameters and nutrients) and ecotoxicity studies (toxicants) and are not specific to the site studied. These guideline values should be considered as default guideline values (DGVs) and their suitability should be verified by establishing local background conditions. DGVs were selected from the ANZECC (2000a) guidelines, with state derived guideline values preferred to regionally derived guideline values.

Within the ANZECC (2000a) guidelines, Wangcol Creek falls into two different categories of ecosystem protection depending on the parameter reviewed, as identified in Table 4-4.

Table 4-4 ANZECC (2000a) protection categories

Parameter	Category
Physicochemical parameters and nutrients	NSW upland river (ANZECC, 2000a; Table 8.2.2 to 8.2.12)
Metals and toxicants	Freshwater category (ANZECC, 2000a; Table 3.4.1), with 95% species protection for slightly-moderately disturbed ecosystems

A list of the DGVs recommended by ANZECC (2000a) to assess water quality in the absence of adequate reference site monitoring data is presented in Table 4-5. The available data for water quality within Wangcol Creek indicates that the water is 'extremely hard' (ANZECC, 2000a; Table 3.4.4). As such, hardness correction factors have been applied to the guideline values for dissolved cadmium, lead, nickel and zinc, as recommended by ANZECC (2000a).

Table 4-5 Default guideline values for assessment of water quality (ANZECC, 2000a)

Parameter	Units	Guideline value	Comments
Physicochemical parameters			
EC	µS/cm	350	NSW upland river (Table 8.2.8).
pH	pH units	6.5–9.0	NSW upland river (Table 8.2.9).
Total suspended solids (TSS)	mg/L	25	NSW upland river (Table 8.2.12).
Turbidity	NTU	25	NSW upland river (Table 8.2.11).
Nutrients			
Ammonia	mg/L	0.9	Freshwater guideline for 95% species protection (Table 3.4.1).
Total nitrogen	mg/L	0.25	NSW upland river (Table 8.2.2).
Total phosphorus	mg/L	0.02	NSW upland river (Table 8.2.3).
Dissolved metals			
Aluminium	mg/L	0.055	Freshwater guideline for 95% species protection (Table 3.4.1). Applies for pH>6.5.
Arsenic	mg/L	0.024	Freshwater guideline for 95% species protection for As(V) (Table 3.4.1).
Boron	mg/L	0.37	Freshwater guideline for 95% species protection (Table 3.4.1).
Cadmium	mg/L	0.0026a	Freshwater guideline for 95% species protection (Table 3.4.1).
Chromium	mg/L	0.001	Freshwater guideline for 95% species protection (Table 3.4.1).
Cobalt	mg/L	0.0025	NSW EPA (2000).
Copper	mg/L	0.0014	Freshwater guideline for 95% species protection (Table 3.4.1).
Iron	mg/L	0.3	Canadian guideline as recommended by ANZECC (2000a; Section 8.3.7.1).
Lead	mg/L	0.129a	Freshwater guideline for 95% species protection (Table 3.4.1).
Manganese	mg/L	1.9	Freshwater guideline for 95% species protection (Table 3.4.1).

Parameter	Units	Guideline value	Comments
Mercury	mg/L	0.0006	Freshwater guideline for 99% species protection (Table 3.4.1).
Nickel	mg/L	0.125a	Freshwater guideline for 95% species protection (Table 3.4.1).
Selenium	mg/L	0.011b	Freshwater guideline for 99% species protection (Table 3.4.1).
Silver	mg/L	0.00005	Freshwater guideline for 95% species protection (Table 3.4.1).
Zinc	mg/L	0.091a	Freshwater guideline for 95% species protection (Table 3.4.1).

[a] Guideline value modified for hardness.

[b] Guideline value for total selenium.

Australian Drinking Water Guidelines

The corresponding ADWG values (NHMRC, 2016) is provided in Table 4-6. In the absence of a guideline for health values, aesthetic guideline values have been adopted.

Table 4-6 ADWG values for assessment of water quality (NHMRC, 2016)

Parameter	Units	ADWG		Additional information
		Health	Aesthetic	
Physicochemical parameters				
pH	pH units	–	6.5–8.5	While extreme pH values (<4 and >11) may adversely affect health, there are insufficient data to set a health guideline value. <6.5 may be corrosive. >8 progressively decreases efficiency of chlorination. >8.5 may cause scale and taste problems.
Total dissolved solids (TDS)	mg/L	–	500	<500 mg/L is regarded as good quality drinking water based on taste. Concentrations of 500 mg/L to 1,000 mg/L is acceptable based on taste.
Turbidity	NTU	–	5	5 NTU is just noticeable in a glass. <0.2 NTU is the target for effective filtration of Cryptosporidium and Giardia. <1 NTU is the target for effective disinfection.

Parameter	Units	ADWG		Additional information
		Health	Aesthetic	
Dissolved metals				
Aluminium	mg/L	–	0.2	Guideline value based on post-flocculation problems; < 0.1 mg/L desirable. Lower levels needed for renal dialysis. No health-based guideline value can be established currently.
Antimony	mg/L	0.003	–	Exposure may rise with increasing use of antimony-tin solder.
Arsenic	mg/L	0.01	–	From natural sources and mining/industrial/agricultural wastes.
Barium	mg/L	2	–	Primarily from natural sources.
Boron	mg/L	4	–	From natural leaching of minerals and contamination. <1 mg/L in uncontaminated sources; higher levels may be associated with seawater intrusion.
Cadmium	mg/L	0.002	–	Indicates industrial or agricultural contamination; from impurities in galvanised (zinc) fittings, solders and brasses.
Copper	mg/L	2	1	From corrosion of pipes/fittings by salt, low pH water. Taste threshold 3 mg/L. High concentrations colour water blue/green. >1 mg/L may stain fittings. >2 mg/L can cause ill effects in some people.
Iron	mg/L	–	0.3	Occurs naturally in water, usually at <1 mg/L, but up to 100 mg/L in oxygen-depleted groundwater. Taste threshold 0.3 mg/L. High concentrations stain laundry and fittings.
Lead	mg/L	0.01	–	Occurs in water via dissolution from natural sources or household plumbing containing lead (e.g. pipes, solder).
Manganese	mg/L	0.5	0.1	Occurs naturally in water; low in surface water, higher in oxygen depleted water (e.g. groundwater at bottom of deep storages). >0.1 mg/L causes taste, staining. <0.05 mg/L desirable.

Parameter	Units	ADWG		Additional information
		Health	Aesthetic	
Mercury	mg/L	0.001	–	From industrial emissions/spills. Very low concentrations occur naturally. Organic forms most toxic, but these are associated with biota, not water.
Molybdenum	mg/L	0.05	–	Concentrations usually <0.01 mg/L; higher concentrations from mining, agriculture, or fly-ash deposits from coal-fuelled power stations.
Nickel	mg/L	0.02	–	Concentrations usually very low; but up to 0.5 mg/L reported after prolonged contact of water with nickel-plated fittings.
Zinc	mg/L	–	3	Usually from corrosion of galvanised pipes/fittings and brasses. Natural concentrations generally <0.01 mg/L. Taste problems >3 mg/L.

Environment Protection Licences

The EPL discharge limits for mine water discharge specified by EPL 3607 which apply to LDP006 (located at the SCSS) and to LDP009 are presented in Table 4-7.

Table 4-7 EPL discharge limits for LDP006 and LDP009

Parameter	Units	Discharge limits	
		LDP006	LDP009
Physicochemical parameters			
EC	µS/cm	–	1,200
pH	pH units	6.5–9.0	6.5–9.0
TSS	mg/L	30	50
Turbidity	NTU	50	50
Metals			
Aluminium (dissolved)	mg/L	–	0.45
Arsenic	mg/L	–	0.024
Boron (dissolved)	mg/L	–	0.37
Copper (dissolved)	mg/L	–	0.007
Iron (dissolved)	mg/L	–	0.4
Manganese (dissolved)	mg/L	–	1.7
Nickel (dissolved)	mg/L	–	0.047

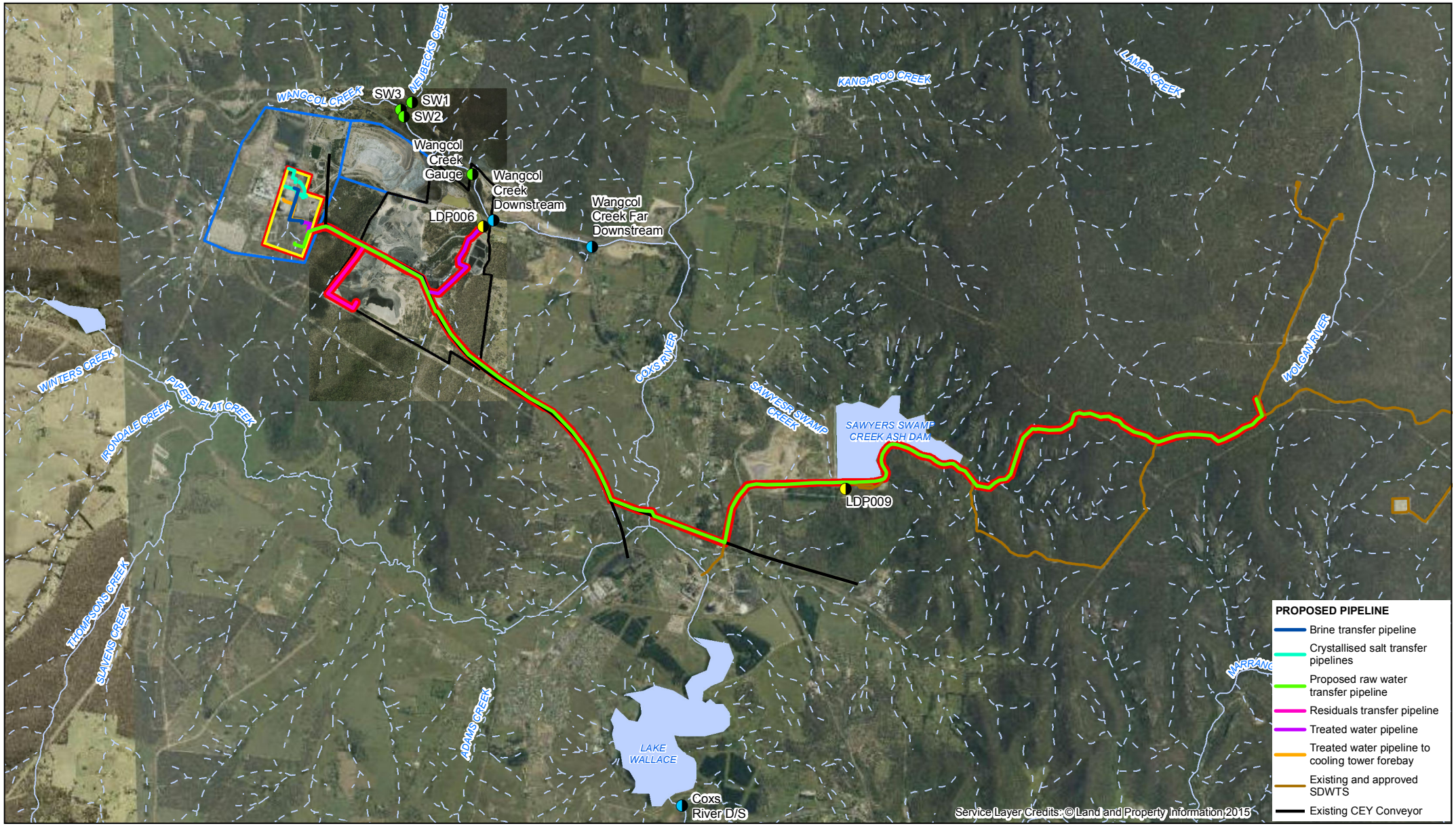
Parameter	Units	Discharge limits	
		LDP006	LDP009
Zinc (dissolved)	mg/L	–	0.05
Other			
Fluoride	mg/L	–	1.8
Oil and grease	mg/L	10	10

Monitoring locations

The water quality assessment considered data from 18 monitoring locations that are part of surface water monitoring programs for Centennial and WaterNSW. Monitoring locations were categorised into the following:

- Upstream locations – upstream of the proposed LDP location on Wangcol Creek.
- Discharge locations – LDP006 on Wangcol Creek and LDP009 on Sawyers Swamp Creek.
- Downstream locations – downstream of the proposed LDP location on Wangcol Creek and Coxs River.
- Regional locations – downstream of upstream, discharge and downstream locations in the Lake Burragorang catchment.

Monitoring locations are shown in Figure 4-5 and Figure 4-6 and are described in Table 4-8. Sites were preferentially chosen from the existing Centennial monitoring network as they were determined to have a larger set of analytes considered.



Paper Size A4

0 0.25 0.5 1 1.5 2

Kilometers

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

N

LEGEND

- Project application area
- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- Discharge locations
- Downstream locations
- Upstream locations
- Waterbody
- Watercourse - Non Perennial
- Watercourse - Perennial

Springvale Coal
Springvale Water Treatment Project
Water Resources Impact Assessment

Job Number 21-25109
Revision 0
Date 10 Aug 2016

Surface water quality monitoring locations Upstream, discharge and downstream locations

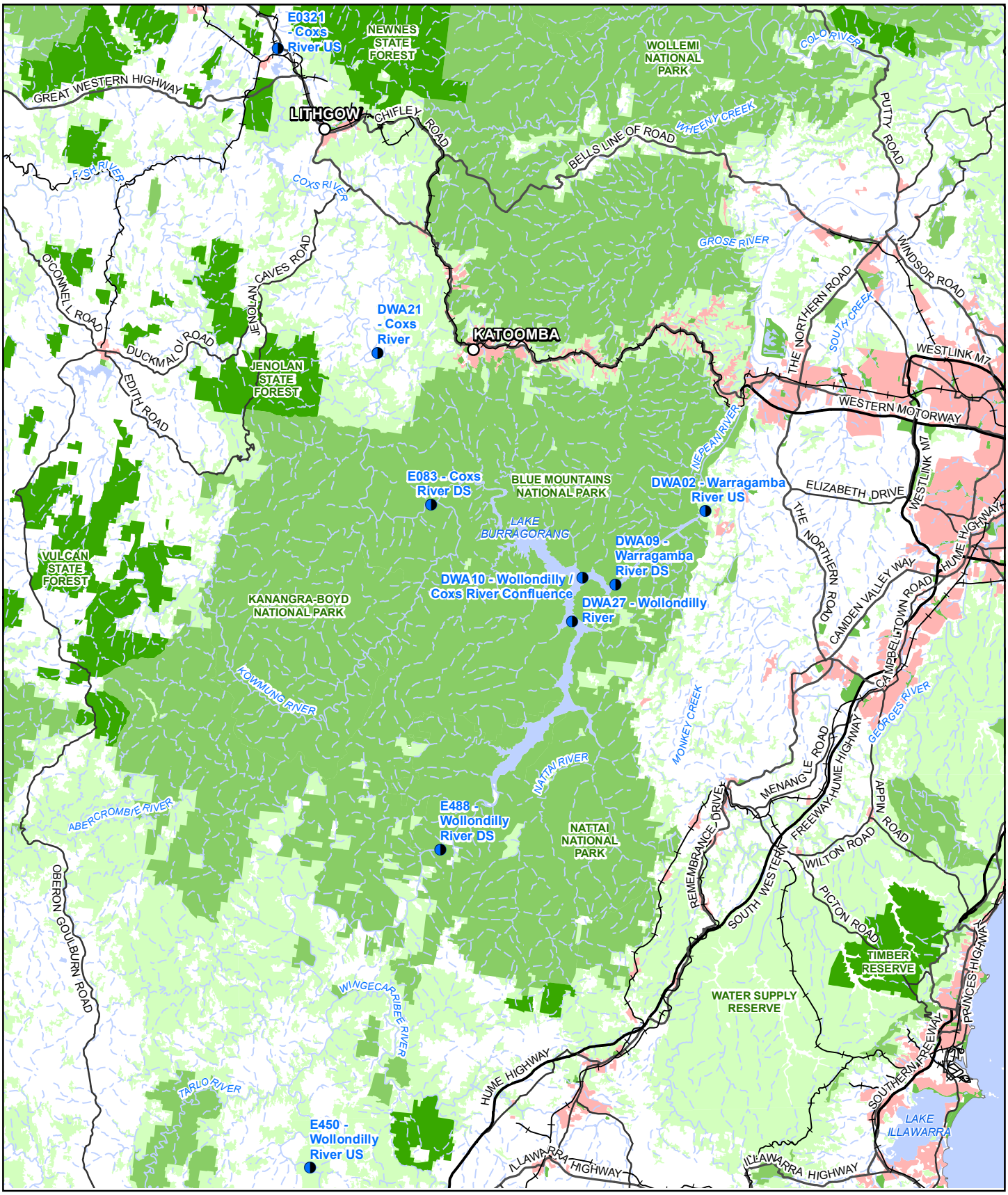
Figure 4-5

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Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial: Site location, boundaries, pipeline; imagery, 2016. Created by: tmorton



LEGEND

- Water quality monitoring location
- Dual Carriageway
- Principal Road
- Secondary Road
- Existing Rail
- Built up area
- Recreation area
- Nature Conservation
- State Forest
- Forest or shrub
- Waterbody
- Watercourse - Non perennial
- Watercourse - Perennial

Paper Size A4

0 2,125 4,250 8,500 12,750 17,000

Metres

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

N

Springvale Coal
Springvale Water Treatment Project
Water Resources Impact Assessment

Surface water quality monitoring locations
Regional locations

Job Number 21-25109
Revision 0
Date 10 Aug 2016

Figure 4-6

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Data source: LPI: DTDB/Imagery, 2012, 2015. Created by: tmorton

Table 4-8 Surface water quality monitoring location descriptions

Location	Site description
Upstream locations	
SW1	Neubecks Creek at the Mount Piper Haul Road culvert, upstream of the Neubecks Creek and Wangcol Creek confluence.
SW2	Wangcol Creek downstream of the Neubecks Creek and Wangcol Creek confluence.
SW3	Wangcol Creek upstream of the Neubecks Creek and Wangcol Creek confluence.
Wangcol Creek gauge	Wangcol Creek downstream of SW2.
Discharge locations	
LDP006	LDP006 discharge from SCSS to Lamberts Gully.
LDP009	LDP009 discharge from the SDWTS to Sawyers Swamp Creek.
Downstream locations	
Wangcol Creek D/S	Wangcol Creek downstream of the Lamberts Gully tributary.
Wangcol Creek far D/S	Wangcol Creek further downstream of the Lamberts Gully tributary.
Cox River D/S	Coxs River downstream of LDP009.
Regional locations	
E0321	Upper Coxs River sub-catchment on Coxs River upstream of the Springvale Creek confluence, near Wallerawang Power Station.
DWA21	Mid Coxs River sub-catchment on Coxs River approximately 20 km south of the Project site and 30 km north of Warragamba Dam.
E083	Lower Coxs River sub-catchment on Coxs River upstream from Lake Burragorang.
E450	Lake Burragorang sub-catchment on Wollondilly River approximately 50 km upstream from Lake Burragorang.
E488	Lake Burragorang sub-catchment on Wollondilly River 8 km upstream from Lake Burragorang.
DWA27	Lake Burragorang sub-catchment on Wollondilly River at Lake Burragorang upstream of the Brimstone Creek tributary and downstream of the Lacys Creek tributary.
DWA10	Lake Burragorang sub-catchment on Wollondilly River and Coxs River confluence.

Location	Site description
DWA02	Lake Burragorang sub-catchment on Warragamba River downstream of the Nepean River confluence at Warragamba Dam.
DWA09	Lake Burragorang sub-catchment on Warragamba River downstream of DWA02 and upstream of Coxs River confluence at Warragamba Dam.

The period of data reviewed for each location is provided in Table 4-9.

Table 4-9 Period of surface water quality data assessed

Location	Frequency	Number of samples	From	To
Upstream locations				
SW1	Fortnightly	15–60	15 March 2012	19 February 2015
SW2	Fortnightly	19–73	15 March 2012	11 January 2016
SW3	Fortnightly	17–69	15 March 2012	11 January 2016
Wangcol Creek gauge	Fortnightly	45–47	2 January 2014	17 December 2015
Discharge locations				
LDP006	Fortnightly	19–36	3 January 2013	3 December 2015
LDP009	Fortnightly	25–104	10 March 2014	15 December 2015
Downstream locations				
Wangcol Creek D/S	Fortnightly	23–34	2 January 2014	17 December 2015
Wangcol Creek far D/S	Fortnightly	23–34	16 January 2014	17 December 2015
Cox River D/S	Weekly	161	2 January 2013	15 December 2015
Regional locations*				
E0321	Fortnightly	24–56	25 July 2014	17 March 2016
DWA21	Fortnightly	1,518–49,296	4 January 1961	10 March 2016
E083	Fortnightly	174–366	20 January 2005	6 April 2016
E450	Fortnightly	148–200	4 January 2005	29 March 2016
E488	Fortnightly	219–453	6 January 2005	6 April 2016
DWA27	Fortnightly	1,412–1,578	5 January 2005	5 April 2016

Location	Frequency	Number of samples	From	To
DWA10	Fortnightly	359	27 April 1984	18 December 2010
DWA02	Fortnightly	1,518–25,995	4 January 2004	28 March 2016
DWA09	Fortnightly	1,348–25,930	4 January 2005	5 April 2016

* Monitoring at the regional locations is conducted automatically (one-minute logger data collected over 15 minutes at midday fortnightly).

4.6.2 Guideline values

Derivation of site-specific guideline values

SSGVs were derived on the basis of the methodology outlined by ANZECC (2000a) by calculating the 80th percentile of data collected at the reference site (and 20th percentile for parameters reported as a range, for example pH). These values were then compared with the DGVs recommended by ANZECC (2000a) as shown in Table 4-5 and the ADWGs determined by NHMRC (2016) as shown in Table 4-6.

Data below the limit of reporting

When the analytical result was below the limit of reporting for a particular parameter, then the detection limit was included in the calculation. This is one of the approaches recommended by ANZECC (2000a; Section 6.2.1). Table 4-10 identifies the limit of reporting for each water quality parameter.

It is understood that this approach has limitations, in particular when over 25% of data is below the detection limit. Where greater than 25% of values for a parameter in the reference site dataset were below the limit of reporting, the lowest detection limit reported for that dataset has been used in establishing the guideline values.

Table 4-10 Limit of reporting for water quality parameters

Parameter	Units	Limit of reporting
Physicochemical parameters		
EC	µS/cm	1
pH	pH units	0.1
TDS	mg/L	1
TSS	mg/L	1
Turbidity	NTU	1
Nutrients		
Ammonia	mg/L	0.01
Nitrate	mg/L	0.01
Nitrite	mg/L	0.01

Parameter	Units	Limit of reporting
Nitrite + nitrate	mg/L	0.01
Total Kjeldahl nitrogen (TKN)	mg/L	0.1
Total nitrogen	mg/L	0.1
Total organic carbon (TOC)	mg/L	1
Total phosphorus	mg/L	0.01
Anions		
Alkalinity	mg/L	1
Chloride	mg/L	1
Sulfate	mg/L	1
Cations		
Calcium	mg/L	1
Magnesium	mg/L	1
Potassium	mg/L	1
Sodium	mg/L	1
Metals		
Aluminium	mg/L	0.01
Antimony	mg/L	0.001
Arsenic	mg/L	0.001
Barium	mg/L	0.001
Boron	mg/L	0.05
Cadmium	mg/L	0.0001
Chromium	mg/L	0.001
Copper	mg/L	0.001
Iron	mg/L	0.05
Lead	mg/L	0.001
Lithium	mg/L	0.001
Manganese	mg/L	0.001
Mercury	mg/L	0.0001
Molybdenum	mg/L	0.001

Parameter	Units	Limit of reporting
Nickel	mg/L	0.001
Selenium	mg/L	0.01
Strontium	mg/L	0.001
Zinc	mg/L	0.005
Other		
Fluoride	mg/L	0.1
Oil and grease	mg/L	5
Phenols	mg/L	0.05
Total cyanide	mg/L	0.004

4.6.3 Ecotoxicology assessment

Sample collection

Three ecotoxicology assessments have been conducted on LDP009 discharge from Springvale Mine, in August and October 2014 (GHD, 2014a), April 2015 (GHD, 2015a) and May 2016 (GHD, 2016e). For the October 2014 testing round, a sample of LDP009 discharge prior to water quality treatment with flocculants was also collected for ecotoxicology testing (GHD, 2014a). Samples of mine water discharge, for all ecotoxicology assessments, were transported to the Ecotox Services Australasia (ESA) laboratory in Sydney for toxicity testing. Samples were also collected and transported to the ALS Environment Division Laboratory in Sydney for water quality analysis.

Direct toxicity assessment

Direct toxicity assessment (DTA) is a common method used to determine the toxicity of mixtures of compounds in ambient waters. The method provides an integrated measure of effects and accounts for interactions (synergistic, additive and ameliorative) within a mixture, therefore closely simulating the effects in the receiving waterway. To ensure a close simulation of the toxic effects of the discharge, site-specific testing was undertaken using species indigenous to, or representative of, the receiving ecosystem.

DTA was undertaken for the mine water discharge samples collected in August 2014 and May 2016. Toxicity testing in October 2014 and April 2015 was conducted using screening tests with freshwater cladoceran, which has been found to be the most sensitive test species in previous toxicity testing conducted by Centennial Coal in the region.

DTA involves exposing laboratory test species to a range of concentrations of sampled water for a specified exposure period. At the end of the exposure period, specific end points are assessed, such as species survival, reproduction or growth. Statistical analysis of the results provides the effect concentration of the discharge where 10% (EC_{10}) and 50% (EC_{50}) of test organisms exhibited an inhibition effect and the no observable effect concentration (NOEC) of the discharge, which represents the highest tested concentration that has no effect on the test organisms (when compared to the results of the control sample).

Species tested

August 2014

The following freshwater species and test protocols were used to test the sample collected from LDP009 in August 2014:

- Seven-day partial life-cycle test using the freshwater cladoceran *Ceriodaphnia dubia*, based on the USEPA (2002) and Bailey *et al.* (2000) protocols.
- 72-hour microalgal growth inhibition test using the freshwater alga *Selenastrum capricornutum*, based on the USEPA (2002) protocol.
- 96-hour growth inhibition test using the freshwater aquatic duckweed *Lemna disperma*, based on the OECD (2006) protocol.
- 96-hour population growth test using the freshwater hydra *Hydra viridissima*, based on the Riethmuller *et al.* (2003) protocol.
- 96-hour imbalance test using the freshwater eastern rainbowfish *Melanotaenia splendida splendida*, based on the USEPA (2002) protocol.

October 2014 and April 2015

The seven-day partial life-cycle toxicity test using the freshwater cladoceran *Ceriodaphnia dubia* was conducted on samples in October 2014 and April 2015, using the protocol specified by USEPA (2002).

May 2016

The following freshwater species and test protocols were used to test the sample collected from LDP009 in May 2016:

- Seven-day partial life-cycle test using the freshwater cladoceran *Ceriodaphnia dubia*, based on the USEPA (2002) and Bailey *et al.* (2000) protocols.
- 72-hour microalgal growth inhibition test using the freshwater alga *Selenastrum capricornutum*, based on the USEPA (2002) protocol.
- 96-hour growth inhibition test using the freshwater aquatic duckweed *Lemna disperma*, based on the OECD (2006) protocol.
- 10-day embryonic development and post-hatch survival test using the freshwater eastern rainbowfish *Melanotaenia splendida splendida*, based on the USEPA (2002) protocol.
- 10-day survival test using the freshwater shrimp *Paratya australiensis*, based on the USEPA (2002) protocol. It should be noted that this bioassay is not accredited with the National Association of Testing Authorities (NATA).

Concentrations tested

ESA recommends the use of laboratory dilution water to provide a more accurate indication of the toxicity of the samples. ESA used in-house diluents for all dilutions and controls to ensure the toxicity observed can be attributed directly to the sample tested. All samples were serially diluted with the appropriate diluent to achieve the test concentration.

For the samples of mine discharge water collected in August 2014 and May 2016, the concentrations used in the toxicity testing were 0%, 3.1% 6.3%, 12.5%, 25%, 50% and 100%. For the samples collected in October 2014 and April 2015, screening tests with the cladoceran bioassay were conducted at 100% concentration (i.e. no dilution of samples).

Water quality analysis

Water samples were tested for the parameters listed in Table 4-11 at the NATA accredited facilities at the ALS Environment Division Laboratory.

Table 4-11 Summary of water quality parameters analysed for ecotoxicology assessments

Category	Parameter
Physicochemical parameters	EC, pH, TDS, TSS.
Nutrients	Ammonia, dissolved organic carbon (DOC), nitrate and nitrite, TKN, total nitrogen, total phosphorus.
Anions	Alkalinity, chloride, sulfate.
Cations	Calcium, magnesium, potassium, sodium.
Metals (dissolved and total)	Aluminium, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, strontium, vanadium, zinc.
Other parameters	Bromide, cyanide (free and total), fluoride, oil and grease.

In addition to the parameters listed in Table 4-11, LDP009 discharge was tested for the following semi-volatile organic compounds in October 2014:

- Phenolic compounds.
- Polynuclear aromatic hydrocarbons.
- Phthalate esters.
- Nitrosamines.
- Nitroaromatics and ketones.
- Haloethers.
- Chlorinated hydrocarbons.
- Anilines and benzidines.
- Organochlorine pesticides.
- Organophosphorus pesticides.

Dilution factor

The BurrliOZ statistical analytical program (Campbell *et al.*, 2000) used the EC_{10} results from the toxicity testing in August 2014 and May 2016 to calculate the concentration of mine water discharge to protect 99%, 95%, 90% and 80% of species in the receiving environment from a 10% reduction in growth or reproduction. Dilution factors were then calculated for each species protection level, which can be used to assist in deriving site-specific concentrations of contaminants that will not adversely impact organisms within the receiving ecosystem. Concentrations of individual contaminants cannot be extrapolated from toxicity testing results for use as guideline values. However, concentrations can be used for monitoring purposes to ensure that the dilution factors are met at the appropriate monitoring site.

It should be noted that the future version of the ANZECC (2000a) guidelines will require the use of a log-logistic distribution for datasets of small sample sizes. The BurrliOZ program requires a minimum of eight datasets to obtain an accurate species sensitivity distribution and results using less datasets must be interpreted with caution.

4.7 Groundwater environment

The assessment of the groundwater environment included a review of baseline groundwater level and quality data and an assessment of the potential impacts of the Project. Groundwater monitoring locations are presented in Figure 4-7. The assessment focused on the risks associated with potential contamination by waste emplacement and brine application activities on existing groundwater resources local to the MPPS and the SCSS operations.

4.8 Downstream water users

The potential impacts of the Project on licensed surface water users and basic landholder rights under the WM Act were assessed by identifying the downstream users within the potential area of impact. The potential area of impact was estimated conservatively based on the results of the assessments on water and salt balance, catchment hydrology and hydraulics, waterway geomorphology, surface water quality and groundwater environment.

Licensed surface water users and domestic and stock rights users with a water supply work approval were identified by searching for all lots within the potential area of impact in the NSW Water Register (DPI-Water, 2016a). Groundwater users were identified by searching the NSW groundwater bore database (DPI-Water, 2016b) for registered groundwater bores.

4.9 Cumulative impacts

The cumulative impacts of the Project were assessed according to the delineation of the cumulative impact assessment boundary. For each of the assessment categories listed above, if the impact to water resources was determined to extend beyond the Project, the Cumulative Impact Assessment Boundary was defined as the predicted area of change plus the catchment area contributing to the waterway at the downstream limit of the impact. It is anticipated that the impacts created by the Project beyond the Cumulative Impact Assessment Boundary will no longer be measurable.

The cumulative impact assessment boundary was defined as the Coxs River catchment, as shown in Figure 4-8. An assessment was undertaken on the following activities within the Cumulative Impact Assessment Boundary which were identified to potentially influence the cumulative impact on surface water and groundwater resources:

- Angus Place Colliery.
- Lidsdale Siding.
- MPPS.
- Pine Dale Coal Mine.
- Springvale Coal Services (Western Coal Services).
- Springvale Mine.

It should be noted that the impacts of other identified operations were not considered unless they have the potential to significantly influence the cumulative impacts of the Project.



Paper Size A4

0 0.075 0.15 0.3 0.45 0.6

Kilometers

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

N

LEGEND

- Project application area
- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- Centennial Coal borehole
- EnergyAustralia borehole
- Watercourse - Non Perennial
- Watercourse - Perennial

Springvale Coal
Springvale Water Treatment Project
Water Resources Impact Assessment

Job Number 21-25109
Revision 0
Date 10 Aug 2016

Groundwater monitoring locations

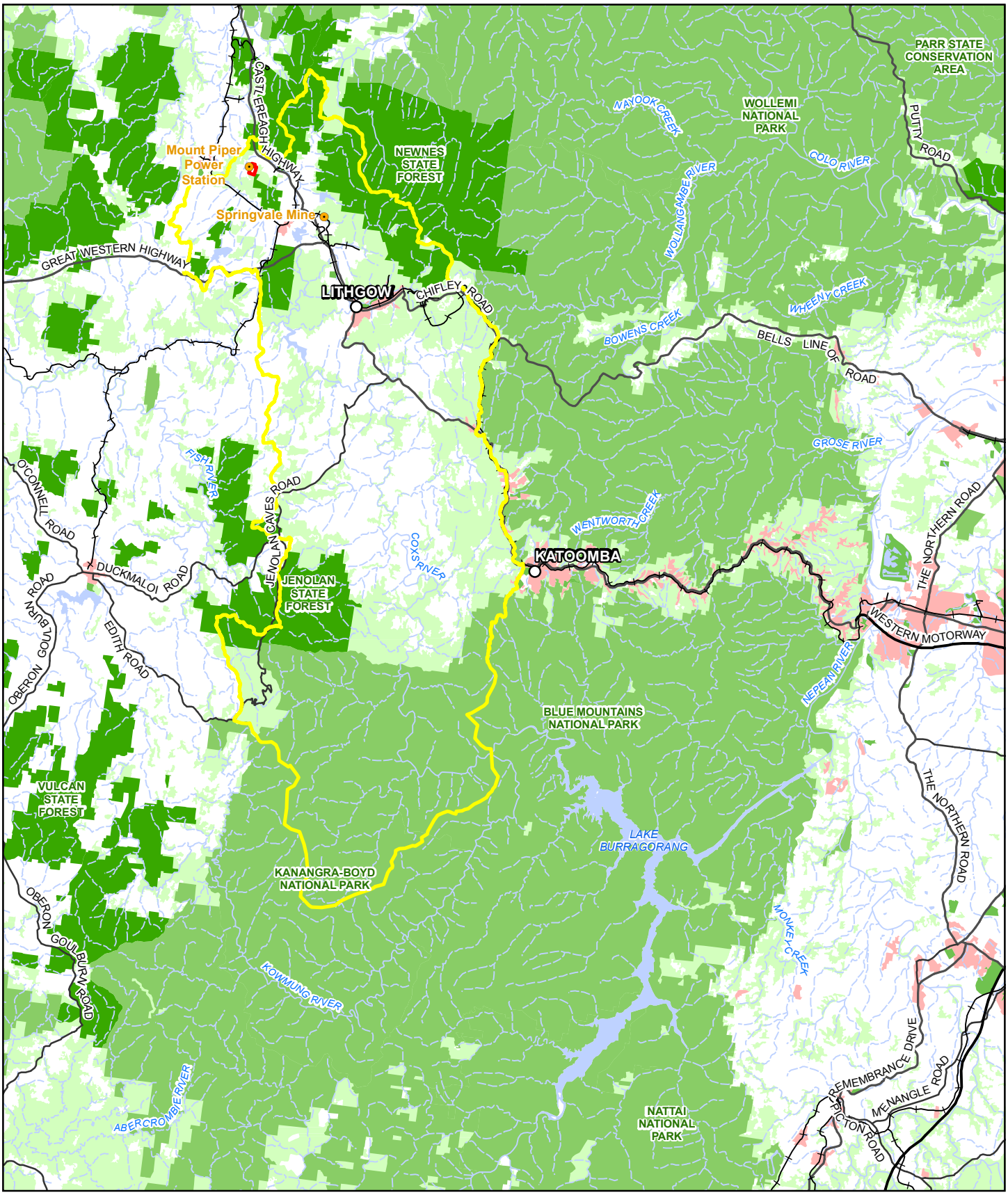
Figure 4-7

G:\22\0105001\GIS\Maps\Deliverables\Western\Springvale\2125109\WRIA\10_3\2125109_WRIA012_GWMonitoringLocations_0.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

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Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial: Site location, boundaries, alignment, monitoring locations, imagery, 2016. Created by: tmorton



LEGEND

- Cumulative impact assessment boundary
- Project location
- Dual Carriageway
- Principal Road
- Secondary Road
- Existing Rail
- Built up area
- Recreation area
- Nature Conservation
- State Forest
- Forest or shrub
- Waterbody
- Watercourse - Non perennial
- Watercoures - Perennial

Paper Size A4

0 1,750 3,500 7,000 10,500 14,000

Metres

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

N

GHD

Springvale Coal
Springvale Water Treatment Project
Water Resources Impact Assessment

Cumulative impact assessment boundary

Job Number	21-25109
Revision	0
Date	10 Aug 2016

Figure 4-8

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

G:\22\0105001\GIS\Maps\Deliverables\Western\Springvale\2125109\WRIA\10_3\2125109_WRIA011_CumulativeImpact_0.mxd

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Data source: LPI: DTDB/Imagery, 2012, 2015. Created by: tmorton

5. Existing conditions

5.1 Existing water management

5.1.1 Mount Piper Power Station

Operational area

Water management at the main operational area of MPPS includes stormwater, process wastewater and sewage management systems. The existing water management features at MPPS are shown in Figure 5-1.

Stormwater is defined as clean runoff from catchments typically associated with grassed, hardstand and car parking areas that do not involve coal handling. This water is captured within a pit and pipe network, directed to trunk open channels and captured in the Final Holding Pond at the north of the site. The Final Holding Pond has two options for management of captured water: pump out with water reused as make-up water for the cooling water system or discharge via LDP1 to Wangcol Creek. Discharges via LDP1 occur infrequently and typically only as a result of rainfall events and when the Final Holding Pond capacity is exceeded.

Process wastewater is defined as blowdown water from the cooling water system and stormwater from areas that are likely to generate oil contamination or contaminated with ash or chemicals. Process wastewater is treated prior to reuse as make-up water. The treatment process is dependent on the source of potential contamination and include settlement, oil/water separation, chemical dosing, brine concentration and reverse osmosis (RO).

Sewage from plant amenities is treated on site and reused as make-up water for the cooling water system. Sludge settling is done on site and settlement ponds are designed for the life of the station.

The existing water management infrastructure present at MPPS includes:

- Contaminated water pond with a capacity of 8 ML.
- Three 8 ML settling ponds for ash and chemical waste.
- Two cooling water blowdown ponds. Pond A has a capacity of 77 ML and Pond B has a capacity of 103 ML.
- Two 20 ML brine waste ponds managing outputs from the existing brine concentrators.
- Clean water pond with a capacity of 30 ML.

Each of these storages is lined with rubber to prevent groundwater interactions, with the brine waste ponds double lined. The existing MPPS groundwater monitoring network acts as a leakage detection system for these lined storages.

Brine management

As water is evaporated from the cooling water system, the concentration of salts contained in the circulating water increases, which may cause scaling on equipment surfaces and impact upon the operation of the system. Blowdown water is regularly removed from the system and replaced with fresh make-up water to prevent scaling.

Blowdown water is treated in two brine concentrators to reduce the EC of the water. An RO system has also been installed to treat blowdown water and is used when additional treatment capacity is required. Distillate from the treatment processes is reused within the cooling water system, with the brine by-product stored within the two brine waste ponds prior to co-disposal with ash.



Paper Size A4

0 0.075 0.15 0.3 0.45 0.6

Kilometers

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

N

LEGEND

- Project application area
- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- Principal Road
- Minor Road
- MPPS Water Storages
- Ash emplacement area
- Mt Piper Power Station LDP
- Watercourse - Non Perennial
- Watercourse - Perennial

Springvale Coal
Springvale Water Treatment Project
Water Resources Impact Assessment

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Revision 0
Date 10 Aug 2016

Mount Piper Power Station
Existing water management features Figure 5-1

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Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial: Imagery, 2016. Created by: tmorton

Ash emplacement

Ash generated as a by-product of power generation at MPPS is deposited within the ash emplacement area, which is located within the mine void of the former Western Main open cut. Ash is conditioned with water or brine to increase the moisture content to improve handling, compaction and dust suppression. The ash emplacement area is approximately 43 ha in size and at completion will extend up to 980 m AHD, as shown in Figure 5-2.

After each ash emplacement lift, the material is compacted to between 98% to 99 % from its placed density. Compaction is undertaken using equipment on-site. The compaction of ash minimises infiltration into the ash emplacement from rainfall. The generation of runoff is directed to a detention pond of approximately 300 ML and has a capacity to capture a 5 year to 10 year ARI event.

The placement of brine conditioned ash occurs above 946 m AHD above the base layer of mine spoil and a layer of water conditioned ash. As brine conditioned ash placement reaches its maximum height, it is covered with a minimum of 1 m of water conditioned ash and then covered with a minimum of 200 mm of compacted soil. Diversion drains exist to collect and direct any surface runoff to the detention pond, which is then reused for dust suppression.

The development of the Lamberts North ash emplacement expansion is currently underway. Currently ash emplacement has occurred up to a level of 928 m AHD within this area, consisting of water conditioned ash only. Brine conditioned ash will occur in the future above the level of 946 m AHD.

Water supply

Make-up water for the cooling water system at MPPS is supplied from the following sources:

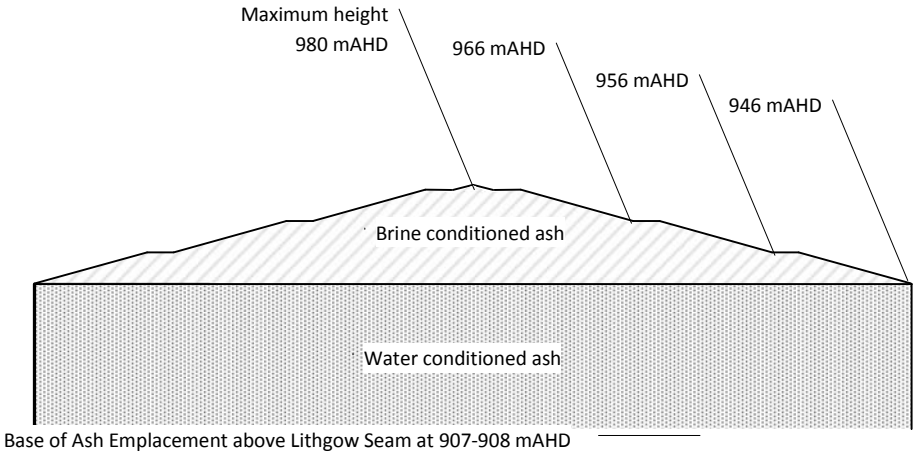
- Treated process wastewater stored on site.
- Coxs River via Lake Lyell and Thompsons Creek Reservoir.
- Fish River water supply scheme.

As discussed, process wastewater includes blowdown water from the cooling water system and potentially contaminated stormwater. Process wastewater is treated prior to reuse as make-up water.

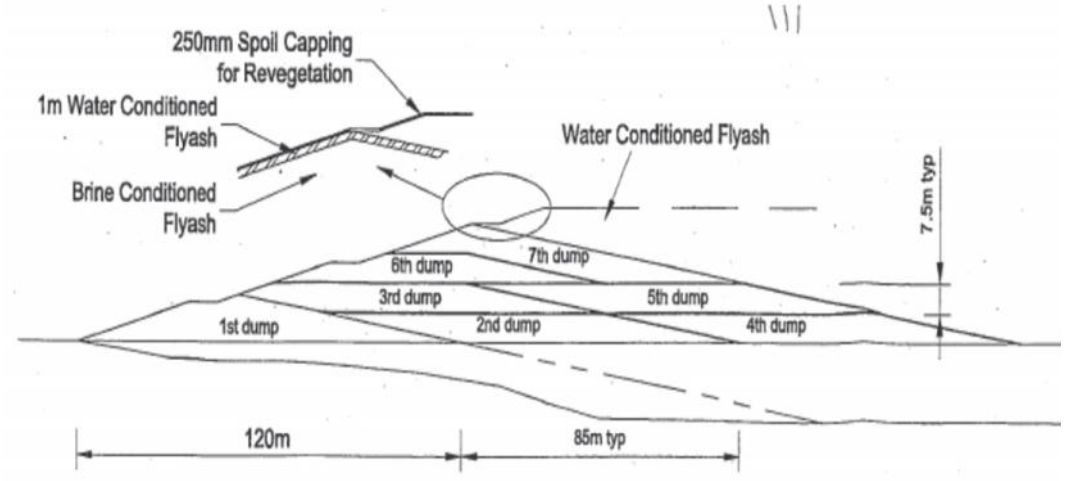
The majority of the make-up water used at MPPS has historically been sourced from the Coxs River. A system of storage dams, interconnecting pipelines and pumping stations exist to supply water to MPPS. Make-up water is pumped from Lake Lyell directly to the cooling water system or to Thompsons Creek Reservoir for storage. EnergyAustralia is currently licensed to extract up to 23,000 ML/year from the Coxs River under WAL 27428 (refer Section 2.1.4).

Make-up water is supplemented by the Fish River water supply scheme, which is sourced from the Duckmaloi Weir and Oberon Dam. EnergyAustralia has an annual allocation of 8,184 ML/year from the Fish River water supply scheme, which is managed by WaterNSW (refer Section 2.1.4).

Figure 5-3 presents the historical make-up water demand for MPPS and Figure 5-4 provides the relationship between power generation and water demand. Historical make-up water demand has varied between 10 ML/day and 62 ML/day since 2010, corresponding to power generation between 20% and 100% of the maximum power generation capacity at MPPS. As shown in Figure 5-3, prior to 2014 demand generally exceeded 30 ML/day, however, demand has reduced in recent years.



Final form of ash emplacement



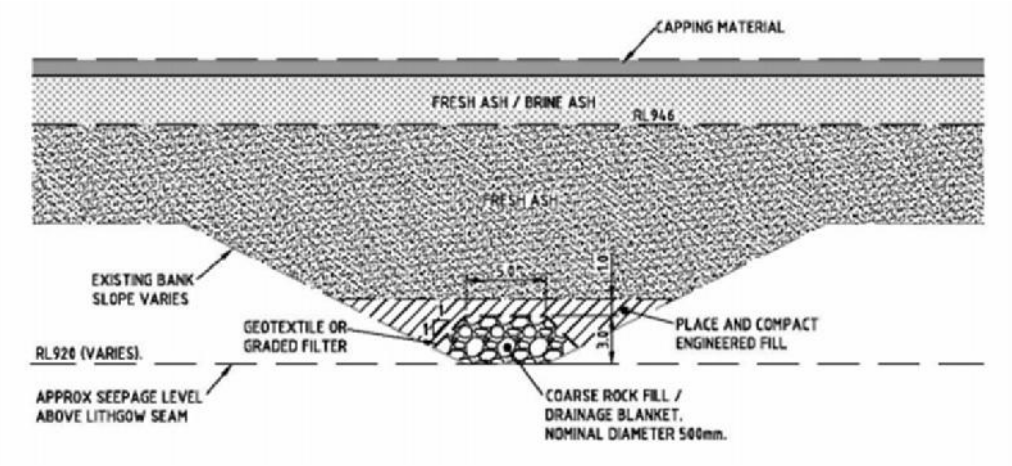
Emplacement strategy and capping detail for Ash

General Notes

Ash emplacement developed at
- 10 m lifts
- 10 m wide berm between lifts graded inwards to capture runoff
- Access roads graded inwards to divert runoff towards detention pond
- Nominal slope of batters at 1V in 4H

Brine co-placement arrangements include:
- Dust and drainage controls
- Dedicated placement cells
- Sprays to prevent dust generation. Mobile watering plant to control dust beyond the area of the sprays.

A drainage system to capture collected runoff to the co-placement area
A lined detention pond of 300 ML allows for capture of runoff up to a 10 year ARI event.



Typical drainage layer for ash emplacement base for Lamberts North Emplacement

Source: Connell Wagner (2007)

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LOCATION	SCS
SEAM	NA
DRAWN	LH
CHECKED	LH
APPROVED	SG
SCALE	NTS

Centennial Coal
EA/CEY Water Treatment Project
Water Resources Impact Assessment

Ash Emplacement Details

Centennial Coal
EnergyAustralia

DATE June 2016

Figure 5-2

\\ghdnet\ghd\AU\Newcastle\Projects\21\25109\Visio\2125109_AshEmplacementTypicalDetails.vsdx

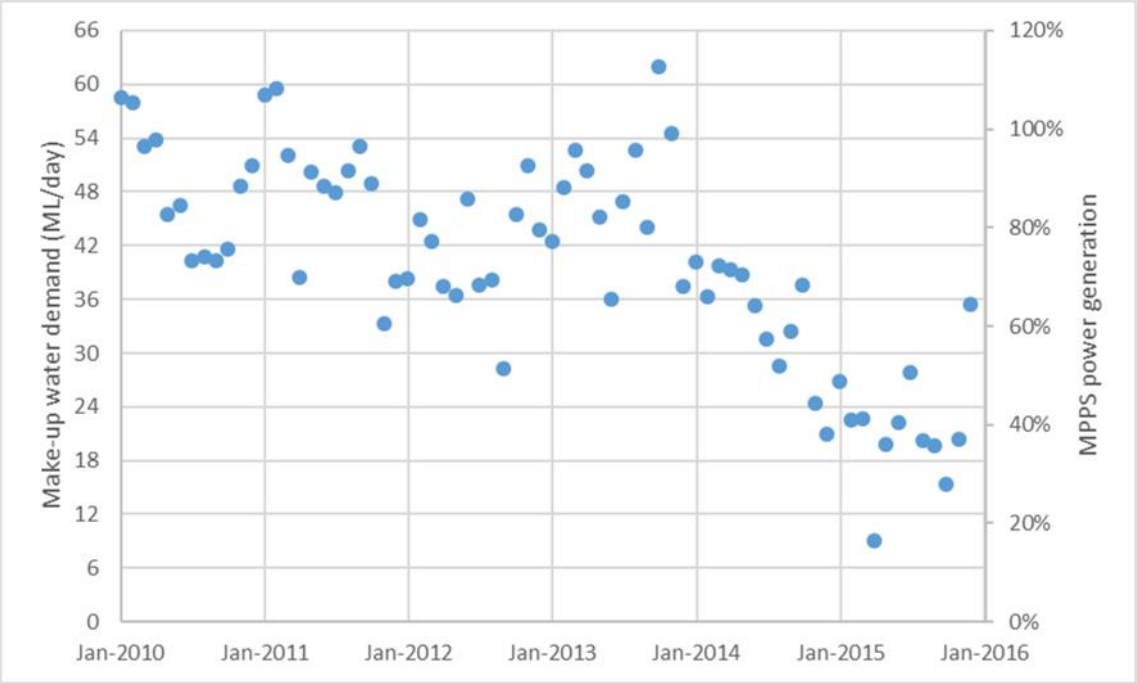


Figure 5-3 Average daily make-up water demand at MPPS

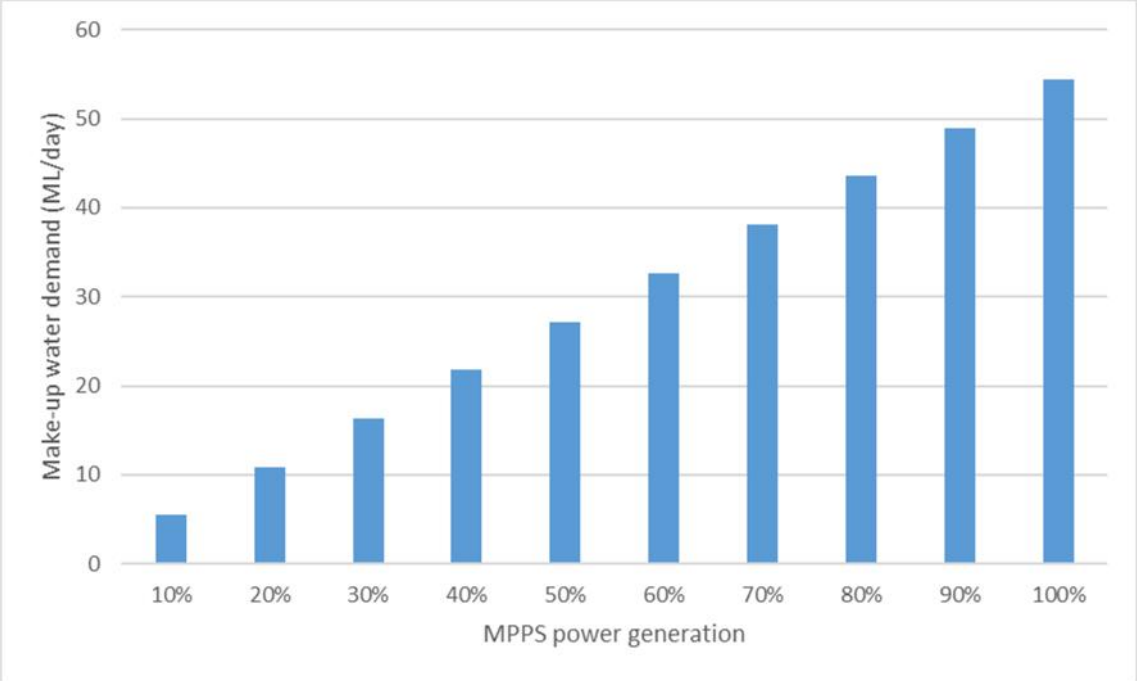


Figure 5-4 Power generation at MPPS and make-up water demand

5.1.2 Angus Place Colliery and Springvale Mine

Groundwater inflows into the underground workings at Angus Place Colliery and Springvale Mine are managed by transfer to the SDWTS. The SDWTS is a pipeline network that was established to transfer water from dewatering facilities at both mines on the Newnes Plateau to Wallerawang Power Station. The decommissioning of Wallerawang Power Station commenced in May 2014. Since this time mine water transferred to the SDWTS has been discharged via LDP009 to Sawyers Swamp Creek.

Currently, the SDWTS receives mine water from Bore 6, Bore 8 and the Ventilation Shaft No. 3 borehole at Springvale Mine and from Bore 940 at Angus Place Colliery at a rate of up to 30 ML/day. Transfers from Springvale Mine take priority, with the remaining capacity of the SDWTS supplied by transfers from Angus Place Colliery. Dewatering of the underground workings at Angus Place Colliery is currently ongoing while the mine is under care and maintenance.

Raw mine water from Angus Place Colliery and Springvale Mine is combined in a single pipeline that finishes at the LDP009 sedimentation ponds. Approximately 100 m before the end of the pipeline, a polymer injection system delivers a chemical into the pipeline. The polymer is designed to attract any suspended solids in the water, forming strings which become heavy and settle in the sedimentation ponds. Water continues to flow through the ponds, removing suspended solids and is discharged via a concrete spillway. LDP009 is located at the bottom of the discharge spillway. The sedimentation ponds are dredged twice annually, with material placed into the REA at the SCSS.

Springvale Mine is licensed under EPL 3607 to discharge up to 30 ML/day through LDP009. Monitored daily discharges through LDP009 from December 2013 to January 2016 are presented in Figure 5-5. Typically, discharges have been between 20 ML/day to 25 ML/day. Over the monitored period approximately seven events occurred where discharge volumes reduced to a low level. These events have been associated with maintenance activities or changes within the underground mine environment.

The water quality of LDP009 discharges is discussed in Section 5.6.1.

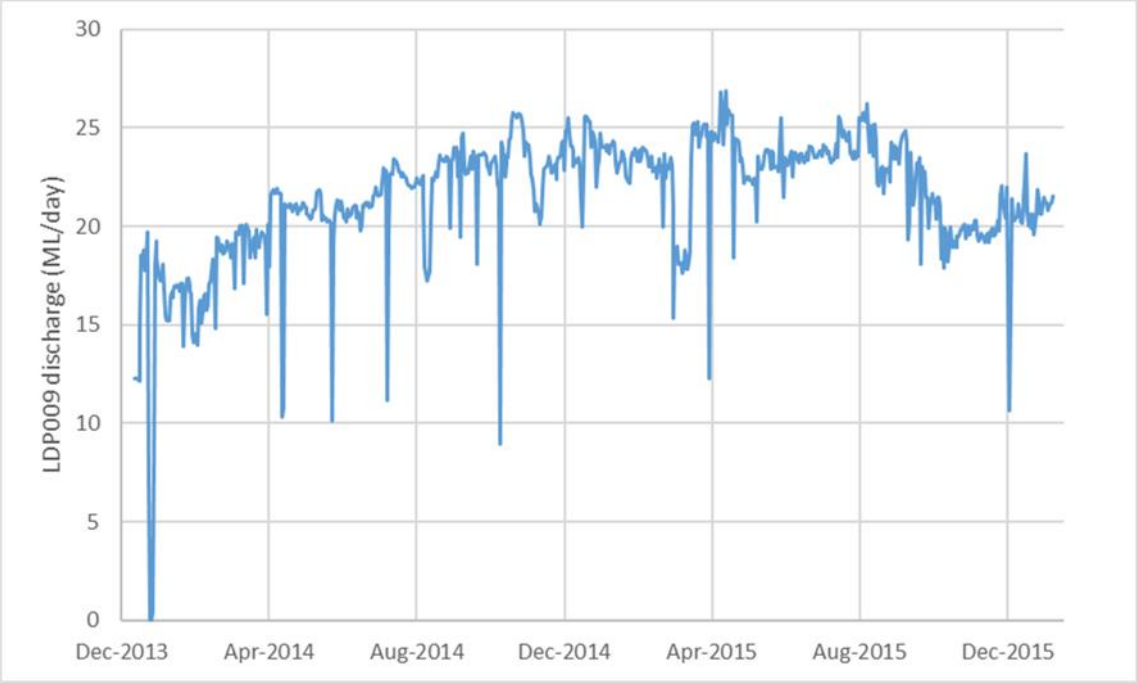


Figure 5-5 Monitored daily LDP009 discharges

5.1.3 Springvale Coal Services

Water management at SCSS is associated with the storage, handling and processing of coal from Springvale Mine. No active mining occurs at the site. The existing water management features of the SCSS are shown in Figure 5-6.



Paper Size A4

0 0.075 0.15 0.3 0.45 0.6

Kilometers

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

N

LEGEND

- Project application area
- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- Principal Road
- Minor Road
- SCS Water Storages
- Springvale Coal Services LDP
- Watercourse - Non Perennial
- Watercourse - Perennial

Springvale Coal
Springvale Water Treatment Project
Water Resources Impact Assessment

Job Number 21-25109
Revision 0
Date 10 Aug 2016

Springvale Coal Services Site
Existing water management features Figure 5-6

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Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

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Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial: Imagery, 2016. Created by: tmorton

The water management system at the SCSS includes the collection of catchment runoff and seepage from historical mine workings in a series of surface water storages. This water is treated (if required) and reused on site within the washery and for dust suppression.

The processing of ROM coal in the washery produces both fine and coarse reject material, which is deposited in the REA. Coarse reject is used to construct cells within the REA, with fine reject stored within these cells. The co-disposal storage facility has historically been used to temporarily store reject material for a drying period prior to being blended with coal product. However, this facility is rarely used with the reject material sent directly from the washery to the REA. Recently the co-disposal storage facility was used temporarily in the interim between the closing of the A Pit REA and the opening of the new REA.

The site has a long history of mining using both underground and open cut methods. There are a number of historical open cut voids in the western part of the SCSS, including the H Pit West, H Pit East and Council Pit. Water stored in these voids is likely to be connected to the historical underground mine workings which contribute down gradient to Cooks Dam. The A Pit is also a historical open cut void that was used as an REA for fine reject material until late 2015. This storage currently forms part of the Lamberts Gully REA system, acting as a sediment pond that receives water decanted from the REA.

Inflows to Cooks Dam have been observed to occur from various locations along the western edge of the dam, originating from historical underground workings. The storage was historically constructed using a small (less than 3 m in height) homogeneous earth fill (overburden) bund, around the crest of an existing open cut pit and is not lined. Cooks Dam is located at the lowest point within the Lithgow Seam and forms a sink for much of the local groundwater environment.

Sub-surface inflows also possibly enter the DML Dam, similar to the relationship observed at Cooks Dam, with groundwater contribution from the Lithgow Seam. The water level in the dam reportedly remains relatively constant, except following significant rainfall events, which causes the water level to rise temporarily. The DML Dam is an unlined storage and it is likely that water from the storage infiltrates into the historical underground mine workings

Discharges from Cooks Dam and the Retention Pond at SCSS occur to Wangcol Creek via LDP006, which is licensed under EPL 3607 held by Springvale Mine. Monitored daily discharges through LDP006 from March 2012 to March 2016 are presented in Figure 5-7. The figure indicates a historical range of discharge volumes between 0 ML/day and 14 ML/day. LDP006 monitors discharges from the SCSS as well as the contribution of catchment runoff to Lamberts Gully and hence discharge volumes become elevated following rainfall events. Typically, discharge volumes from the SCSS are on average 1.29 ML/day which is predominately contribution of groundwater to Cooks Dam.

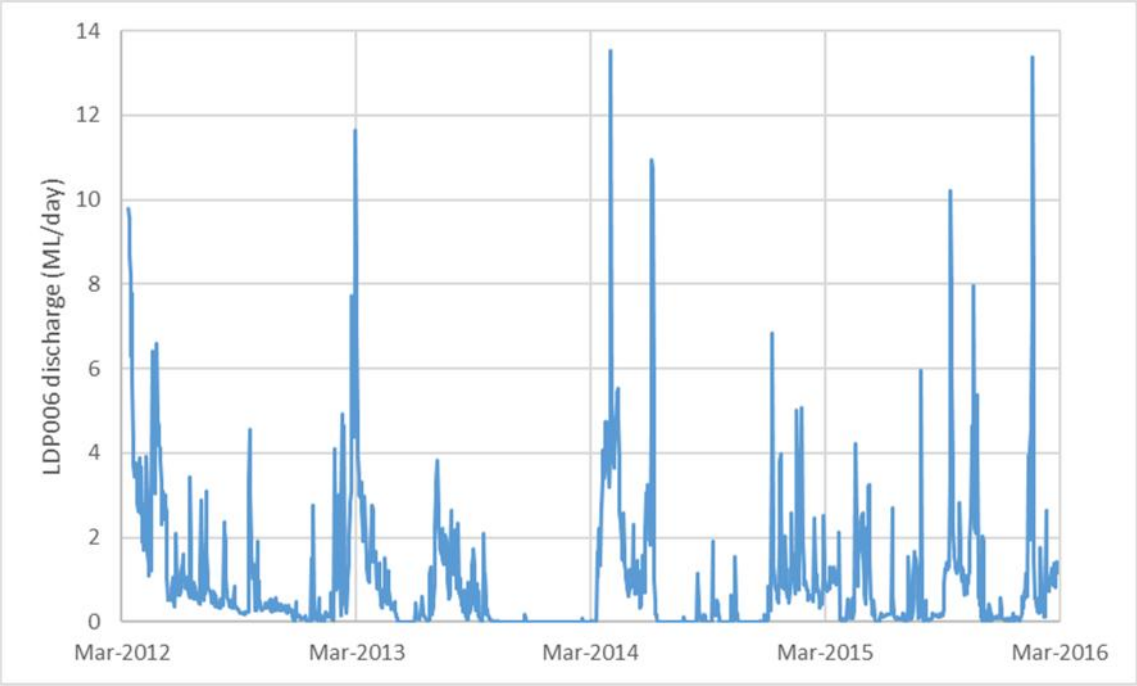


Figure 5-7 Monitored daily LDP006 discharges

5.2 Water and salt balance assessment

5.2.1 Model validation

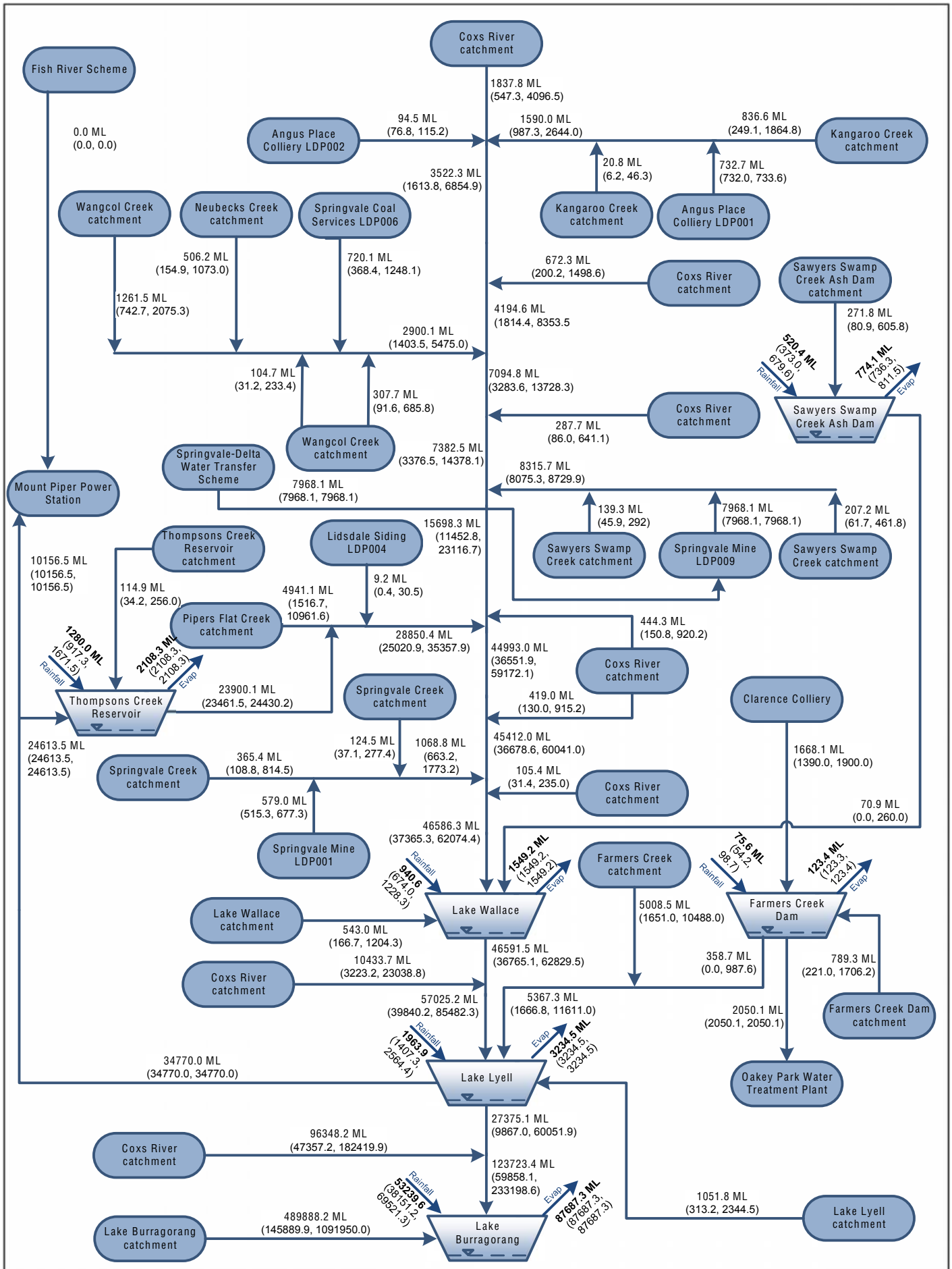
Outputs of the water and salt balance model were compared to available stream flow and EC data to provide an indication of the validity of the representation of existing conditions in the model. Data from two monitoring locations on the Coxs River over a period of ten years was used to verify the modelling outputs. The results of the model validation are provided in Appendix B.

5.2.2 Water balance results

The water cycle for the Coxs River catchment was modelled based on the current conditions in 2016, using a historical time series of daily rainfall data extending over 127 years. A total of 127 simulations were applied with each simulation modelling a different rainfall pattern (refer Section 4.2.2). As a result, 127 annual totals were available for each element within the water balance model, thereby representing a wide range of possible rainfall conditions.

Water balance modelling estimated the annual volumetric transfers between the water cycle components under existing conditions, as shown in Figure 5-8. These results are based on a 50% power generation requirement at MPPS. The results present the average annual transfers between water management elements as well as the 10th percentile and 90th percentile values. The purpose of displaying the three results for each water transfer is to show the average transfer volume and an indication of the range of values expected due to possible variation in rainfall.

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 remove the impact of skewing by infrequent to extreme wet and dry conditions.



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LOCATION	Coxs River
SEAM	NA
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

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Annual water transfers
Existing conditions (2016)

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Figure 5-8

From the results provided in Figure 5-8, average inputs and outputs were assessed for Wangcol Creek at the confluence with the Coxs River and for the Coxs River upstream of Lake Burragorang.

Wangcol Creek catchment

A summary of the average annual inputs and outputs for the water balance for the Wangcol Creek catchment under existing conditions in 2016 is presented in Table 5-1.

As seen in Table 5-1, the discharge from Wangcol Creek into the Coxs River was modelled to be approximately 2,900 ML/year on average. Catchment runoff into Wangcol Creek was estimated to be approximately 2,180 ML/year on average, which equates to 75% of the total flow to the confluence with the Coxs River. Discharges from the SCSS was estimated to contribute approximately 720 ML/year on average to the creek, equating to 25% of the total flow modelled.

Table 5-1 Summary of average annual water inputs and outputs for Wangcol Creek catchment under existing conditions in 2016

	Existing conditions (ML/year)
	50% power generation
INPUTS	
Catchment runoff	2,180.0
LDP discharge from SCSS (LDP006)	720.1
TOTAL INPUTS (rounded)	2,900
OUTPUTS	
Contribution to Coxs River	2,900.1
TOTAL OUTPUTS (rounded)	2,900
BALANCE	
Inputs – outputs	0

Coxs River catchment

A summary of the average annual inputs and outputs for the water balance for the Coxs River catchment under existing conditions in 2016 is presented in Table 5-2.

As seen in Table 5-2, the largest source of water into the Coxs River catchment was rainfall onto surface water storages and catchment runoff, which accounted for approximately 131,923 ML/year on average, equating to 92% of the total inflows to the system. The second largest input under existing conditions was modelled to be associated with the mine water from Angus Place Colliery and Springvale Mine dewatered to the SDWTS. The inflow from the SDWTS of 7,968 ML/year, which was modelled to be discharged to Sawyers Swamp Creek via Springvale Mine's LDP009 under existing conditions, contributed approximately 6% of the total inflows to the system.

Table 5-2 Summary of average annual water inputs and outputs for Coxs River catchment under existing conditions in 2016

	Existing conditions (ML/year)
	50% power generation
INPUTS	
Direct rainfall onto storages and catchment runoff	131,923.2
Supply from Fish River water supply scheme to MPPS	0.0
Transfer from Clarence Colliery to Farmers Creek Dam	1,668.1
LDP discharge from Angus Place Colliery (LDP001)	732.7
LDP discharge from Angus Place Colliery (LDP002)	94.5
LDP discharge from Lidsdale Siding (LDP004)	9.2
LDP discharge from SCSS (LDP006)	720.1
LDP discharge from Springvale Mine (LDP001)	579.0
LDP discharge from Springvale Mine (LDP009)	7,968.1
TOTAL INPUTS (rounded)	143,695
OUTPUTS	
Evaporation	7,789.5
Additional make-up water used at MPPS*	10,156.5
Oakey Park WTP use	2,050.1
Contribution to Lake Burragorang	123,723.4
TOTAL OUTPUTS (rounded)	143,720
CHANGE IN STORAGE	
Farmers Creek Dam	0.8
Lake Lyell	28.6
Lake Wallace	0.1
Thompsons Creek Reservoir	0.0
Sawyers Swamp Creek Ash Dam	-53.8
TOTAL CHANGE IN STORAGE (rounded)	-24
BALANCE	
Inputs –outputs – change in storage	0

* Additional make-up water sourced from Coxs River via Lake Lyell and Thompsons Creek Reservoir.

The volume of make-up water used by MPPS in the cooling water system was modelled under existing conditions to be 10,157 ML/year with a 50% power generation requirement. This water was modelled to be supplied by the Coxs River via Lake Lyell and Thompsons Creek Reservoir and equates to 7% of the total inflows into the Coxs River catchment.

Under the existing conditions modelled, the total annual flow within the Coxs River upstream of Lake Burragorang was estimated to be approximately 123,723 ML/year on average. Of this, 8% on average was contributed by site-based discharges from Angus Place Colliery, Lidsdale Siding, the SCSS and Springvale Mine.

5.2.3 Salt balance results

As discussed in Section 4.2.6, the salt balance model was developed as an extension of the water balance model with expected concentrations of salt applied to water inflows into the system. Similar to the water balance, salt balance modelling provided 127 possible annual totals of salt transfers between the water cycle components of the Coxs River catchment under existing conditions, as shown in Figure 5-9. As with the water balance results, the salt balance results are based on a 50% power generation requirement at MPPS. The results present the average annual salt transfers as well as the 10th percentile and 90th percentile values to provide an indication of the range of values expected due to possible variation in rainfall. In addition to the salt transfer quantities, the average salinity of each transfer is also displayed on the figure.

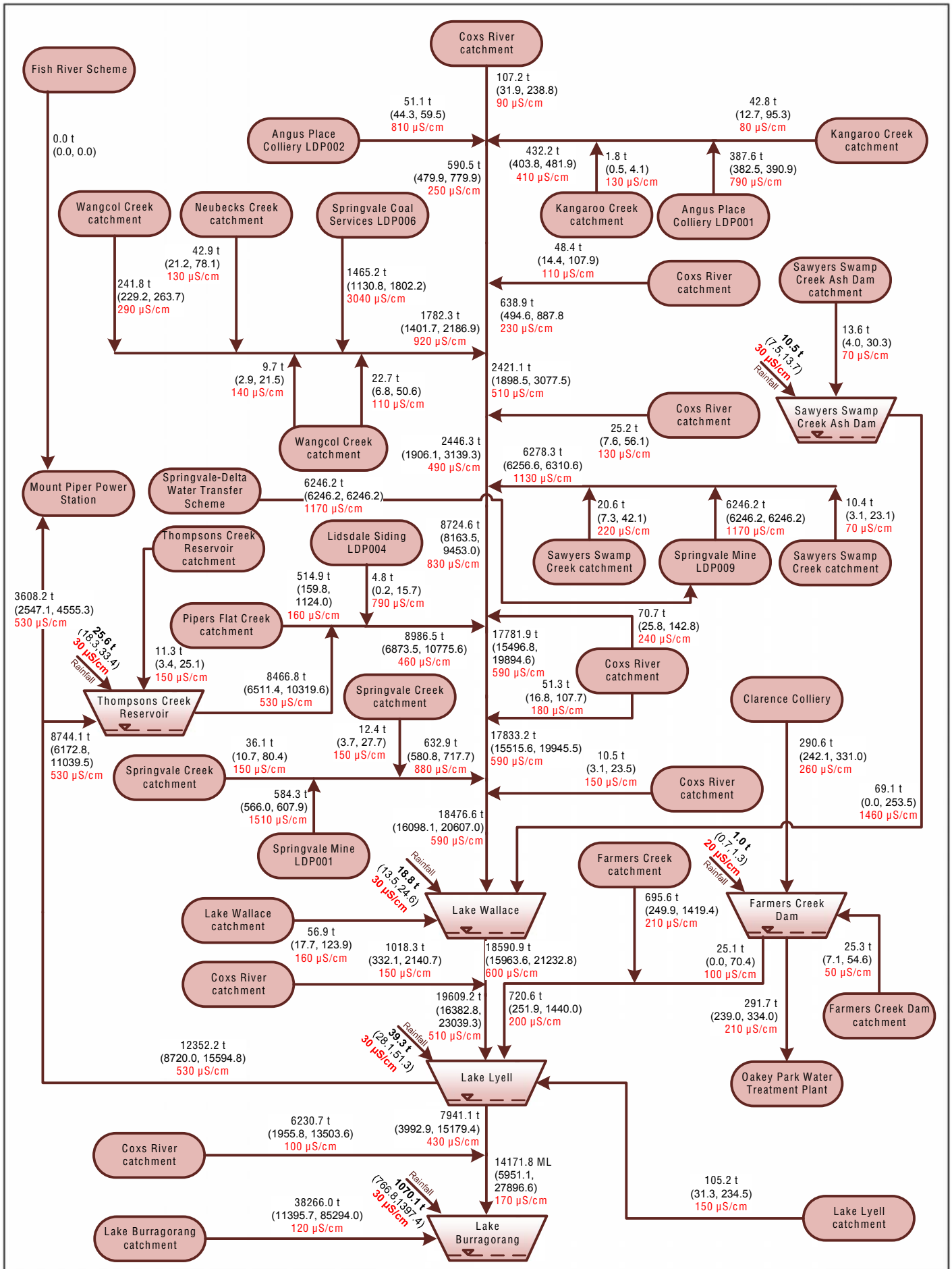
Wangcol Creek catchment

A summary of the average annual inputs and outputs for the salt balance for the Wangcol Creek catchment under existing conditions in 2016 is presented in Table 5-3.

Table 5-3 Summary of average annual salt inputs and outputs for Wangcol Creek catchment under existing conditions in 2016

	Existing conditions (t/year)
	50% power generation
INPUTS	
Catchment runoff	317.1
LDP discharge from SCSS (LDP006)	1,465.2
TOTAL INPUTS (rounded)	1,782
OUTPUTS	
Contribution to Coxs River	1,782.3
TOTAL OUTPUTS (rounded)	1,782
BALANCE	
Inputs – outputs	0

As shown in Table 5-3, the discharge from Wangcol Creek into the Coxs River was modelled to contribute approximately 1,782 t/year of salt on average. Although catchment runoff was the largest source of water into Wangcol Creek, it did not contribute a significant salt load. Salt associated with catchment runoff was estimated to be approximately 317 t/year on average, which equates to 18% of the total salt load of Wangcol Creek.



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LOCATION	Coxs River
SEAM	NA
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

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Annual salt transfers
Existing conditions (2016)

Centennial Coal
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Figure 5-9

The major source of salt into Wangcol Creek was associated with the discharge from the SCSS via LDP006, which was predicted to contribute approximately 1,465 t/year on average, equating to 82% of the total salt load.

Coxs River catchment

A summary of the average annual inputs and outputs for the salt balance for the Coxs River catchment under existing conditions in 2016 is presented in Table 5-4.

Table 5-4 Summary of average annual salt inputs and outputs for Coxs River catchment under existing conditions in 2016

	Existing conditions (t/year)
	50% power generation
INPUTS	
Direct rainfall onto storages and catchment runoff	9,521.3
Supply from Fish River water supply scheme to MPPS	0.0
Transfer from Clarence Colliery to Farmers Creek Dam	290.6
LDP discharge from Angus Place Colliery (LDP001)	387.6
LDP discharge from Angus Place Colliery (LDP002)	51.1
LDP discharge from Lidsdale Siding (LDP004)	4.8
LDP discharge from SCSS (LDP006)	1,465.2
LDP discharge from Springvale Mine (LDP001)	584.3
SDWTS (discharged via Springvale Mine LDP009)	6,246.2
TOTAL INPUTS (rounded)	18,551
OUTPUTS	
Additional make-up water used at MPPS*	3,608.2
Oakey Park WTP use	291.7
Contribution to Lake Burragorang	14,171.8
TOTAL OUTPUTS (rounded)	18,072
CHANGE IN STORAGE	
Farmers Creek Dam	0.1
Lake Lyell	181.0
Lake Wallace	30.5
Thompsons Creek Reservoir	314.2

	Existing conditions (t/year)
	50% power generation
Sawyers Swamp Creek Ash Dam	-46.0
TOTAL CHANGE IN STORAGE (rounded)	480
BALANCE	
Inputs – Outputs – Change in storage	0

* Additional make-up water sourced from Coxs River via Lake Lyell and Thompsons Creek Reservoir.

As shown in Table 5-4, the sources and sinks for the salt balance were broadly similar to the water balance. The largest source of salt into the Coxs River catchment was rainfall onto surface water storages and catchment runoff, which accounted for approximately 9,521 t/year on average. This equates to 51% of the total salt load within the system. The average salinity of the total contribution of rainfall and runoff to the catchment was estimated to be approximately 108 µS/cm.

The second largest annual salt input under existing conditions was modelled to be associated with the mine water dewatered to the SDWTS that is currently discharged to Sawyers Swamp Creek via LDP009. This transfer was estimated to input 6,246 t/year of salt on average to the Coxs River catchment, which equates to 34% of the total salt inflows to the system. The average salinity of the discharge was estimated to be 1,170 µS/cm.

The salt load associated with make-up water used by MPPS with a 50% power generation requirement was predicted by the model to be approximately 3,608 t/year on average. This equates to 19% of the total salt inflows into the Coxs River catchment, which is essentially removed from the catchment. The average salinity of extractions from Lake Lyell to supply MPPS were modelled to be 530 µS/cm.

Salt associated with the total annual flow within the Coxs River upstream of Lake Burragorang was estimated to be approximately 14,172 t/year on average under existing conditions. Site-based discharges from Angus Place Colliery, Lidsdale Siding, the SCSS and Springvale Mine were modelled to contribute 62% of this total salt load on average.

5.3 Catchment hydrology and hydraulics

5.3.1 Hydrology

Wangcol Creek gauge

The Wangcol Creek gauge (Station 212055) is managed by DPI-Water and monitors the stream level and discharge. The gauge is located approximately 0.6 km upstream of the SCSS, as shown in Figure 4-5. The gauge has been in operation since 1991 and is referred to as 'Neubecks Ck U/S Wall'.

Figure 5-10 and Figure 5-11 present the average daily discharge recorded at the Wangcol Creek gauge between December 1991 and December 2015. It should be noted that the gauge remains un-calibrated and the recorded data varies significantly over time.

The maximum level recorded by the Wangcol Creek gauge is 0.886 m (DPI-Water, 2016c), which corresponds to a flow rate of approximately 340 ML/day. Flows over this rate are extrapolated using a level versus discharge rating table, which is currently under revision and is unconfirmed. This therefore limits the usefulness of the gauged data for assessing events larger than approximately the 100 year ARI event.

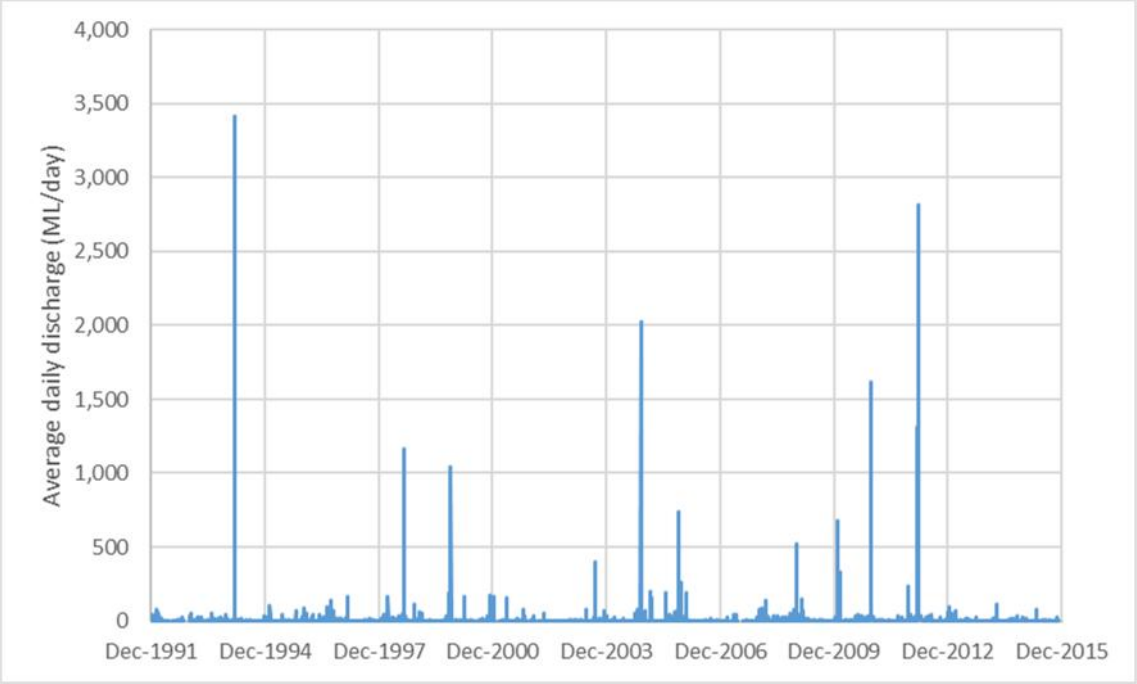


Figure 5-10 Average daily discharge recorded at Wangcol Creek gauge

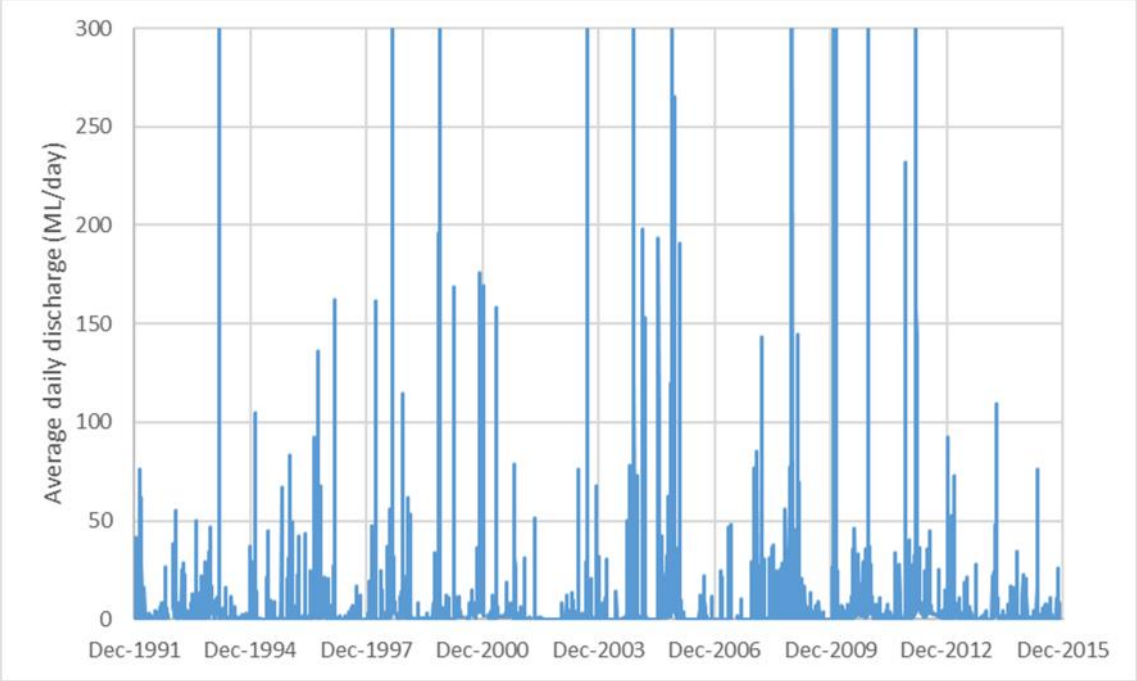


Figure 5-11 Average daily discharge recorded at Wangcol Creek gauge (between 0 ML/day and 300 ML/day)

The full dataset from the Wangcol Creek gauge for flow volume was extracted from 1991 to 2015 and assessed using River Analysis Package by ewater toolkit (Version 3.0.7). Table 5-5 presents the results, which indicate that on the average, flow within Wangcol Creek is variable with steeper rises than falls in water levels predominantly as a result of rainfall events.

Table 5-5 Wangcol Creek gauge flow statistics

Statistic	Result
Greatest rate of rise	2,563.5 ML
Mean rate of rise	19.4 ML/day
Mean duration of rise	2.4 days
Greatest rate of fall	1,137.8 ML
Mean rate of fall	7.6 ML/day
Mean duration of fall	6.6 days

With respect to determining the potential baseflow conditions for Wangcol Creek, a low flow analysis has been undertaken by DPI-Water (2016c) with the result provided in Figure 5-12. It is clear that baseflow within Wangcol Creek is a dominant feature, with a 10% probability of average flow volume over a 90-day period being less than 0.001 ML/day. From Figure 5-12 the low flow assessment considered the most likely average daily baseflow volume was 1.22 ML/day (that is, 110 ML over 90 days).

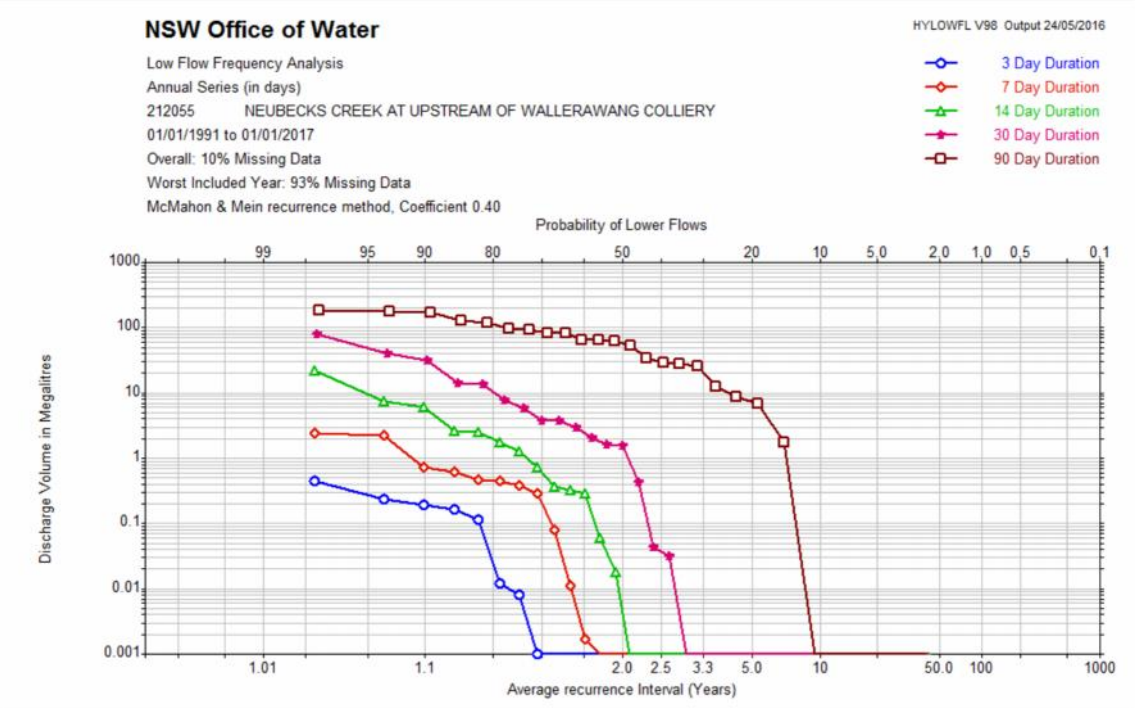


Figure 5-12 Low flow frequency analysis for Wangcol Creek gauge (DPI-Water, 2016c)

Figure 5-13 presents the level data at the Wangcol Creek gauge between 1991 and 2015. As indicated in Figure 5-13, the creek has from time to time dried prior to 2010. However, since 2010, the level within the creek has been maintained at approximately 0.4 m to 0.5 m above the gauge datum (unknown height relative to AHD).

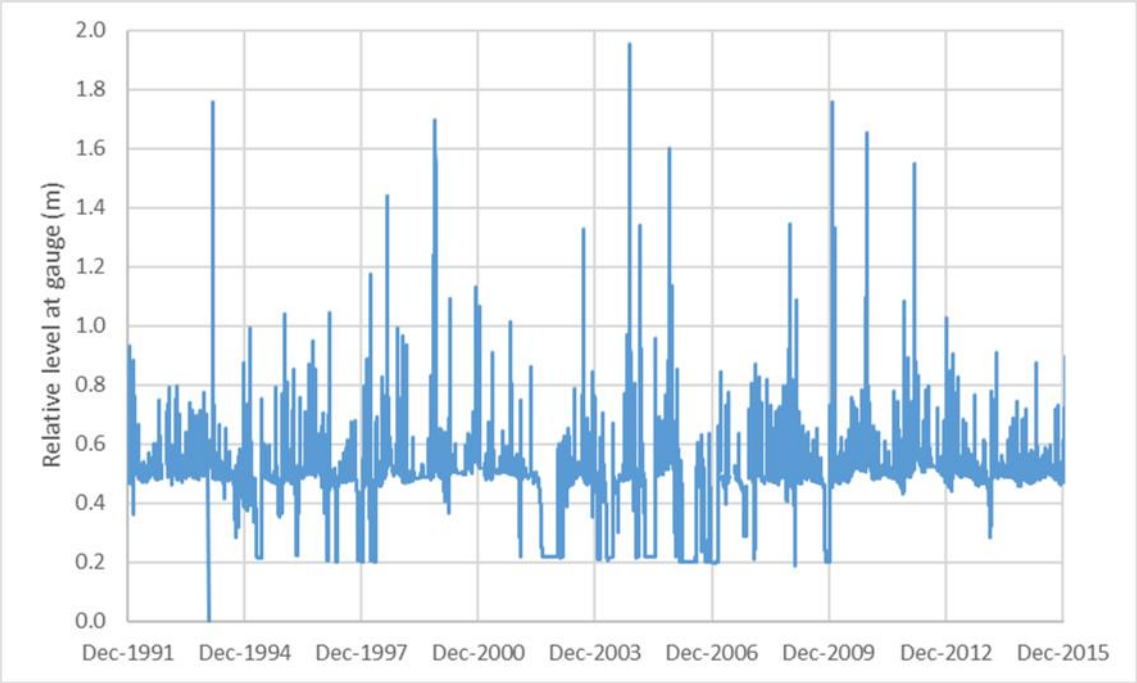


Figure 5-13 Flow level recorded at Wangcol Creek gauge

Model calibration

One previous flood study has been undertaken for Wangcol Creek, prepared by WRM (2005) for Pine Dale Coal Mine. This study considered two specific events for calibration, one in October 1999 (68 mm over 28 hours) and the other in November 2004 (79.5 mm over nine hours). As there have been some catchment modifications since these events, the review of potential storm events was considered after 2004.

There was only one event from the available Wangcol Creek gauge data that was comparable to that of the previously assessed calibration events, which was observed in March 2012. This event recorded approximately 69 mm of rainfall over one day with an additional 62 mm of rainfall over the following two days. The observed and modelled daily flow and modelled peak flow is presented in Figure 5-14 for the March 2012 event.

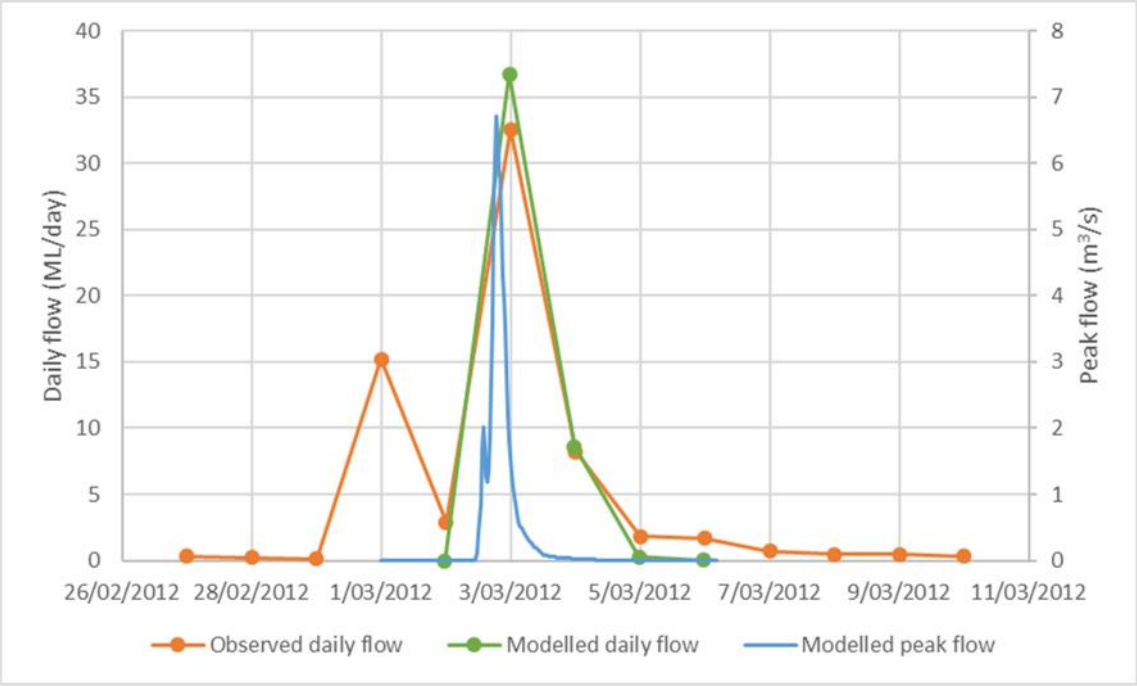


Figure 5-14 Hydrological model calibration results

As part of calibration of the hydrological model to historical events, the model results were reviewed at the Wangcol Creek gauge site (212055). The model was compared against two events, which were the October 1999 event used by WRM (2005) and the more recent 2012 event. The calibrated parameters are outlined in Table 5-6 below.

Table 5-6 Hydrological model calibration results

	October 1999 event	March 2012 event
Observed peak flow rate	29 m^3/s	32.6 m^3/s *
Modelled peak flow rate	29 m^3/s	36.8 m^3/s*
Initial loss	10 mm	30 mm
Continuing loss	2.5 mm/hr	2.5 mm/hr
Model modifications	Lag travel times across the catchment halved	

* Cumulative flow rate over the event due to limitations in observations

From Table 5-6, the results of the two similar storm events from 1999 and 2012 indicated other influencing factors within the catchment. It is probable that surface water storages present within the catchment have increased in their influence on peak runoff volumes to Wangcol Creek between the 1999 and 2012 events. The prevalence of historical open cut mining and the progressive infilling of areas that were previously storages are likely to support the better calibration result for 2012 where an elevated initial loss was used.

An initial loss of 10 mm from the calibration to the 1999 event were adopted for the hydrology model to provide conservative results. This is also consistent with ARR initial losses recommended for NSW and also the outcomes presented within the previous WRM (2005) study.

Results

XPRAFTS modelling

The hydrological model results for Wangcol Creek under existing conditions have been provided in Table 5-7 for the following locations:

- Wangcol Creek gauge.
- Confluence with Lamberts Gully.
- Outlet of Wangcol Creek.

Results are presented in Table 5-7 for the 1 year, 10 year and 100 year ARI events, as well as the 200 year and 500 year ARI events, to consider the influence of climate change on the hydrology of Wangcol Creek, and an extreme event of three times the 100 year ARI event.

Table 5-7 Results of hydrological model for existing conditions

Event	Wangcol Creek gauge		Confluence with Lamberts Gully		Outlet of Wangcol Creek	
	Flow rate (m^3/s)	Storm duration (hours)	Flow rate (m^3/s)	Storm duration (hours)	Flow rate (m^3/s)	Storm duration (hours)
1 year ARI	25.0	12	33.2	24	38.2	48
10 year ARI	66.4	2	82.7	6	93.4	6
100 year ARI	119.2	2	143.6	2	155.1	2
200 year ARI	137.0	2	166.2	2	179.0	2
500 year ARI	161.5	2	198.0	2	212.7	2
Extreme event (3 x 100 year ARI)	438.5	2	539.5	2	570.6	2

The results from the 200 year and 500 year ARI events indicate that the peak flow rates are in the order of 15% to 37% above the predicted flow rate for the 100 year ARI event at the outlet of Wangcol Creek. For the extreme event modelled, the results indicate that the peak flow rate is in the order of 267% greater than the 100 year ARI event.

Figure 5-15 below provides a comparison between the modelled peak flow rates for the 1 and 100 year ARI events in the form of predicted hydrographs at the outlet of the Wangcol Creek catchment.

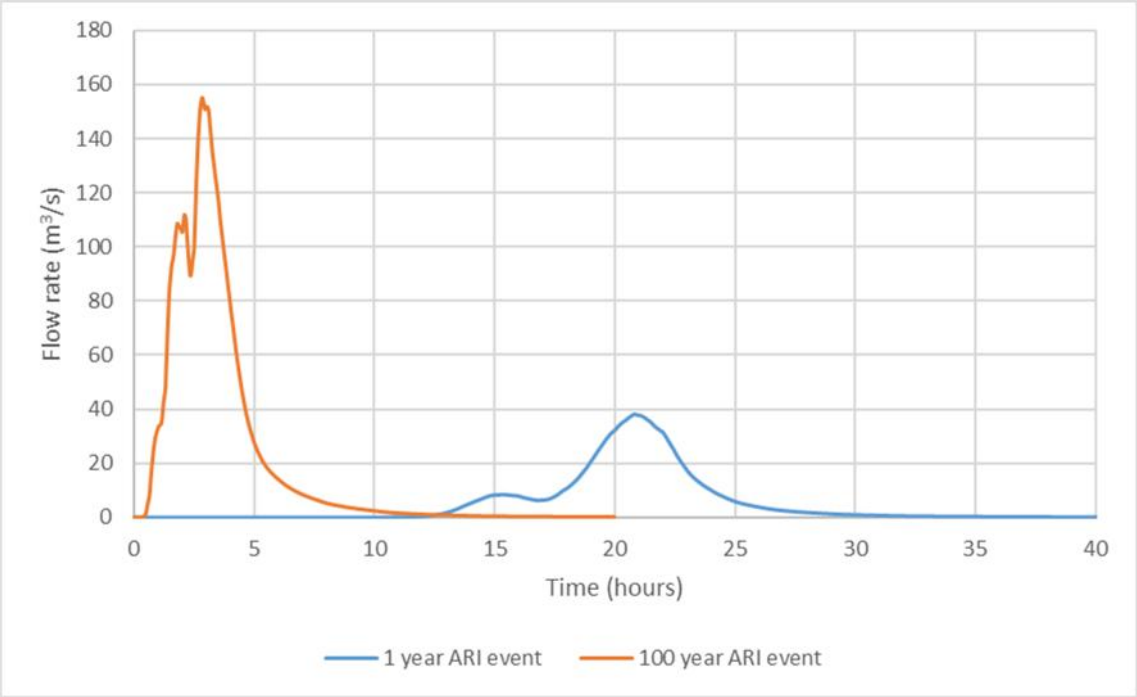


Figure 5-15 Hydrographs for peak 1 year and 100 year ARI events for Wangcol Creek under existing conditions

Comparative design flow rates

To provide a comparison to allow for checking of the modelled flow rates, a newly developed method established by the draft ARR (Institute of Engineers Australia, 2012) was used to predict flow rates for the Wangcol Creek catchment contributing to the Coxs River. The predictive equation is in the following form:

$$\log_{1}(Q_{1}) = -1.30 + 0.94\log_{1}(A) + 1.48\log_{1}(I_{t}\,100)$$

where Q_{100} (m^3/s) is the flow rate for the 100 year ARI event, A (km^2) is the catchment area and I_{tc} (mm/hr) is the rainfall intensity of the 100 year ARI event at the catchment's time of concentration. The predictive equation does not allow for the consideration of impervioμS/pervious area composition of the catchment, however as the majority of the catchment is pervious, the typical approach from ARR (institute of Engineers Australia, 2012) is applicable.

The results from using the equation for the 100 year ARI event indicated a calculated peak flow rate of 133.4 m^3/s. When comparing this result to those predicted from the XPRAFTS modelling (155.1 m^3/s), a percentage difference of 14% is achieved. This result indicates a reasonable 'order of magnitude' check on the XPRAFTS results.

5.3.2 Hydraulics

Model setup

Peak flow rates of the critical duration storm from the hydrology assessment were input into the hydraulic model along with the existing waterway topography of Wangcol Creek determined from available LIDAR survey. LIDAR was available downstream approximately 680 m downstream from the confluence with Lamberts Gully where it then utilised 1 m contour data for the remaining 1.6 km of creek.

A Manning's n value of 0.06 was adopted to represent the vegetated nature of the waterway channels and overbank areas (Chow, 1959). This decreased to 0.04 with areas where the creeks were defined and the overbank areas were cleared of any trees with the typical vegetation less than 0.5 m high.

For the consideration of the baseflow scenario within Wangcol Creek, the baseflow volume was defined as a constant flow rate of 1.22 ML/day.

The hydraulic model layout and assessment extent is provided in Figure 5-16. The hydraulic model layout also shows the location of existing waterway crossing structures.

Results

Due to limitations in the three-dimensional dataset from which the hydraulic model was developed, Wangcol Creek in some locations within the model is not truly representative of the actual waterway geometry. This is mostly due to the water line of the creek during survey representing the bottom of the creek. This results in the model cross-sections having flatter creek bases.

The flood extents from the hydraulic modelling for Wangcol Creek under existing conditions for a baseflow scenario, 1 year, 10 year and 100 year ARI events are provided in Figure 5-17.

The hydraulic results for all modelled events are provided in Table 5-8. Results have been provided at a number of key reporting locations including:

- Wangcol Creek gauge (Section 2920.83).
- The access road at the SCSS (Section 2269.62).
- Midway down Wangcol Creek (Section 1272.77).
- End of Wangcol Creek at the connection point to waterbody formed from the Commonwealth Mine open cut area (Section 311.22).

The results provided in Table 5-8 indicate a hydraulic gradient down Wangcol Creek of approximately 0.5% and velocities between 1.0 m/s to 2.5 m/s.

Figure 5-18 presents the hydraulic gradient for the 1 year and 100 year ARI events along Wangcol Creek. The results indicate varied velocity along the creek as a result of changing flow area and the occurrence of overbank flows. A general flow constriction is indicated around the end of Wangcol Creek where it migrates through more narrow channels to enter into the Commonwealth Mine open cut area. Water levels indicate a flatter profile for approximately 250 m in the results for both the 1 year and 100 year ARI events suggesting capacity constraints and the choking of flows (supported with a corresponding drop in predicted velocity).

From the model predictions, overbank flooding from Wangcol Creek corridor occurred in events equal to or greater than the 10 year ARI event. Specifically, these overbank flows were attributed to potential flooding of the Castlereagh Highway between model sections 1,644 to 1,317, approximately 700 m to east of the proposed LDP. It is noted that previous assessments along Wangcol Creek (WRM, 2005) did not predict this breakout and the fact that it was predicted as part of this modelling may be a result varying surface elevation information used in each of the models or detailed information not captured in the scale of the modelling.

Along the northern banks of Wangcol Creek, flows were mostly contained to the creek corridor. However, some areas of breakout occurred for the 100 year ARI event behind amenity and noise bunding of Pine Dale Coal Mine's operation that is currently in care and maintenance.

Results for stream power and stream shear are discussed within Section 5.4.



Paper Size A4

0 50 100 200 300 400

Meters

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

N

LEGEND

- Model Sections
- Structures within creek
- Watercourse - Non Perennial
- Watercourse - Perennial

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Hydraulic model layout and extent

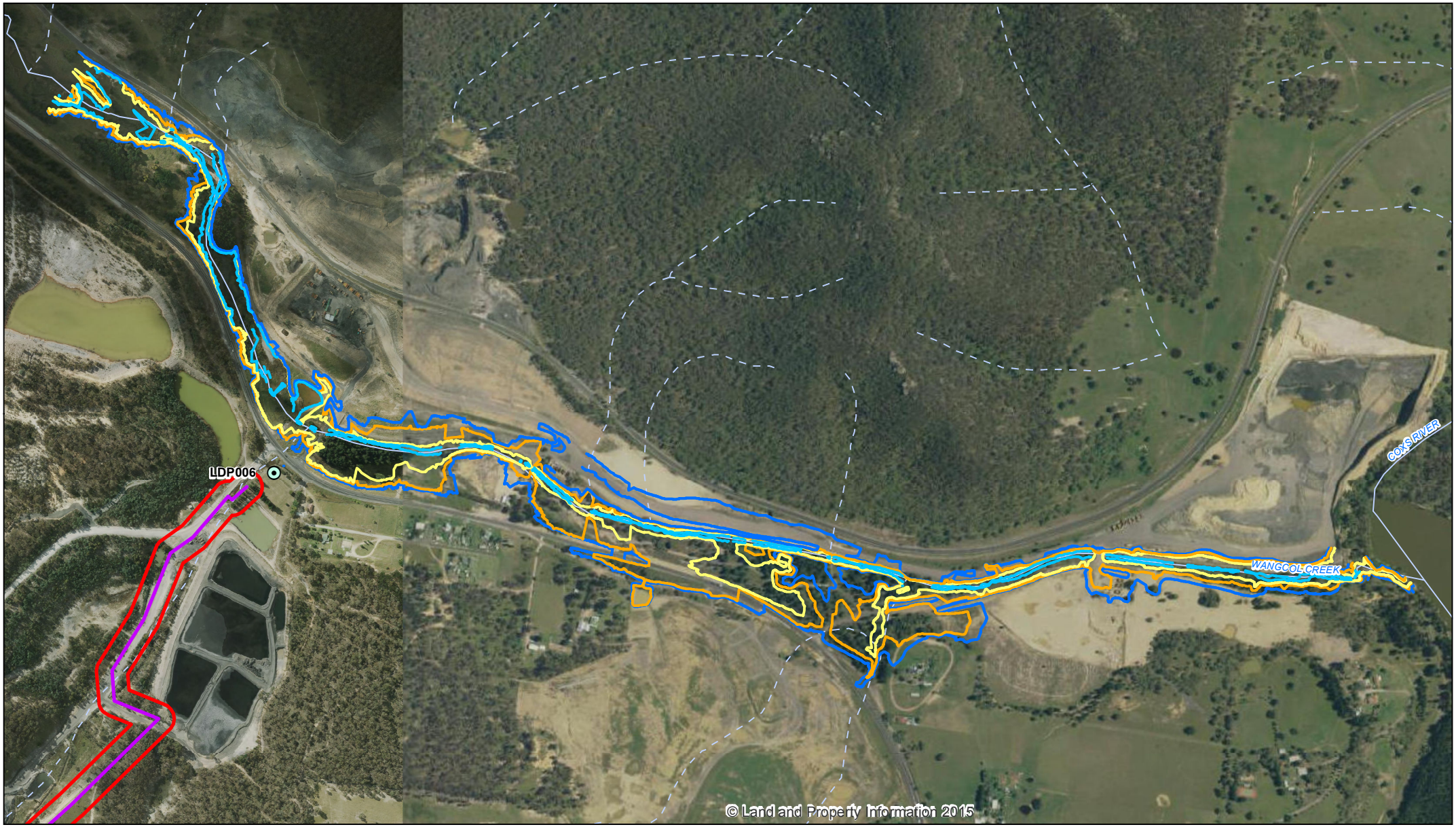
Figure 5-16

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Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial: Imagery, 2016. Created by: tmorton



Paper Size A4

0 50 100 200 300 400

Meters

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

N

LEGEND

- Project application area
- 100 year ARI flood event
- 10 year ARI flood extent
- 1 year ARI flood extent
- Baseflow Scenario
- Treated water pipeline
- Watercourse - Non Perennial
- Watercourse - Perennial

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Modelled flood extents along Wangcol Creek under existing conditions

Figure 5-17

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Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial: Monitoring location; imagery, 2016. Created by: tmorton

Table 5-8 Results of hydraulic model of Wangcol Creek for existing conditions

Event	Wangcol Creek gauge			Access road at the SCSS			Midway down Wangcol Creek			End of Wangcol Creek		
	Flow depth		Average velocity	Flow depth		Average velocity	Flow depth		Average velocity	Flow depth		Average velocity
	m	m AHD	m/s	m	m AHD	m/s	m	m AHD	m/s	m	m AHD	m/s
Baseflow*	0.05	903.05	0.17	0.01	900.01	0.37	0.01	894.01	0.28	0.06	889.06	0.05
1 year ARI	1.25	904.25	1.08	1.24	901.24	1.92	1.36	895.36	1.37	2.08	891.08	0.86
10 year ARI	1.79	904.79	1.42	1.56	901.56	2.28	2.25	896.25	1.01	3.11	892.11	1.12
100 year ARI	2.27	905.27	1.70	1.83	901.83	2.51	2.82	896.82	1.03	3.97	892.97	1.22

* Limitations exist in modelling relatively small flow rates of baseflow in hydraulic model compared with the design events. Results indicate highly variable results between sections and poor flood extent mapping.

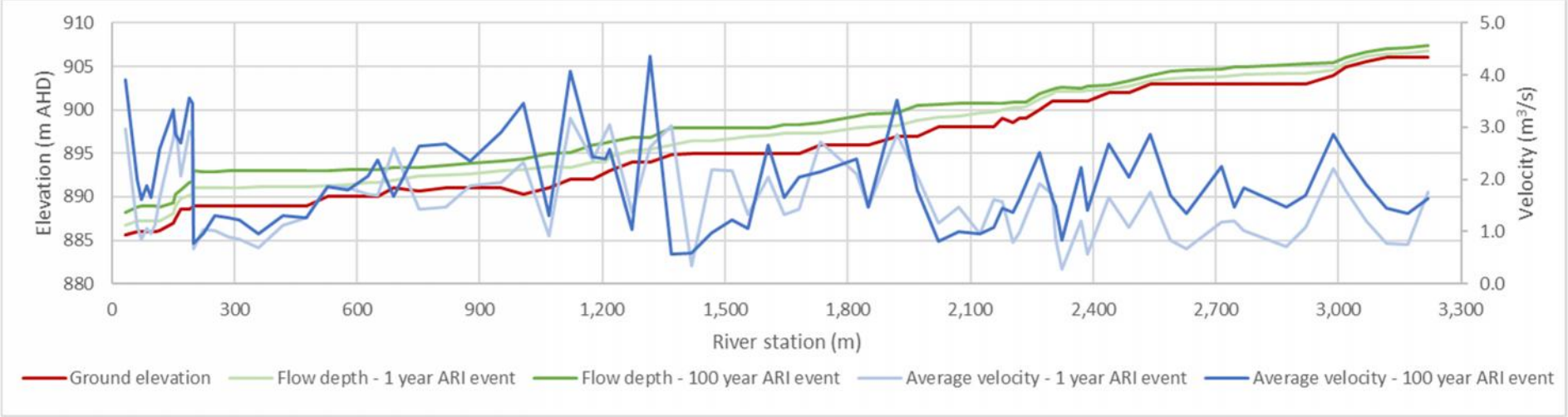


Figure 5-18 Water level and velocity results for existing Wangcol Creek for 1 year and 100 year ARI events

Culverts and other crossing structures

The following culverts and other waterway crossing structures existing along Wangcol Creek, as shown in Figure 5-16. Table 5-9 and Table 5-10 summarise the details of these structures.

Table 5-9 Description and dimensions of crossing structures along Wangcol Creek

Structure		Description	Dimensions
1	Castlereagh Highway culvert	Three cell reinforced concrete box culvert (RCBC)	4.6 m[a] wide x 1.5 m high
2	Pine Dale Mine Gate Road	One cell RCBC	2.75 m wide x 1.0 m high
3	Pine Dale Light Vehicle Access Road	Bridge	5 m wide x 2 m high
4	Pine Dale Access Road # 2	Three cell RCBC	1.8 m wide x 2.0 m high
5	Pine Dale Access Road # 3	Two reinforced concrete pipes	450 mm diameter[b]
6	Railway crossing	Bridge (three sections, two piers)	5 m wide x 2 m high

[a] Estimated from information provided by Roads and Maritime Services (RMS).

[b] Estimated from visual inspection.

Table 5-10 Crossing structure details

Structure	Upstream invert* (m AHD)	Overflow invert (m AHD)	Distance from SCSS entry (m)	Corresponding river station in hydraulic model (m)
1	Unknown	Unknown	0	N/A
2	898.2	900.9	100	Upstream 2,269.62 Downstream 2,233.97
3	896.2	898.9	530	Upstream 1,849.91 Downstream 1,822.24
4	892.6	894.9	1,150	Upstream 1,217.86 Downstream 1,207.85
5	Unknown	Unknown	1,695	Upstream 688.17 Downstream 649.06
6	Unknown	Unknown	2,207	Upstream 168.78 Downstream 156.47

* Where no downstream invert was provided, a gradient of Wangcol Creek was assumed.

The crossing structures on Wangcol Creek were assessed using Manning's equations to determine the approximate maximum flow capacity for each structure prior to overtopping or bypass (that is, the maximum allowable water level at overflow level). The results are presented in Table 5-11.

Table 5-11 Flow capacity of crossing structures

Structure	Maximum permissible flow through culvert (m^3/s)	Watercourse	Corresponding velocity from culvert (m/s)	Depth at culvert inlet (m)
1	52.9	Lamberts Gully	3.9	1.0
2	11.4	Wangcol Creek	4.1	1.0
3	30.0		4.25	1.4
4	25.5		3.8	1.2
5	1.3		4.0	0.45
6	20.3		2.8	0.5

From the results provided in Table 5-11, the existing Wangcol Creek crossing structures have a capacity to convey a maximum of 30 m^3/s. As this is less than the predicted flow from a 1 year ARI event within Wangcol Creek, predicted at a location nearby the entry to SCSS, it is likely that structures along the creek operate generally as flow constraints. The expected flood immunity design criteria for these crossings would be minimal with alternate routes of access available for Pine Dale Coal Mine via the Mount Piper Private Haul road. Of note is the predicted water depths at structures 2 and 5, compared with the structure height. Many of the structures were visually determined to have a shallow amount of cover above the structure. From the results of Table 5-11, structures 2 and 5 would most likely be overtopped in flow rates that match their maximum permissible flow.

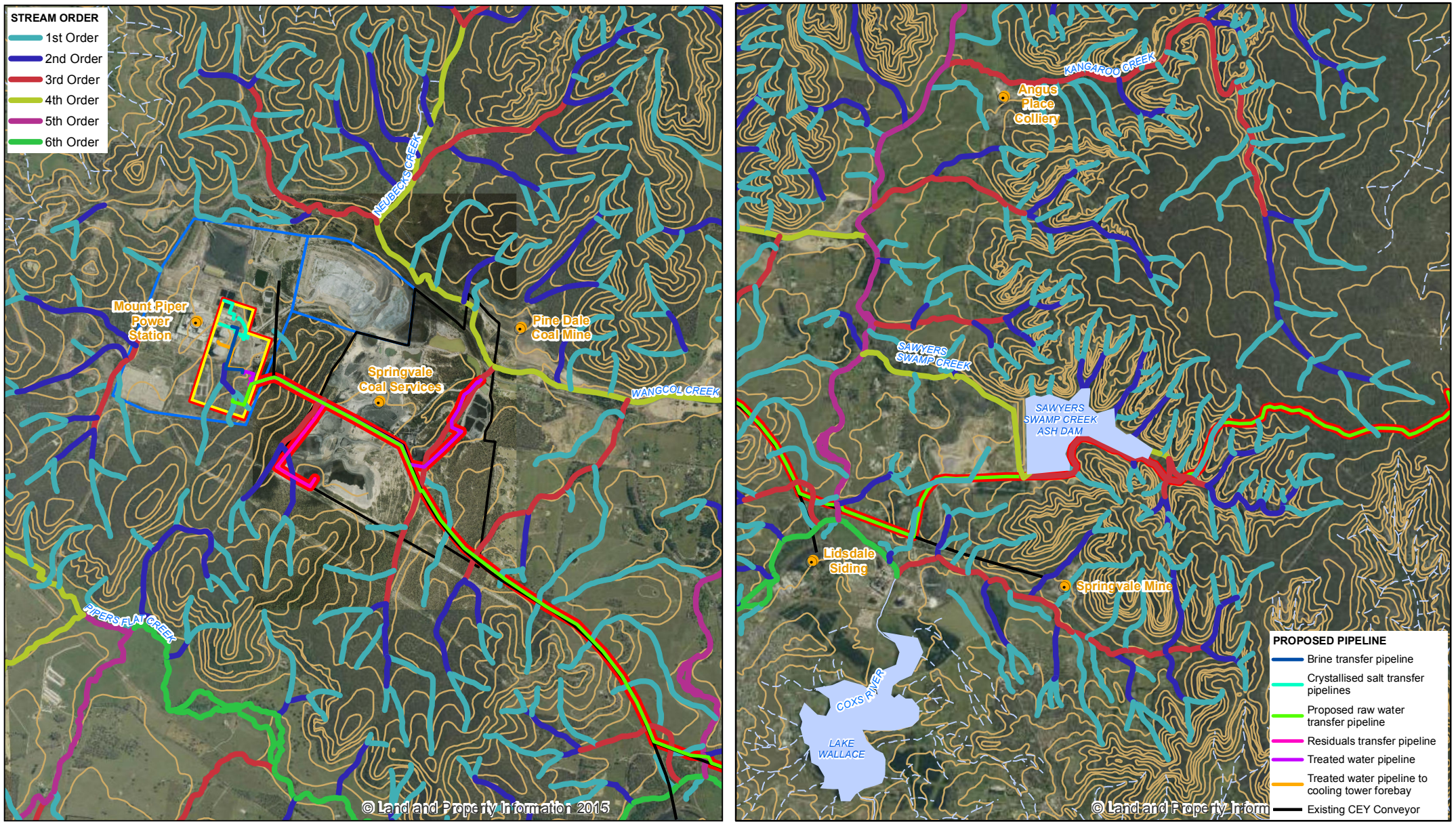
The crossing structure located directly downstream of LDP006 on Lamberts Gully and Castlereagh Highway (structure 1) has the largest determined capacity of all structures considered. This is typical of the significance of the Lamberts Gully catchment contributing to the highway at this location and the likely higher design flood immunity of the Castlereagh Highway. It should be noted that the culvert is currently significantly blocked with debris and vegetation.

5.4 Waterway geomorphology

A desktop assessment and site visit were undertaken to assess the existing geomorphic characteristics of the reaches of watercourses that may be affected by the Project. Specific reaches assessed were:

- Wangcol Creek downstream of LDP006.
- Coxs River in the vicinity of the alignment of the proposed pipeline.
- Sawyer Swamp Creek and tributaries upstream of the Sawyers Swamp Creek Ash Dam.

The geomorphic assessment included characterising streams by stream order, watercourse types and watercourse condition. Stream ordering for waterways in the vicinity of the Project are shown in Figure 5-19.



Paper Size A4

0 0.2 0.4 0.8 1.2 1.6

Kilometers

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

N

LEGEND

- Site location
- Project application area
- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- 20m Contour
- Watercourse - Non Perennial
- Watercourse - Perennial
- Waterbody

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Stream order of waterways in the vicinity of the Project

Figure 5-19

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Data source: LPI: DTDB/Imagery, 2012, 2015; Centennial: Site location, boundaries, alignment, imagery, 2016. Created by: tmorton

5.4.1 Wangcol Creek

At LDP006, Wangcol Creek has a catchment area in the order of 20 km^2 and is a 4^{th} order watercourse. Downstream of LDP006, Wangcol Creek flows an approximate further 2.2 km before discharging into the Coxs River. At this location, the Coxs River is characterised by a lake-like environment created by the past capture of the river into the open cut pit voids of the abandoned Commonwealth Mine. Downstream of LDP006, Wangcol Creek exhibits four different watercourse types (per the River Styles framework, Brierley and Fryirs, 2005). The watercourse types identified were:

- Valley fill system – These are relatively flat, featureless valley floor surfaces, lacking a continuous, well-defined channel. Typically, the substrate comprises of fine alluvial silts and muds vertically deposited out of suspension.
- Low sinuosity, gravel bed system – Exhibits a low-sinuosity channel surrounded by continuous floodplains. The banks of this stream type are relatively cohesive and stable due to the presence of fine-grained materials (clay, mud and silt). Bed sediments typically consist of gravel and cobble materials.
- Partly confined, gravel bed system – Exhibits a low-sinuosity channel set within a partly confined valley, whereby floodplain continuity is disrupted by the channel having regular contact with the valley margins. Bed sediments typically consist of gravel and cobble materials.
- Gorge system – Exhibits a single, low-sinuosity channel confined within bedrock or terrace margins with no floodplains.

The headwaters of tributaries to Wangcol Creek largely drain forested catchments; however, the middle and lower reaches have been disturbed by mining and agricultural practices. In particular, the channel is highly modified downstream of LDP006, having been diverted through excavation into *in situ* soil or bedrock materials as well as being bounded by overburden and/or reject coal material in sections. Despite this, the channel is generally stable and the reach of Wangcol Creek downstream of LDP006 is considered to be in poor to moderate geomorphic condition.

Based on the watercourse types and condition, the assessed extent of Wangcol Creek downstream of LDP006 has been subdivided into eight reaches as mapped in Figure 5-20 and summarised in Table 5-12.



Paper Size A4

0 0.0425 0.085 0.17 0.255 0.34

Kilometers

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

N

LEGEND

- Springvale Coal Services Development Consent
- Historical mining area
- Proposed LDP

Reach

- WC1
- WC2
- WC3
- WC4
- WC5
- WC6
- Waterbody
- Watercourse - Non Perennial
- Watercourse - Perennial

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Distribution of reaches along Wangcol Creek downstream of LDP006

Figure 5-20

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Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial Coal: Imagery, 2016. Created by: tmorton

Table 5-12 Wangcol Creek geomorphology summary

Reach	Length	Type	Condition	Comments	Photographs	
WC1	N/A, extends upstream from LDP006 discharge entry point.	Valley fill	Moderate	Swampy area with no defined channel. Active headcut zone at downstream extent. LDP006 discharges enter Wangcol Creek uncontrolled on the right bank upstream of culvert crossing causing bank erosion.	 Upstream view towards headcut zone.	 Discharges are eroding the right bank upstream of the culvert Pine Dale Access Road crossing (Structure 2, Table 5-9)
WC2	440 m	Low-sinuosity, gravel bed	Poor	Low-sinuosity channel with limited in-channel diversity. Channel is considered to have been largely excavated into the surrounding in situ material including clay and bedrock.	 Clay and conglomerate exposed in right bank.	 Uniform excavated channel

Reach	Length	Type	Condition	Comments	Photographs	
WC3	845 m	Low-sinuosity, gravel bed	Poor to moderate	In the upstream section, the channel is inset within natural materials and banks are prone to localised erosion. In the downstream section, the channel is deeper and bounded by overburden and coal reject material.	 Upstream section displays localised erosion of banks composed of in situ alluvial silt.	 View of right bank composed of coal reject materials.
WC4	740 m	Partly confined, gravel bed	Moderate	Typically, stable channel with well vegetated banks composed of overburden materials. Valley is confined by Pine Dale haul road to the north and a flood and/or visual bund to the south of the channel.	 Upstream view with southern bank adjacent to Pine Dale haul road.	 Downstream view displaying right bank composed of overburden.

Reach	Length	Type	Condition	Comments	Photographs	
WC5	130 m	Partly confined, gravel bed	Poor	Section impacted by disused railway bridge crossing. Shotcrete channel to protect crossing which discharges via an approximate 1 m drop into a large scour pool with eroding banks.	 Upstream view of rail crossing and shotcrete channel (Structure 6 Table 5-9).	 Large scour pool downstream of rail crossing with eroding banks.
WC6	85 m	Gorge	Poor	Excavated channel in bedrock before discharging into flooded open pit void of the Commonwealth Mine.	 Downstream view of gorge section.	 Wangcol Creek discharges to flooded void of Commonwealth Mine.

5.4.2 Coxs River

The proposed alignment of the pipeline will cross the Coxs River approximately 30 m to 40 m upstream of Brays Lane. At this location, the Coxs River has been subject to channel realignment in the past. The low-sinuosity realigned channel has a trapezoidal cross-section as shown in Figure 5-21 and has been excavated across a low spur such that sandstone outcrops across the bed and in the lower half of the bank profiles. As a result, the channel has a high degree of vertical and lateral stability despite vegetation being limited to groundcover such as grasses and sedges.



Figure 5-21 Upstream view of Coxs River from Bray Lane

5.4.3 Sawyers Swamp Creek and tributaries

The alignment of the proposed pipeline descends down the escarpment from Newnes Plateau along a steep gradient gully with a poorly defined channel. The valley floor is typically between 20 m to 40 m wide and is densely vegetated as presented in Figure 5-22. Colluvial materials dominate the valley floor sediments with large boulders observed in a matrix of sandy loam and organic materials. The boulders have been derived from rockfalls from the surrounding undercut cliffs.

This gully flow into Sawyers Swamp Creek at the base of the escarpment. At this location, Sawyers Swamp Creek has been substantially modified, with the creek having been diverted in the past to flow along the edge of the Sawyers Swamp Creek Ash Dam.



Figure 5-22 View across tributary of Sawyers Swamp Creek

5.5 Erosion and sediment control

Table 5-13 summarises the various soil landscapes in the vicinity of the Project and associated erosion hazard.

Table 5-13 Applicable soil landscapes for erosion risk

Site component	Soil landscape	Typical terrain	Erosion hazard
Pipeline	Hassans Walls	Cliffs and steep side slopes/open forests and woodlands	Extreme
	Cullen Bullen	Hill crests	High
	Newnes Plateau	Gently undulating wide crests and ridges	Low
	Deanes Creek	Narrow low-lying valley swamps along drainage lines and open woodlands	High
	Mount Sinai	Narrow undulating crests and steep side slopes	Extreme

Site component	Soil landscape	Typical terrain	Erosion hazard
	Lithgow	Lower slopes and poorly drained areas	Moderate
	Long Swamp	Low-lying swamps and alluvial areas	High
	Pipers Flat	Alluvial areas	High
Water treatment plant	Cullen Bullen	Hill crests	High
	Lithgow	Lower slopes and poorly drained areas	Moderate

As shown in Table 5-13, erosion hazard associated with the soil landscapes within the Project area generally varies from a low to extreme erosion hazard. The pipeline has a greater variability in erosion hazard depending on specific locations of the pipeline. The majority of the pipeline route has previously been disturbed from either an existing pipeline or conveyor systems. The highest risk sections of construction with regards to erosion are likely to be elevated transitions from the Newnes Plateau down to Sawyers Swamp Creek, of which there has been no disturbance.

5.6 Surface water quality

5.6.1 ANZECC water quality assessment

Upstream surface water quality

Surface water quality at upstream sites considered data available at monitoring sites SW1, located on Neubecks Creek (a tributary of Wangcol Creek), and SW2, SW3 and the Wangcol Creek gauge, located on Wangcol Creek. All sites are upstream of the LDP proposed as part of the Project and LDP006 discharges from the SCSS.

A statistical summary of the water quality at upstream monitoring sites SW1, SW2, SW3 and Wangcol Creek gauge is provided in Table 5-14. The median (50th percentile) results provided are representative of the ambient water conditions. DGVs recommended by ANZECC (2000a) as presented in Table 4-5 are provided in Table 5-14 for comparative purposes. Time series graphs for selected water quality parameters monitored at the upstream sites are provided in Appendix D.

Table 5-14 Statistical summary of upstream surface water quality monitoring

Parameter	Units	DGV (ANZECC, 2000a)	SW1		SW2		SW3		Wangcol Creek gauge	
			Count	Median	Count	Median	Count	Median	Count	Median
Physicochemical parameters										
EC	µS/cm	350	60	77	67	244	63	361	47	585
pH	pH units	6.5–9.0	60	6.9	73	7.0	69	7.0	47	7.1
TSS	mg/L	25	60	5	73	5	69	7	47	5
Turbidity	NTU	25	60	12	69	9	65	17	47	3
Nutrients										
Ammonia	mg/L	0.9	59	0.01	70	0.02	66	0.01	–	–
Nitrate	mg/L	–	60	0.01	71	0.01	67	0.01	47	0.01
Nitrite	mg/L	–	60	0.01	71	0.02	67	0.01	47	0.01
Nitrite + nitrate	mg/L	–	60	0.01	71	0.02	67	0.01	47	0.01
TKN	mg/L	–	60	0.4	71	0.3	67	0.3	–	–
Total nitrogen	mg/L	0.25	60	0.4	71	0.3	67	0.3	–	–
TOC	mg/L	–	60	4	68	3	63	5	–	–
Total phosphorus	mg/L	0.02	60	0.02	71	0.03	67	0.02	45	0.01
Anions										
Alkalinity	mg/L	–	60	7	71	39	66	70	47	46

Parameter	Units	DGV (ANZECC, 2000a)	SW1		SW2		SW3		Wangcol Creek gauge	
			Count	Median	Count	Median	Count	Median	Count	Median
Chloride	mg/L	–	60	8	71	9	67	9	47	26
Sulfate	mg/L	–	60	10	71	23	67	71	47	193
Cations										
Calcium	mg/L	–	60	3	71	20	67	24	47	36
Magnesium	mg/L	–	60	2	71	10	67	14	47	23
Potassium	mg/L	–	60	2	71	4	67	5	47	5
Sodium	mg/L	–	60	7	71	15	67	23	47	38
Dissolved metals										
Aluminium	mg/L	0.055	60	0.15	73	0.11	68	0.02	47	0.01
Antimony	mg/L	–	60	0.001	68	0.001	64	0.001	–	–
Arsenic	mg/L	0.024	60	0.001	71	0.001	67	0.001	–	–
Barium	mg/L	–	60	0.026	68	0.026	64	0.029	–	–
Boron	mg/L	0.37	60	0.05	73	0.05	69	0.05	47	0.09
Cadmium	mg/L	0.0026*	60	0.0001	71	0.0001	67	0.0001	47	0.0001
Chromium	mg/L	0.001	15	0.001	22	0.001	20	0.001	–	–
Copper	mg/L	0.0014	60	0.002	73	0.002	69	0.002	–	–

Parameter	Units	DGV (ANZECC, 2000a)	SW1		SW2		SW3		Wangcol Creek gauge	
			Count	Median	Count	Median	Count	Median	Count	Median
Iron	mg/L	0.3	60	0.17	70	0.19	69	0.17	47	0.09
Lead	mg/L	0.129*	60	0.001	71	0.001	67	0.001	–	–
Lithium	mg/L	–	60	0.001	68	0.010	63	0.015	–	–
Manganese	mg/L	1.9	60	0.063	73	0.191	69	0.236	47	0.318
Mercury	mg/L	0.0006	15	0.0001	22	0.0001	20	0.0001	–	–
Molybdenum	mg/L	–	60	0.001	68	0.001	64	0.001	–	–
Nickel	mg/L	0.125*	60	0.002	73	0.003	69	0.002	47	0.013
Strontium	mg/L	–	60	0.025	68	0.046	64	0.083	–	–
Zinc	mg/L	0.091*	60	0.012	73	0.009	69	0.009	47	0.014
Total metals										
Aluminium	mg/L	–	60	0.50	68	0.29	64	0.20	–	–
Antimony	mg/L	–	15	0.001	19	0.001	17	0.001	–	–
Arsenic	mg/L	–	60	0.001	68	0.001	64	0.001	–	–
Barium	mg/L	–	60	0.035	68	0.029	64	0.033	–	–
Boron	mg/L	–	15	0.05	19	0.05	17	0.05	–	–
Cadmium	mg/L	–	15	0.0001	19	0.0001	17	0.0001	–	–

Parameter	Units	DGV (ANZECC, 2000a)	SW1		SW2		SW3		Wangcol Creek gauge	
			Count	Median	Count	Median	Count	Median	Count	Median
Chromium	mg/L	–	15	0.002	19	0.001	17	0.001	–	–
Copper	mg/L	–	15	0.002	19	0.001	16	0.002	–	–
Iron	mg/L	–	60	0.41	68	0.73	64	0.79	–	–
Lead	mg/L	–	60	0.001	68	0.001	64	0.001	–	–
Lithium	mg/L	–	15	0.002	19	0.015	17	0.015	–	–
Manganese	mg/L	–	56	0.075	68	0.236	64	0.323	–	–
Mercury	mg/L	–	15	0.0001	19	0.0001	17	0.0001	–	–
Molybdenum	mg/L	–	15	0.001	19	0.001	17	0.001	–	–
Nickel	mg/L	–	60	0.002	68	0.003	63	0.003	47	0.015
Strontium	mg/L	–	15	0.043	19	0.097	17	0.097	–	–
Zinc	mg/L	–	60	0.012	68	0.008	64	0.009	47	0.013
Other										
Fluoride	mg/L	–	60	0.1	70	0.1	66	0.2	–	–
Oil and grease	mg/L	–	60	5	70	5	66	5	47	5
Phenols	mg/L	–	60	0.05	68	0.05	64	0.05	–	–
Total cyanide	mg/L	–	60	0.004	68	0.004	64	0.004	–	–

* ANZECC (2000a) DGV modified for hardness.

Physicochemical parameters

EC recorded at upstream sites SW1, SW2 and SW3 generally ranged between 50 µS/cm and 500 µS/cm. An increasing trend in EC is apparent with increasing distance downstream in the catchment, with the Wangcol Creek gauge recording EC results in the range of approximately 200 µS/cm to 2,000 µS/cm. EC levels reported at SW2, SW3 and the Wangcol Creek gauge frequently exceeded the ANZECC (2000a) DGV of 350 µS/cm.

The pH levels at the upstream sites indicated that the water is neutral to slightly acidic, with samples typically ranging between 6.0 and 7.6. The majority of pH levels were within the ANZECC (2000a) DGVs of 6.5 and 9.0.

Results for TSS were generally below the ANZECC (2000a) DGV of 25 mg/L for all upstream monitoring sites.

The majority of turbidity results have been below 60 NTU at SW1, SW2 and SW3. Maximum levels of turbidity of 281 NTU in February 2015, 174 NTU in May 2012 and 171 NTU in September 2013 have been recorded for SW1, SW2 and SW3 respectively. Approximately 30% to 40% of all turbidity results for monitoring locations SW1, SW2 and SW3 exceeded the ANZECC (2000a) DGV of 25 NTU. The majority of turbidity results for the Wangcol Creek gauge have been below the ANZECC (2000a) DGV of 25 NTU, with the exception of two results in February 2014 and April 2015 recorded at 26 NTU.

Nutrients

The majority of recorded ammonia concentrations at SW1, SW2 and SW3 have ranged between the LOR of 0.01 mg/L and 0.1 mg/L. All results have been below the ANZECC (2000a) DGV of 0.9 mg/L. No monitoring of ammonia has been undertaken at the Wangcol Creek gauge.

Total nitrogen concentrations generally ranged between the LOR of 0.1 mg/L and 0.6 mg/L for SW1, SW2 and SW3, with a maximum level of 1.9 mg/L recorded at SW3 in September 2013. Approximately 60% to 70% of all total nitrogen results for monitoring locations SW1, SW2 and SW3 exceeded the ANZECC (2000a) DGV of 0.25 mg/L. No monitoring of total nitrogen has been undertaken at the Wangcol Creek gauge.

Concentrations of total phosphorus were typically below 0.1 mg/L at SW1, SW2 and SW3. Maximum results of 0.24 mg/L in February 2015, 0.3 mg/L in November 2013 and 0.12 mg/L in September 2013 have been recorded for SW1, SW2 and SW3 respectively. Approximately 30% to 50% of all total phosphorus results for monitoring locations SW1, SW2 and SW3 exceeded the ANZECC (2000a) DGV of 0.02 mg/L. The results for total phosphorus at the Wangcol Creek gauge were generally below the ANZECC (2000a) DGV of 0.02 mg/L.

Metals

Dissolved aluminium results were found to be elevated at sites SW1 and SW2 compared to results for SW3 and the Wangcol Creek gauge. The majority of results at SW1 and SW2 were below 0.4 mg/L. The maximum concentration of dissolved aluminium of 1.18 mg/L was reported for SW2 in March 2013. Results for SW3 and the Wangcol Creek gauge displayed less variability, with results typically below the ANZECC (2000a) DGV of 0.055 mg/L.

Dissolved antimony concentrations were below the LOR of 0.001 mg/L for SW1, SW2 and SW3, with the exception of five samples collected at SW2 in February and March 2014 and between January and March 2015. The maximum concentration of dissolved antimony reported for SW2 was 0.003 mg/L. No monitoring of antimony has been undertaken at the Wangcol Creek gauge.

Dissolved arsenic results for upstream locations SW1, SW2 and SW3 have been below the LOR of 0.001 mg/L, with the exception of five samples collected at SW2 and one sample collected at SW3. The maximum concentration of dissolved arsenic reported was 0.003 mg/L at SW2 in March 2014. All results were below the ANZECC (2000a) DGV of 0.024 mg/L. No monitoring of arsenic has been undertaken at the Wangcol Creek gauge.

Dissolved barium results generally ranged between 0.04 mg/L and 0.06 mg/L for SW1, SW2 and SW3, with the maximum result of 0.15 mg/L recorded at SW2 in February 2014. Concentrations of dissolved barium have been found to increase over time, with elevated results for 2014 compared to 2013. Limited results are available for 2015. No monitoring of barium has been undertaken at the Wangcol Creek gauge.

The majority of results for dissolved boron were below the LOR of 0.05 mg/L for all upstream monitoring locations. Concentrations reported at the Wangcol Creek gauge displayed more variability than SW1, SW2 and SW3 results, with the maximum dissolved boron result of 1.58 mg/L in August 2014 recorded for the Wangcol Creek gauge. All results were found to be below the ANZECC (2000a) DGV of 0.37 mg/L, with the exception of two results recorded at the Wangcol Creek gauge.

Concentrations of dissolved cadmium were generally below the LOR of 0.0001 mg/L for all upstream sites. Dissolved cadmium was detected in several samples collected at SW1 and SW2, however all results were reported below the ANZECC (2000a) DGV of 0.0026 mg/L.

Dissolved chromium concentrations were consistently reported below the LOR, equivalent to the ANZECC (2000a) DGV of 0.001 mg/L, for SW2 and SW3, with one exception for SW1 in August 2014 recorded at 0.002 mg/L. No monitoring of chromium has been undertaken at the Wangcol Creek gauge.

Concentrations of dissolved copper varied throughout the monitoring period and were similar between sites SW1, SW2 and SW3, ranging between the LOR of 0.001 mg/L and 0.004 mg/L. Approximately 50% to 70% of all dissolved copper results for monitoring locations SW1, SW2 and SW3 exceeded the ANZECC (2000a) DGV of 0.0014 mg/L. No monitoring of copper has been undertaken at the Wangcol Creek gauge.

Reported dissolved iron concentrations at all sites were found to range between the LOR of 0.05 mg/L and 1 mg/L in general. A maximum of 9.84 mg/L of dissolved iron has been recorded at SW2 in February 2014. Approximately one quarter of results for SW1, SW2 and SW3 were found to be above the ANZECC (2000a) DGV of 0.3 mg/L. The majority of results for the Wangcol Creek gauge were below the DGV, with the two most recent results exceeding the guideline in December 2015.

The majority of dissolved lead results for SW1, SW2 and SW3 were recorded to be below the LOR of 0.001 mg/L. The maximum concentration recorded was 0.006 mg/L for SW3 in April 2015. All results for SW1, SW2 and SW3 were below the ANZECC (2000a) DGV of 0.129 mg/L. No monitoring of lead has been undertaken at the Wangcol Creek gauge.

Dissolved manganese concentrations reported for upstream monitoring locations were found to be generally lower than the ANZECC (2000a) DGV of 1.9 mg/L. Results ranged between the LOR of 0.001 mg/L and 1 mg/L, with SW1 concentrations typically lower than other sites. Less than 10% of all dissolved manganese results were found to exceed the DGV.

Dissolved mercury concentrations at SW1 were consistently reported below the LOR of 0.0001 mg/L, which is below the ANZECC (2000a) DGV of 0.0006 mg/L. No monitoring of mercury has been undertaken at the Wangcol Creek gauge.

Dissolved molybdenum results have generally been reported to be below the LOR of 0.001 mg/L for SW1, SW2 and SW3. Several results for SW2 and SW3 have been found to be above the detection limit, with a maximum concentration of 0.006 mg/L recorded at SW2 in January 2014. No monitoring of molybdenum has been undertaken at the Wangcol Creek gauge.

The majority of dissolved nickel concentrations varied between the LOR of 0.001 mg/L and 0.02 mg/L. Results reported for the Wangcol Creek gauge were elevated compared to results for SW1, SW2 and SW3. The ANZECC (2000a) DGV of 0.125 mg/L was exceeded on three occasions at the Wangcol Creek gauge, with a concentration of 0.156 mg/L reported in February 2014, 0.39 mg/L reported in August 2014 and 0.24 mg/L reported in December 2015. All other results were found to be below the DGV.

Dissolved strontium concentrations were found to range between 0.014 mg/L and 0.178 mg/L for SW2 and SW3, which were elevated compared with SW1 results, which varied between the LOR of 0.001 mg/L and 0.069 mg/L. No monitoring of strontium has been undertaken at the Wangcol Creek gauge.

Concentrations of dissolved zinc generally varied from the LOR of 0.001 mg/L to 0.05 mg/L. The maximum result of 0.353 mg/L was reported for SW2 in February 2014. The majority of results were below the ANZECC (2000a) DGV of 0.091 mg/L, with the exception of one result for both SW2 and SW3 in February 2014 and six results for the Wangcol Creek gauge.

Other parameters

The majority of fluoride results for SW1, SW2 and SW3 were reported to be below the LOR of 0.1 mg/L. The maximum concentration of fluoride recorded was 0.5 mg/L at SW3 in March 2013. No monitoring of fluoride has been undertaken at the Wangcol Creek gauge.

The majority of oil and grease results for all upstream monitoring locations were found to be below the LOR of 5 mg/L. One sample of 6 mg/L was recorded at SW1 in June 2013. Three samples at the Wangcol Creek gauge were found to be above the detection limit, with a maximum concentration of 11 mg/L reported in April 2015.

All results for phenols were reported to be below the LOR of 0.05 mg/L for SW1, SW2 and SW3. No monitoring of phenols has been undertaken at the Wangcol Creek gauge.

Total cyanide results for SW1, SW2 and SW3 were generally found to be below the LOR of 0.004 mg/L. Two samples were found to be above the detection limit, with 0.006 mg/L reported for SW1 in November 2013 and for SW3 in May 2013. No monitoring of cyanide has been undertaken at the Wangcol Creek gauge.

Mine water discharge quality

A statistical summary of the water quality of the discharge from the SCSS through LDP006 to Wangcol Creek and the SDWTS through LDP009 to Sawyers Swamp Creek is provided in Table 5-15. SSGVs derived for LDP006 (GHD, 2014b) and LDP009 (GHD, 2014a) discharge are provided in Table 5-15 for comparative purposes, as well as the recommended ANZECC (2000a) DGVs. Time series graphs for selected water quality parameters monitored at the discharge sites are provided in Appendix D.

Table 5-15 Statistical summary of surface water quality monitoring of LDP006 and LDP009

Parameter	Units	DGV (ANZECC, 2000a)	LDP006			LDP009		
			SSGV (GHD, 2014b)	Count	Median	SSGV (GHD, 2014a)	Count	Median
Physicochemical parameters								
EC	µS/cm	350	690	42	3,040	350	96	1,167
pH	pH units	6.5–9.0	–	46	6.8	5.9–8.0	104	7.87
TSS	mg/L	25	–	44	5	25	102	5
Turbidity	NTU	25	–	42	9	25	100	4
Nutrients								
Ammonia	mg/L	0.9	–	25	0.05	0.9	10	0.47
Nitrate	mg/L	–	–	42	0.08	–	7	0.33
Nitrite	mg/L	–	–	41	0.01	–	7	0.01
Nitrite + nitrate	mg/L	–	–	41	0.08	–	9	0.33
TKN	mg/L	–	–	–	–	–	9	0.5
Total nitrogen	mg/L	0.25	–	–	–	0.6	9	0.9
TOC	mg/L	–	–	–	–	–	6	1
Total phosphorus	mg/L	0.02	–	45	0.01	0.06	11	0.01

Parameter	Units	DGV (ANZECC, 2000a)	LDP006			LDP009		
			SSGV (GHD, 2014b)	Count	Median	SSGV (GHD, 2014a)	Count	Median
Anions								
Alkalinity (bicarbonate)	mg/L	–	–	42	38	–	9	624
Alkalinity (carbonate)	mg/L	–	–	42	1	–	9	1
Alkalinity (total)	mg/L	–	–	42	38	–	9	624
Chloride	mg/L	–	–	42	190	–	9	6
Sulfate	mg/L	–	–	42	1,505	–	9	37
Cations								
Calcium	mg/L	–	–	42	188	–	9	2
Magnesium	mg/L	–	–	42	131	–	9	1
Potassium	mg/L	–	–	42	30	–	9	11
Sodium	mg/L	–	–	42	333	–	9	263
Dissolved metals								
Aluminium	mg/L	0.055	–	42	0.02	0.204	99	0.02
Antimony	mg/L	–	–	–	–	–	13	0.001
Arsenic	mg/L	0.024	–	29	0.001	0.024	97	0.016
Barium	mg/L	–	–	–	–	0.0368	9	0.022

Parameter	Units	DGV (ANZECC, 2000a)	LDP006			LDP009		
			SSGV (GHD, 2014b)	Count	Median	SSGV (GHD, 2014a)	Count	Median
Beryllium	mg/L	–	–	–	–	–	2	0.001
Boron	mg/L	0.37	–	31	0.93	0.37	91	0.06
Cadmium	mg/L	0.0026*	–	42	0.0001	0.0005*	11	0.0001
Chromium	mg/L	0.001	–	18	0.001	0.001	5	0.001
Chromium (trivalent)	mg/L	–	–	25	0.01	–	2	0.01
Chromium (hexavalent)	mg/L	–	–	14	0.01	–	4	0.01
Cobalt	mg/L	0.0025	–	26	0.054	0.005	3	0.001
Copper	mg/L	0.0014	–	27	0.001	0.004	97	0.001
Iron	mg/L	0.3	0.3	42	0.43	4.00	96	0.05
Lead	mg/L	0.129*	–	24	0.001	0.011*	11	0.001
Manganese	mg/L	1.9	1.9	42	3.27	1.9	97	0.007
Mercury	mg/L	0.0006	–	27	0.0001	0.0006	1	0.0001
Molybdenum	mg/L	–	–	–	–	–	10	0.043
Nickel	mg/L	0.125*	0.114*	42	0.253	0.025*	97	0.003
Selenium	mg/L	–	–	43	0.01	0.11	3	0.01
Strontium	mg/L	–	–	–	–	–	8	0.018

Parameter	Units	DGV (ANZECC, 2000a)	LDP006			LDP009		
			SSGV (GHD, 2014b)	Count	Median	SSGV (GHD, 2014a)	Count	Median
Uranium	mg/L	–	–	5	0.001	–	9	0.001
Zinc	mg/L	0.091*	0.135*	42	0.203	0.019	97	0.01
Total metals								
Antimony	mg/L	–	–	–	–	–	1	0.001
Arsenic	mg/L	–	–	–	–	–	2	0.025
Barium	mg/L	–	–	–	–	–	2	0.03
Beryllium	mg/L	–	–	–	–	–	2	0.001
Boron	mg/L	–	–	14	1.10	–	6	0.06
Cadmium	mg/L	–	–	–	–	–	3	0.0001
Chromium	mg/L	–	–	–	–	–	4	0.001
Cobalt	mg/L	–	–	–	–	–	3	0.001
Copper	mg/L	–	–	–	–	–	2	0.001
Lead	mg/L	–	–	–	–	–	3	0.001
Manganese	mg/L	–	–	3	3.56	–	2	0.007
Mercury	mg/L	–	–	–	–	–	4	0.0001
Molybdenum	mg/L	–	–	–	–	–	2	0.051

Parameter	Units	DGV (ANZECC, 2000a)	LDP006			LDP009		
			SSGV (GHD, 2014b)	Count	Median	SSGV (GHD, 2014a)	Count	Median
Nickel	mg/L	–	–	45	0.283	–	1	0.003
Selenium	mg/L	0.011	–	–	–	–	3	0.01
Uranium	mg/L	–	–	–	–	–	2	0.001
Zinc	mg/L	–	–	45	0.235	–	2	0.007
Other								
Fluoride	mg/L	–	–	26	0.2	–	99	1.2
Oil and grease	mg/L	–	–	42	5	–	96	5
Phenols	mg/L	–	–	–	–	–	7	0.05
Total cyanide	mg/L	–	–	25	0.004	–	11	0.004

* ANZECC (2000a) DGV/SSGV modified for hardness.

LDP006 water quality

Physicochemical parameters

EC of LDP006 discharges generally ranged between 1,000 µS/cm and 4,500 µS/cm, with a median concentration of 3,040 µS/cm. An increasing trend in EC is apparent over the assessed time period. However, the EC recorded at LDP006 is sensitive to rainfall due to the clean catchment runoff contribution from Lamberts Gully that also flows through the discharge point. All recorded EC levels at LDP006 exceeded the SSGV (GHD, 2014b) of 690 µS/cm and ANZECC (2000a) DGV of 350 µS/cm.

LDP006 discharge was found to be slightly acidic to slightly alkaline, with results ranging from 6.1 to 8.0. The majority of pH levels were within the ANZECC (2000a) DGVs of 6.5 and 9.0.

Results for TSS were generally below the ANZECC (2000a) DGV of 25 mg/L for LDP006 discharge, with the exception of one sample collected in April 2015 with a concentration of 63 mg/L.

The majority of turbidity results were below the ANZECC (2000a) DGV of 25 NTU. Median turbidity was found to be 8 NTU for LDP006 discharge. With the exception of one sample collected in April 2015 of 148 NTU, all results for LDP006 discharge from July 2013 to December 2015 have been below the ANZECC (2000a) DGV.

Nutrients

Concentrations of ammonia at LDP006 were found to range between 0.01 mg/L and 0.15 mg/L, with a median concentration of 0.05 mg/L. All results have been below the ANZECC (2000a) DGV of 0.9 mg/L.

No monitoring of total nitrogen has been undertaken at LDP006.

The majority of total phosphorus results were below the LOR of 0.01 mg/L. A maximum result of 0.12 mg/L was reported for LDP006 discharge in June 2013. Less than 10% of all total phosphorus results exceeded the ANZECC (2000a) DGV of 0.02 mg/L.

Metals

Dissolved aluminium results were found to be below the ANZECC (2000a) DGV of 0.055 mg/L, with a median value of 0.02 mg/L. The maximum concentration of dissolved aluminium of 0.46 mg/L was reported in February 2013.

Dissolved arsenic results have been below the LOR of 0.001 mg/L, with the exception of one sample of 0.012 mg/L collected in December 2014. All results were below the ANZECC (2000a) DGV of 0.024 mg/L.

Concentrations of dissolved boron for LDP006 discharge ranged between 0.15 mg/L and 1.83 mg/L, with a median value of 0.93 mg/L. Approximately 77% of all dissolved boron results exceeded the ANZECC (2000a) DGV of 0.37 mg/L.

Dissolved cadmium concentrations ranged between the LOR of 0.0001 mg/L and 0.0004 mg/L. All results for LDP006 were reported below the ANZECC (2000a) DGV of 0.0026 mg/L.

Dissolved chromium concentrations were consistently reported below the LOR, equivalent to the ANZECC (2000a) DGV of 0.001 mg/L. All dissolved trivalent and hexavalent chromium results for LDP006 were found to be below the LOR of 0.01 mg/L. The only exception was one sample in April 2015, which reported a dissolved hexavalent concentration of 0.1 mg/L.

Concentrations of dissolved cobalt varies throughout the assessment period between 0.004 mg/L and 0.118 mg/L. All dissolved cobalt results exceeded the ANZECC (2000a) DGV of 0.0025 mg/L.

The majority of results for dissolved copper were below the LOR of 0.001 mg/L. However, seven samples collected at LDP006 were above the ANZECC (2000a) DGV of 0.0014 mg/L, with the maximum dissolved copper result of 0.008 mg/L recorded in August 2013.

Reported dissolved iron concentrations were found to range between the LOR of 0.05 mg/L and 2.1 mg/L in general. A maximum of 6.1 mg/L was recorded at LDP006 in May 2013. Approximately 60% of all dissolved iron results were found to be above the SSGV (GHD, 2014b) and ANZECC (2000a) DGV of 0.3 mg/L.

Dissolved lead concentrations were consistently reported below the LOR of 0.001 mg/L, with the exception of one sample in December 2014 recorded at 0.002 mg/L. All results were found to be below the ANZECC (2000a) DGV of 0.129 mg/L.

Results for dissolved manganese for LDP006 discharge varied from 0.48 mg/L to 5.22 mg/L in general, with a maximum result of 9.36 mg/L recorded in May 2013. Approximately 75% of all dissolved manganese results were found to be above the SSGV (GHD, 2014b) and ANZECC (2000a) DGV of 1.9 mg/L.

Dissolved mercury concentrations at were consistently reported below the LOR of 0.0001 mg/L, which is below the ANZECC (2000a) DGV of 0.0006 mg/L.

Dissolved nickel concentrations varied between 0.015 mg/L and 0.48 mg/L. Approximately 75% of all results for LDP006 were found to be above the ANZECC (2000a) DGV of 0.125 mg/L.

All dissolved selenium results for LDP006 discharge were reported to be at or below the LOR of 0.01 mg/L.

All dissolved uranium results for LDP006 were reported to be below the LOR of 0.001 mg/L.

Concentrations of dissolved zinc generally varied from 0.01 mg/L to 0.04 mg/L. The maximum result of 0.571 mg/L was reported for LDP006 in February 2013. Approximately 85% of dissolved zinc results were found to be above the ANZECC (2000a) DGV of 0.091 mg/L. Elevated concentrations of zinc, along with dissolved nickel, are a typical indication of groundwater influenced by previous mining activities contributing to the discharge through LDP006.

Other parameters

The majority of fluoride results for LDP006 discharge were found to vary between 0.1 mg/L and 0.4 mg/L. The maximum concentration of fluoride recorded was 1.4 mg/L in March 2015.

All results for oil and grease were found to be below the LOR of 5 mg/L for LDP006.

All total cyanide results were found to be below the LOR of 0.004 mg/L for LDP006.

LDP009 water quality

Physicochemical parameters

Physicochemical parameters monitored at LDP009 were found to typically have low variability due to the existing flocculent treatment system in place upstream of the discharge point

EC recorded at LDP009 generally ranged between 980 µS/cm and 1,300 µS/cm. All EC results were found to be above the SSGV (GHD, 2014a) and ANZECC(2000a) DGV of 350 µS/cm.

The pH levels indicated that LDP009 discharge is neutral to slightly alkaline, with samples ranging between 7.7 and 8.3. The majority of pH levels were within the SSGVs of 5.9 to 8.0 (GHD, 2014a), with all results within the recommended ANZECC (2000a) DGVs of 6.5 to 9.0.

Results for TSS ranged between the LOR of 5 mg/L and 17 mg/L for LDP009. All results were found to be below the SSGV (GHD, 2014a) and ANZECC (2000a) DGV of 25 mg/L, with the exception of one sample of 49 mg/L reported in December 2014.

The majority of turbidity results have been reported to be below 10 NTU at LDP009. The SSGV (GHD, 2014a) and ANZECC (2000a) DGV of 25 NTU was exceeded on three sampling occasions in September and December 2014, with a maximum result of 70 NTU reported.

Nutrients

Concentrations of ammonia at LDP009 were found to range between 0.1 mg/L and 0.56 mg/L. All results have been below the SSGV (GHD, 2014a) and ANZECC (2000a) DGV of 0.9 mg/L.

Total nitrogen concentrations ranged between 0.6 mg/L and 1.1 mg/L for LDP009. All concentrations exceeded the ANZECC (2000a) DGV of 0.25 mg/L and were at or above the SSGV of 0.6 mg/L (GHD, 2014a).

Concentrations of total phosphorus recorded at LDP009 were found to be at or below the LOR of 0.01 mg/L, which is below the SSGV of 0.06 mg/L (GHD, 2014a) and the ANZECC (2000a) DGV of 0.02 mg/L.

Metals

The majority of dissolved aluminium results were found to range between the LOR of 0.01 mg/L and 0.06 mg/L. The maximum concentration of 0.22 mg/L was reported for LDP009 discharge in August 2015. This was the only occasion when the SSGV of 0.204 mg/L (GHD, 2014a) was exceeded over the monitoring period. Less than 10% of all dissolved aluminium results were found to exceed the recommended ANZECC (2000a) DGV of 0.055 mg/L.

Dissolved antimony concentrations were at or below the LOR of 0.001 mg/L for LDP009, with the exception of four samples collected in August, October and November 2014 and August 2015. The maximum concentration of dissolved antimony reported was 0.024 mg/L in October 2014.

Dissolved arsenic concentrations varied throughout the monitoring period for LDP009, ranging between 0.003 mg/L and 0.032 mg/L. Approximately 15% of all dissolved arsenic results exceeded the SSGV (GHD, 2014a) and ANZECC (2000a) DGV of 0.024 mg/L.

Results for dissolved barium ranged between 0.005 mg/L and 0.026 mg/L.

Dissolved beryllium has been monitored on two occasions at LDP009, with both results reported to be below the LOR of 0.001 mg/L.

The majority of results for dissolved boron were found to range between 0.05 mg/L and 0.08 mg/L, with a maximum concentration of 0.13 mg/L recorded at LDP009 in August 2015. All results were below the SSGV (GHD, 2014a) and ANZECC (2000a) DGV of 0.37 mg/L.

Dissolved cadmium concentrations were found to be at or below the LOR of 0.0001 mg/L for all LDP009 samples analysed. All results were below the SSGV of 0.0005 mg/L (GHD, 2014a) and the ANZECC (2000a) DGV of 0.0026 mg/L.

Dissolved chromium concentrations were consistently reported below the LOR, equivalent to the SSGV (GHD, 2014a) and ANZECC (2000a) DGV of 0.001 mg/L. All dissolved trivalent and hexavalent chromium results for LDP009 were found to be below the LOR of 0.01 mg/L. The only exception was one sample in April 2015, which reported a dissolved hexavalent concentration of 0.05 mg/L.

Dissolved cobalt has been monitored at LDP009 on three occasions, with all results reported to be below the LOR of 0.001 mg/L as well as the SSGV of 0.005 mg/L (GHD, 2014a) and ANZECC (2000a) DGV of 0.0025 mg/L.

Concentrations of dissolved copper were found to range between the LOR of 0.001 mg/L and 0.003 mg/L in general. Approximately 5% of all dissolved copper results exceeded the SSGV of 0.004 mg/L (GHD, 2014a), with the maximum result of 0.014 mg/L recorded in February 2015. The ANZECC (2000a) DGV of 0.0014 mg/L was exceeded at LDP009 for approximately 24% of samples.

The majority of dissolved iron concentrations monitored at LDP009 were found to be below the LOR of 0.05 mg/L. All results were below the SSGV of 4 mg/L (GHD, 2014a). The ANZECC (2000a) DGV of 0.3 mg/L was exceeded on one occasion, with a maximum concentration of 0.39 mg/L reported in April 2015.

All dissolved lead results for LDP009 were recorded to be below the LOR of 0.001 mg/L. The maximum concentration recorded was 0.134 mg/L in November 2015. This result was the only point reported to be above the SSGV of 0.011 mg/L (GHD, 2014a) and ANZECC (2000a) DGV of 0.129 mg/L.

Dissolved manganese results reported for LDP009 were found to range between 0.002 mg/L and 0.017 mg/L in general. A maximum concentration of 0.096 mg/L was reported in August 2015. All results were found to be below the SSGV (GHD, 2014a) and ANZECC (2000a) DGV of 1.9 mg/L.

Dissolved mercury has been monitored on one occasion at LDP009, with the result reported to be below the LOR of 0.0001 mg/L. This concentration is below the SSGV (GHD, 2014a) and ANZECC (2000a) DGV of 0.0006 mg/L.

Dissolved molybdenum results at LDP009 have ranged between 0.001 mg/L and 0.06 mg/L.

The majority of dissolved nickel concentrations varied between 0.001 mg/L and 0.004 mg/L. A maximum concentration of 0.02 mg/L was reported for LDP009 discharge in September 2014. All results were below the SSGV of 0.025 mg/L (GHD, 2014a) and ANZECC (2000a) DGV of 0.125 mg/L.

Dissolved selenium has been monitored on three occasions at LDP009, with all results reported to be below the LOR of 0.01 mg/L.

Dissolved strontium concentrations were found to range between 0.005 mg/L and 0.018 mg/L in general. The maximum concentration reported for LDP009 was 0.099 mg/L in August 2015.

All dissolved uranium results for LDP009 were reported to be below the LOR of 0.001 mg/L.

Concentrations of dissolved zinc generally varied from the LOR of 0.005 mg/L to 0.028 mg/L in general. The maximum result of 0.044 mg/L was reported for LDP009 in June 2015. Less than 10% of results were found to exceed the SSGV of 0.019 mg/L (GHD, 2014a). All results were below the ANZECC (2000a) DGV of 0.091 mg/L.

Other parameters

Fluoride concentrations reported for LDP009 were found to range between 0.8 mg/L and 1.4 mg/L.

The majority of oil and grease results for LDP009 discharge were found to be below the LOR of 5 mg/L. The maximum concentration of 10 mg/L was reported in July 2014.

All results for phenols were reported to be below the LOR of 0.05 mg/L for LDP009 discharge.

All total cyanide results were found to be below the LOR of 0.004 mg/L for LDP009 discharge.

Additional water quality analysis

As part of the assessment requirements for the Project, the EPA requested additional water quality parameters to be added to the standard suites of analysis undertaken at LDP006 and LDP009 (refer Appendix A). A one-off sampling round was undertaken in May 2016 to sample both LDP006 and LDP009 discharge for these previously undetermined analytes. The results of this water quality analysis are presented in Table 5-16.

Table 5-16 Results of one-off sampling round for LDP006 and LDP009 water quality

Parameter	Units	DGV (ANZECC, 2000a)	LDP006		LDP009	
			SSGV (GHD, 2014b)	Result	SSGV (GHD, 2014a)	Result
Nutrients						
TKN	mg/L	–	–	0.1	–	0.5
Total nitrogen	mg/L	0.25	–	0.3	0.6	0.8
Dissolved metals						
Arsenic	mg/L	0.024	–	<0.001	0.024	0.023
Barium	mg/L	–	–	0.011	0.0368	0.029
Beryllium	mg/L	–	–	<0.001	–	<0.001
Chromium (trivalent)	mg/L	–	–	<0.01	–	<0.01
Chromium (hexavalent)	mg/L	–	–	<0.01	–	<0.01
Molybdenum	mg/L	–	–	<0.001	–	0.037
Total metals						
Aluminium	mg/L	–	–	0.01	–	0.29
Arsenic	mg/L	–	–	<0.001	–	0.028
Barium	mg/L	–	–	0.010	–	0.030
Beryllium	mg/L	–	–	<0.001	–	<0.001
Cadmium	mg/L	–	–	0.0002	–	<0.0001
Cobalt	mg/L	–	–	0.098	–	<0.001
Copper	mg/L	–	–	<0.001	–	<0.001
Iron	mg/L	–	–	0.77	–	0.10
Lead	mg/L	–	–	<0.001	–	0.421
Mercury	mg/L	–	–	<0.0001	–	<0.0001
Molybdenum	mg/L	–	–	<0.001	–	0.042

Parameter	Units	DGV (ANZECC, 2000a)	LDP006		LDP009	
			SSGV (GHD, 2014b)	Result	SSGV (GHD, 2014a)	Result
Selenium	mg/L	–	–	<0.01	–	<0.01
Other						
Phenols	mg/L	–	–	<0.05	–	<0.05

Total nitrogen concentrations for both LDP006 and LDP009 discharge exceeded the ANZECC (2000a) DGV of 0.25 mg/L. In addition, the result for LDP009 discharge exceeded the SSGV of 0.6 mg/L (GHD, 2014a).

All other parameters analysed in May 2016 were found to be below relevant SSGVs for LDP006 and LDP009 (GHD, 2014b; GHD, 2014a) and ANZECC (2000a) DGVs.

Downstream sites

Surface water quality at sites downstream of the Project considered two sites on Wangcol Creek located downstream of LDP006 discharge and the proposed LDP (Wangcol Creek D/S and Wangcol Creek far D/S) and one site on Coxs River located downstream of Lake Wallace (Coxs River D/S). The Coxs River D/S site is also referred to as Coxs River-Delta Site by Springvale Mine. This monitoring point is dominated by the mine water discharge from LDP009 which currently contribute 20 ML/day to 25 ML/day to Sawyers Swamp Creek and the Coxs River (refer Section 5.1.2).

A statistical summary and time series graphs of the water quality at downstream monitoring sites are provided in Appendix D.

Physicochemical parameters

EC recorded at both monitoring sites on Wangcol Creek generally ranged between 500 µS/cm and 4,300 µS/cm. An increasing trend in EC is apparent over time, paralleling the increase in EC at LDP006. The Coxs River D/S site recorded EC results of generally in the range of 910 µS/cm to 1,140 µS/cm, indicating the Coxs River at this point is dominated by LDP009 discharge with EC in the same range. The majority of EC results for all downstream monitoring sites were found to be above the ANZECC (2000a) DGV of 350 µS/cm.

The pH levels at the downstream sites indicated that the water is generally neutral in Wangcol Creek, with samples ranging between 6.3 and 7.7. Results from the Coxs River indicate the water is slightly alkaline, with pH generally reported between 8.1 and 8.7. The majority of pH levels were within the ANZECC (2000a) DGVs of 6.5 and 9.0.

Results for TSS and turbidity were generally below the ANZECC (2000a) DGVs for all downstream monitoring sites.

Nutrients

Concentrations of ammonia recorded for the Coxs River D/S site have ranged between the LOR of 0.01 mg/L and 0.5 mg/L, with all results below the ANZECC (2000a) DGV of 0.9 mg/L. No monitoring of ammonia has been undertaken at the Wangcol Creek monitoring sites.

Total nitrogen concentrations at Coxs River D/S ranged between 0.4 mg/L and 1.0 mg/L. All results exceeded the ANZECC (2000a) DGV of 0.25 mg/L. No monitoring of total nitrogen has been undertaken at the Wangcol Creek monitoring sites.

The majority of total phosphorus results for Wangcol Creek sites were found to be below the LOR of 0.01 mg/L. Maximum results of 0.1 mg/L in November 2015 and 0.06 mg/L in February 2014 have been recorded for Wangcol Creek D/S and Wangcol Creek far D/S respectively. Approximately 10% of all total phosphorus results for Wangcol Creek far D/S exceeded the ANZECC (2000a) DGV of 0.02 mg/L. Results for total phosphorus at the Coxs River monitoring site were generally above the ANZECC (2000a) DGV, ranging between the LOR of 0.01 mg/L and 0.06 mg/L.

Metals

Dissolved aluminium results generally ranged between the LOR of 0.01 mg/L and 0.04 mg/L for all downstream monitoring sites. However, concentrations reported for Coxs River D/S increased up to 0.27 mg/L in late 2014 and 2015. Generally, all results for the two Wangcol Creek sites were found to be below the ANZECC (2000a) DGV of 0.055 mg/L. Approximately a third of results for the Coxs River exceeded the ANZECC (2000a) DGV.

Dissolved antimony results for Coxs River D/S generally ranged between the LOR of 0.001 mg/L and 0.02 mg/L, with the exception of one sample which recorded a concentration of 0.23 mg/L in December 2013. No monitoring of dissolved antimony has been undertaken at the Wangcol Creek monitoring sites.

Concentrations of dissolved arsenic generally ranged between 0.001 mg/L and 0.02 mg/L for Coxs River D/S, with results showing an increase in concentration in 2014 and 2015 compared to 2013. All results were found to be below the ANZECC (2000a) DGV of 0.024 mg/L. No monitoring of dissolved arsenic has been undertaken at the Wangcol Creek monitoring sites.

Limited results were available for dissolved barium. Results ranged between 0.001 mg/L and 0.035 mg/L for the Coxs River D/S monitoring site. No monitoring of dissolved barium has been undertaken at the Wangcol Creek monitoring sites.

The majority of results for dissolved boron were below the ANZECC (2000a) DGV of 0.37 mg/L for the Coxs River D/S site. Concentrations reported for the Wangcol Creek sites displayed more variability, ranging between 0.09 mg/L and 1.5 mg/L. Approximately half of all dissolved boron results for Wangcol Creek D/S and Wangcol Creek far D/S were found to exceed the ANZECC (2000a) DGV.

Concentrations of dissolved cadmium were generally below the LOR of 0.0001 mg/L for all downstream sites. All results were reported below the ANZECC (2000a) DGV of 0.0026 mg/L.

Dissolved copper concentrations at Coxs River D/S generally varied between the LOR of 0.001 mg/L and 0.004 mg/L. The maximum concentration of 0.037 mg/L was reported in August 2014. Approximately a third of results for the Coxs River exceeded the ANZECC (2000a) DGV of 0.0014 mg/L. No monitoring of dissolved copper has been undertaken at the Wangcol Creek monitoring sites.

Reported dissolved iron concentrations were found to range between the LOR of 0.05 mg/L and 1 mg/L in general for the two monitoring sites located on Wangcol Creek. Approximately 10% of results for Wangcol Creek D/S and 35% of results for Wangcol Creek far D/S were found to be above the ANZECC (2000a) DGV of 0.3 mg/L. The majority of concentrations of dissolved iron recorded at Coxs River D/S were below the LOR of 0.05 mg/L. Only one sample was reported to exceed the ANZECC (2000a) DGV, with a maximum concentration of 0.48 mg/L recorded in March 2015.

Concentrations of dissolved lead were generally below the LOR of 0.001 mg/L for Coxs River D/S. All results were reported below the ANZECC (2000a) DGV of 0.129 mg/L. No monitoring of dissolved lead has been undertaken at the Wangcol Creek monitoring sites.

Dissolved manganese concentrations for the Wangcol Creek monitoring sites were found to vary between 0.11 mg/L and 3.5 mg/L, with approximately 10% to 20% of all results exceeding the ANZECC (2000a) DGV of 1.9 mg/L. Results for the Coxs River monitoring site displayed less variability, ranging between 0.006 mg/L and 0.838 mg/L, with all results below the ANZECC (2000a) DGV.

Limited results were available for dissolved molybdenum. Results ranged between 0.005 mg/L and 0.040 mg/L for the Coxs River D/S monitoring site, with an increasing trend apparent over the assessed monitoring period. No monitoring of dissolved molybdenum has been undertaken at the Wangcol Creek monitoring sites.

Dissolved nickel results varied between 0.008 mg/L and 0.203 mg/L for both Wangcol Creek monitoring sites, which is slightly lower than results from monitoring of LDP006 discharge. Approximately 20% of reported results were found to be above the ANZECC (2000a) DGV of 0.125 mg/L. Concentrations of dissolved nickel were reduced at Coxs River D/S, with results reported between 0.001 mg/L and 0.036 mg/L. All results for this site were below the ANZECC (2000a) DGV.

All dissolved selenium results for Wangcol Creek D/S and Wangcol Creek far D/S were found to be below the LOR of 0.01 mg/L. No monitoring of dissolved selenium has been undertaken for the Coxs River D/S monitoring site.

Dissolved strontium at Coxs River D/S was found to vary between 0.016 mg/L and 0.167 mg/L, with a decreasing trend in concentration apparent over the assessed monitoring period. No monitoring of dissolved strontium has been undertaken at the Wangcol Creek monitoring sites.

Dissolved zinc results varied between 0.005 mg/L and 0.203 mg/L for both Wangcol Creek monitoring sites, which is slightly lower than results from monitoring of LDP006 discharge. Approximately 20% of reported results were found to be above the ANZECC (2000a) DGV of 0.091 mg/L. Concentrations of dissolved zinc were reduced at Coxs River D/S, with results reported between the LOR of 0.005 mg/L and 0.070 mg/L. All results for this site were below the ANZECC (2000a) DGV.

Other parameters

Fluoride concentrations ranged between 0.5 mg/L and 1.5 mg/L at Coxs River D/S. No monitoring of fluoride has been undertaken at the Wangcol Creek monitoring sites.

The majority of oil and grease results for all downstream monitoring locations were found to be below the LOR of 5 mg/L. A maximum concentration of 15 mg/L was recorded at Wangcol Creek D/S in August 2015.

All results for phenols were reported to be below the LOR of 0.05 mg/L for Coxs River D/S. No monitoring of phenols has been undertaken at the Wangcol Creek monitoring sites.

All total cyanide results were found to be below the LOR of 0.004 mg/L for Coxs River D/S. No monitoring of cyanide has been undertaken at the Wangcol Creek monitoring sites.

Site-based discharge water quality

To consider surface water quality regionally, a broad assessment of existing water quality data from sites that discharge to Wangcol Creek and Coxs River within the upper Coxs River catchment were assessed. This included Angus Place Colliery, Lidsdale Siding, MPPS, Pine Dale Coal Mine, the SCSS and Springvale Mine.

Angus Place Colliery

Angus Place Colliery has historically discharged mine water to the upper Coxs River catchment via LDP001 (to Kangaroo Creek) and LDP002 (to Coxs River). Angus Place Colliery moved to a care and maintenance phase in March 2015, during which mining operations have ceased but environmental management of the site, including dewatering of the underground workings, is ongoing.

An assessment of surface water quality was undertaken as part of the Angus Place Mine Extension Project: Surface Water Impact Assessment (RPS, 2014a), prior to the care and maintenance phase of the mine. Key water quality issues relevant to Kangaroo Creek and Coxs River were identified as pH, EC, TSS, oil and grease, some dissolved metals and levels of dissolved oxygen. Concentrations of dissolved copper and zinc were relatively high, however were not attributed to mining activities. Downstream of the confluence with Kangaroo Creek, water within the Coxs River was fresh with an EC of 515 µS/cm. TSS and turbidity were generally found to be low within the Coxs River at this location.

A more recent assessment of surface water quality at Angus Place Colliery was undertaken by GHD (draft 2015), which considered data from the monitoring period between January 2013 and June 2015 for LDP001 and LDP002 discharges. The location of these LDPs is provided in Figure 3-9. Recorded pH levels during this time reported a range of 6.8 to 8.4, with EC results of between 51 µS/cm and 1,170 µS/cm indicating fresh and slightly alkaline water. Exceedances of TSS up to 95 mg/L were noted at LDP002. Elevated turbidity was recorded at both LDP locations.

Lidsdale Siding

Discharges from Lidsdale Siding through LDP004 occur due to overflows from a surface water storage to Pipers Flat Creek adjacent to the confluence with the Coxs River, downstream of the Project. Water quality monitoring of discharges over 2014 and 2015 (Ivanhoe Coal, 2015; 2016) reported pH levels between 6.4 and 7.8 and a median EC of 600 µS/cm. TSS and concentrations of oil and grease were found to be relatively low. As discharges through LDP004 occur infrequently during high rainfall events and prolonged wet periods, Lidsdale Siding has minimal influence on water quality within Pipers Flat Creek and the Coxs River.

Mount Piper Power Station

As discussed in Section 5.1.1, MPPS operates as a zero liquid discharge site with no release of water from the cooling water system or other by-products from the water treatment process to receiving waters. Stormwater is discharged from the Final Holding Pond to Wangcol Creek via LDP1. These discharges are typically a low flow, with higher flows only as a result of rainfall events. As such, MPPS has minimal influence on water quality within Wangcol Creek as a result of site-based discharges.

Pine Dale Coal Mine

Pine Dale Coal Mine is located adjacent and to the east of the Project and has historically discharged water into Wangcol Creek. The mine is currently in a phase of care and maintenance and discharges have ceased. Pine Dale Coal Mine has monitoring locations on both Wangcol Creek and the Coxs River.

Within Wangcol Creek, pH levels have been recorded generally between 6 and 8, with water quality changing from slightly acidic to slightly alkaline in May 2012. EC results indicated water is slightly brackish and concentrations of TSS were found to be below the recommended ANZECC (2000a) DGV. Elevated concentrations of dissolved manganese, nickel and zinc have been reported., with elevated concentrations of dissolved iron also reported at discharge locations.

With the Coxs River, water quality monitoring results indicate that water is generally slightly alkaline and has an EC ranging from 300 µS/cm to 1,400 µS/cm (GSS Environmental, 2010). TSS and turbidity results were consistently reported below the recommended ANZECC (2000a) DGVs. Elevated concentrations of iron and nickel were evident in 2012, however concentrations reduced and a decreasing trend in concentration was reported during 2013. Reported concentrations of zinc were found to be consistently above the recommended ANZECC (2000a) DGV.

Springvale Coal Services site

Discharges occur from the SCSS to Wangcol Creek via LDP006 and are influenced by mine water seepage from historical underground mine workings. Monitoring over the last four years has indicated that seepage volume has increase with additional recharge of the historical mine voids.

As discussed above, pH was found to be slightly acidic to slightly alkaline, with results ranging from 6.1 to 8.0. EC reported for LDP006 ranged between 1,000 µS/cm and 4,500 µS/cm, with an increasing trend apparent over time. Elevated concentrations of dissolved nickel and zinc were reported, indicative of the groundwater influenced by previous mining activities that contributes to the discharge through LDP006.

Springvale Mine

Springvale Mine discharges mine water from the SDWTS to Sawyers Swamp Creek via LDP009. As discussed above, pH levels indicated that slightly acidic to slightly alkaline, with results ranging from 6.1 to 8.0. Recorded EC generally ranged between 980 µS/cm and 1,300 µS/cm. Generally, dissolved metal concentrations were found to be low range and below relevant SSGVs (GHD, 2014a) and ANZECC (2000a) DGVs.

Regional water quality

Regional surface water quality has been assessed using monitoring data collected by WaterNSW within the catchment of Lake Burragorang. Water quality data included results for physicochemical parameters and major ions, however results for metals and nutrients were limited.

Upper Coxs River catchment

Results from water quality data collected at site E0321 located on the Coxs River upstream of Springvale Creek indicated the water is slightly brackish, with an average EC of 1,066 µS/cm, alkaline, with an average pH of 8.61, and soft. TSS concentrations were on average very low compared to the ANZECC (2000a) DGV, with an average concentration of 6 mg/L. Reported average physicochemical results were a pH of 8.61, conductivity of and total suspended solids of 6 mg/L. Sodium concentrations were on average elevated to the ADWG (NHMRC, 2016) aesthetic value of 224 mg/L. Magnesium and potassium concentrations both averaged 11 mg/L, while an average value of 17 mg/L was reported for calcium.

Mid Coxs River catchment

Water quality data for monitoring site DWA21 located on Coxs River indicate that water was pH neutral to alkaline, fresh, soft with very low level TSS concentrations. Average physicochemical parameter results were found to be 7.43 for pH, 176 µS/cm for EC and 3 mg/L for TSS. Average ion concentrations were determined as 9.5 mg/L for calcium, 5 mg/L for magnesium, 2 mg/L for potassium and 14 mg/L for sodium.

Lower Coxs River catchment

The monitoring site E083 located on the lower reach of the Coxs River reported slightly alkaline pH, with an average result of 7.55. Water was slightly fresher compared to the upstream site DWA21, with an average EC recorded at 132 µS/cm. Average ion concentrations were generally 1 mg/L higher than concentrations reported for DWA21. TSS was low range with an average concentration of 7 mg/L and the calculated water hardness was categorised as soft.

Lake Burragorang catchment

Upstream Wollondilly River

The WaterNSW monitoring site E450 is located approximately 50 km upstream from of Lake Burragorang on the Wollondilly River. Water quality data provided form this site indicated that it is fresh with an average EC of 437 µS/cm, neutral to slightly alkaline with an average pH of 7.6. TSS was found to be in the low range at 10 mg/L on average. Reported average sodium concentrations of 34 mg/L were dominant over calcium, with an average concentration of 16 mg/L and magnesium, with an average concentration of 13 mg/L. Potassium had the lowest reported ion concentration at 4 mg/L on average.

Downstream Wollondilly River

The monitoring site E488 is located approximately 8 km upstream from of Lake Burragorang. Water quality data provided form this site indicated that it is fresh with an EC of 190 µS/cm, pH was neutral to slightly alkaline with an average pH of 7.6 and calculated hardness category was soft. TSS concentrations were reported below ANZECC (2000a) DGV, with an average concentration of 23 mg/L. Concentrations of calcium, at an average of 10 mg/L, and sodium, at an average of 16 mg/L, were dominant compared to concentrations of magnesium, at an average of 6 mg/L, and potassium, at an average of 3 mg/L.

Lake Burragorang (Wollondilly River)

Situated within Lake Burragorang water storage body on the Wollondilly River, upstream of the Brimstone Creek tributary and downstream of the Lacys Creek tributary is WaterNSW site DWA27. At this site water on average was fresh with an EC of 187 µS/cm, pH neutral with an average of 7.3 reported. The water has low level TSS concentrations with an average of 2 mg/L and calculated hardness has been categorised as soft. Sodium concentrations, which were 14 mg/L on average, and calcium concentrations, which were 10 mg/L on average dominated over magnesium, at 6 mg/L on average, and potassium, at 3 mg/L on average.

Wollondilly River – Coxs River confluence

The WaterNSW site DWA10 is located on the confluence of the Wollondilly River and Coxs River. Upstream from this site is the confluence of the Coxs River and the Warragamba River. Available data was limited to only physicochemical parameters. Water was found to be fresh with an average EC of 160 µS/cm and pH neutral to slightly alkaline at 7.66 on average.

It is expected that there is some mixing at the Wollondilly River and Coxs River confluence; however, there is limited data at this site to provide more detailed water quality characterisation. The water quality data from nearby sites on Wollondilly River and Coxs River indicate that both rivers share very similar characteristics in the location of DWA10.

Upstream Warragamba River

The Warragamba River at upstream site DWA02 flows into the Warragamba Dam and is located downstream of the Nepean River confluence. Water quality at DWA02 was fresh with EC recorded at 168 µS/cm on average, pH neutral to slightly alkaline at 7.27 on average, had a low TSS concentration at 2 mg/L on average and calculated hardness categorised as soft. Dominant ions were sodium at 14 mg/L and calcium at 12 mg/L on average over magnesium at 6 mg/L and potassium at 2 mg/L on average.

Downstream Warragamba River

Site DWA09 is located downstream of DWA02 on the Warragamba River and upstream of site DWA10. Water quality at DWA09 was similar to other sites within the Lake Burragorang sub-catchment. EC recorded an average of 170 µS/cm, with pH levels indicating neutral to slightly alkaline water with an average pH of 7.26. TSS concentration was also low at 2 mg/L on average. Concentrations of sodium, with an average of 14 mg/L, and calcium, with an average of 9 mg/L, were dominant over magnesium, with an average of 5 mg/L, and potassium, with an average of 2 mg/L.

Summary

Throughout Wangcol Creek, monitoring sites were characteristic of extremely hard, pH neutral, slightly saline water and dissolved metals generally below the ANZECC (2000a) DGVs. Background sites located near the Neubecks Creek and Wangcol Creek confluence were observed to have increased levels of nutrients and some dissolved metals which are reflective of rainfall runoff influences. Site SW1 generally had lower concentrations of nutrients and some dissolved metals and fresher water compared to SW2 and SW3. The slightly elevated analyte levels recorded at SW2 and SW3 may also be a reflection of groundwater influences from historical underground mine workings.

Water quality reported for the Coxs River was characteristic of slightly alkaline and soft water. The upper reaches of the catchment were slightly saline, likely a result of mine water discharge activities from operations in in the upper Coxs River catchment. Dissolved metals were generally below the ANZECC (2000a) DGVs, with the exception of copper. An increasing trend in concentration over time evident for dissolved aluminium, arsenic, boron and molybdenum.

The mid to lower reaches of the Coxs River into Lake Burragorang were found to have fresh, pH neutral to slightly alkaline, soft water. The Wollondilly River flowing into Lake Burragorang also shared these characteristics. It is expected that there are mixing processes within the lake at the Coxs River and Wollondilly River confluence and likely influences from other tributaries flowing into the water storage body.

5.6.2 Ecotoxicology assessment

Toxicity testing

The toxicity testing conducted by ESA on mine water discharges from LDP009 at Springvale Mine in August and October 2014, April 2015 and May 2016 fulfilled the criteria for NATA accredited tests (with the exception of the freshwater shrimp bioassay that is not NATA accredited) with all quality assurance/quality control parameters being met.

As discussed in Section 4.6.3, statistical analysis of the toxicity testing results provide the concentration of the sample where 10% (EC_{10}) and 50% (EC_{50}) of test organisms exhibit the specific end point of the bioassay and the NOEC, which represents the highest concentration that has no effect upon the test species.

Screening bioassay results are considered to show toxicity if the results are less than 80% of the control. This is based on the quality control parameter for test acceptability used by the testing laboratory.

August 2014

A summary of the toxicity testing results from August 2014 at LDP009 is provided in Table 5-17 (GHD, 2014a).

Table 5-17 Summary of ecotoxicology assessment results for LDP009 discharge (August 2014)

Bioassay	Endpoint	Concentration (95% confidence limits)		
		EC_{10}	EC_{50}	NOEC
Cladoceran	Survival	34%*	59% (48%–72%)	50%
	Reproduction	9.3% (5.2%–16%)	29% (16%–50%)	25%
Microalga	Growth	3.7%*	6.0% (5.5%–6.7%)	3.1%
Duckweed	Growth	<3.1%	>96.8%	96.8%
Hydra	Growth	5.1%*	18% (14%–25%)	3.1%
Fish	Imbalance	25%*	50% (41%–62%)	25%

* 95% confidence limits not reliable.

The results of the toxicity testing conducted in August 2014 (GHD, 2014a) presented in Table 5-17 indicate that the discharge was toxic to the test species, with the alga, cladoceran and hydra species showing significant toxicity to the discharge. The alga was observed to have the most sensitivity to the discharge from LDP009. The duckweed test showed no toxicity to the discharge and the fish bioassay showed only slight sensitivity.

October 2014

A summary of the toxicity testing results from October 2014 is provided in Table 5-18 (GHD, 2014a) for LDP009 discharges pre- and post-treatment with flocculants.

Table 5-18 Summary of ecotoxicology assessment results for LDP009 discharges using cladoceran bioassay (October 2014)

Sample	Reproduction (% of control)	Survival (%)
Laboratory control	100	100
LDP009 discharge (pre-treatment)	12	80
LDP009 discharge	4	40

The results of the cladoceran screening tests conducted in October 2014 (GHD, 2014a) indicate the LDP009 discharge water prior to water quality treatment with flocculants is not acutely toxic, however does show chronic toxicity. The discharge through LDP009 following treatment was found to be less toxic than the sample tested in August 2014.

April 2015

A summary of the toxicity testing results from April 2015 is provided in Table 5-19 (GHD, 2015a).

Table 5-19 Summary of ecotoxicology assessment results for LDP009 discharge using cladoceran bioassay (April 2015)

Sample	Reproduction (% of control)	Survival (%)
Laboratory control	100	90
LDP009 discharge	11.6	90

The reproduction results of the screening test presented in Table 5-19 indicate that the LDP009 discharge at Springvale Mine in April 2015 was chronically toxic. The sample was observed to not be acutely toxic to the cladoceran test species with survival showing no difference to the laboratory control.

May 2016

A summary of the toxicity testing results from May 2016 is provided in Table 5-20 (GHD, 2016e).

Table 5-20 Summary of ecotoxicology assessment results for LDP009 discharge (May 2016)

Bioassay	Endpoint	Concentration (95% confidence limits)		
		EC_{10}	EC_{50}	NOEC
Cladoceran	Survival	50%*	>100%	100%
	Reproduction	<3.1%	47% (34%–64%)	25%
Microalga	Growth	<3.1%	7.6% (5.4%–9.6%)	3.1%
Duckweed	Growth	17%*	>96.8%	96.8%
Fish	Survival	<3.1%	>100%	100%
Shrimp	Survival	17% (13%–20%)	28% (24%–32%)	12.5%

* 95% confidence limits not reliable.

The results of the toxicity testing presented in Table 5-20 conducted in May 2016 indicate that the LDP009 discharge was toxic to the test species, with the alga and shrimp species showing significant toxicity to the discharge. The cladoceran reproduction results indicated chronic toxicity, however the survival results showed no acute toxicity. The duckweed and fish tests showed no toxicity to the 100% sample of LDP009 discharge.

Water quality analysis

A summary of the results of the water quality analysis for the LDP009 discharge is provided in Table 5-21. The results for the October 2014 testing round include samples of LDP009 discharge pre- and post-treatment with flocculants. It should be noted that all semi-volatile organic compounds tested in October 2014 in both pre- and post-treatment samples were found to be below the limit of reporting and are not presented in Table 5-21.

Table 5-21 Summary of water quality analysis for LDP009 ecotoxicology assessments

Parameter	Units	August 2014	October 2014		April 2015	May 2016
			Pre-treatment	Post-treatment		
Physicochemical parameters						
EC	µS/cm	1,148	1,192	1,127	1,159	1,120
pH	pH units	8.04	7.32	7.93	7.91	7.91
TDS	mg/L	780	692	652	738	728
TSS	mg/L	19	13	9	6	10
Turbidity	NTU	13.5	22	8.5	–	0.6
Nutrients						
Ammonia	mg/L	0.44	0.14	0.43	0.56	0.41
DOC	mg/L	55	41	5	<1	7
Nitrite + nitrate	mg/L	0.21	0.78	0.43	0.31	0.31
TKN	mg/L	0.6	0.2	0.5	0.6	0.5
Total nitrogen	mg/L	0.8	1	0.9	0.9	0.8
Total phosphorus	mg/L	0.02	0.02	0.01	<0.01	0.02
Anions						
Alkalinity	mg/L	625	516	531	597	640
Chloride	mg/L	6	5	6	5	7
Sulfate	mg/L	34	34	33	6	27
Cations						
Calcium	mg/L	1	1	1	<1	4

Parameter	Units	August 2014	October 2014		April 2015	May 2016
			Pre-treatment	Post-treatment		
Magnesium	mg/L	<1	1	1	<1	3
Potassium	mg/L	9	8	9	8	10
Sodium	mg/L	291	251	252	291	300
Dissolved metals						
Aluminium	mg/L	0.01	<0.01	0.1	0.04	0.02
Arsenic	mg/L	0.024	0.023	0.033	0.016	0.023
Barium	mg/L	0.028	0.028	0.025	0.005	0.029
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.07	0.07	0.07	0.07	0.12
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	<0.001	<0.001	0.001	<0.001	<0.001
Iron	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Lead	mg/L	<0.001	<0.001	0.001	<0.001	<0.001
Manganese	mg/L	0.008	0.002	0.004	0.007	0.012
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.038	0.036	0.035	0.055	0.037
Nickel	mg/L	0.004	0.002	0.004	0.003	0.003
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01

Parameter	Units	August 2014	October 2014		April 2015	May 2016
			Pre-treatment	Post-treatment		
Strontium	mg/L	0.03	0.028	0.018	0.005	0.019
Vanadium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.007	0.017	0.012	0.010	0.010
Total metals						
Aluminium	mg/L	0.19	0.24	0.24	–	0.29
Arsenic	mg/L	0.023	0.03	0.03	–	0.028
Barium	mg/L	0.027	0.027	0.026	0.030	0.030
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.06	0.07	0.07	–	0.12
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	<0.001	0.001	0.005	<0.001	<0.001
Cobalt	mg/L	<0.001	0.001	<0.001	0.001	<0.001
Copper	mg/L	0.003	0.003	<0.001	–	<0.001
Iron	mg/L	0.3	0.41	0.14	–	0.10
Lead	mg/L	<0.001	0.001	<0.001	<0.001	0.421
Manganese	mg/L	0.014	0.006	0.008	–	0.012
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.036	0.048	0.049	0.050	0.042
Nickel	mg/L	0.003	0.004	0.007	–	0.003
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01

Parameter	Units	August 2014	October 2014		April 2015	May 2016
			Pre-treatment	Post-treatment		
Strontium	mg/L	0.015	0.02	0.018	0.023	0.020
Vanadium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.017	0.006	<0.005	–	0.008
Other						
Bromide	mg/L	0.046	0.034	0.019	–	0.012
Free cyanide	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Total cyanide	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Fluoride	mg/L	1.5	1.3	1.3	1.2	1.2
Oil and grease	mg/L	<5	<5	<5	<1	<5

Dilution factor

The EC_{10} values presented in Table 5-17 and Table 5-20 for LDP009 discharge tested in August 2014 and May 2016 were analysed in the BurrliOZ software package (Campbell et al., 2000) and the concentration for varying species protection levels were calculated, as shown in Table 5-22.

Table 5-22 Dilution factors for LDP009 determined from ecotoxicology results

Species protection (%)	August 2014		May 2016	
	Concentration of LDP009 (%)	Dilution factor	Concentration of LDP009 (%)	Dilution factor
80	5.1	1:20	5.2	1:19
90	3.6	1:28	2.4	1:42
95	2.7	1:37	1.1	1:91
99	1.7	1:59	0.2	1:500

Discussion

The results of alga and duckweed bioassays were similar in the August 2014 and May 2016 testing rounds, with the alga showing significant toxicity and the duckweed showing no toxicity. The Cladoceran reproduction results have indicated chronic toxicity in all toxicity assessments in August and October 2014, April 2015 and May 2016. The results for the Cladoceran survival test in April 2015 and May 2016 show improvement from the two sets of results in 2014, with no acute toxicity detected. Comparing the toxicity and water quality results indicates that the current flocculent agent and dosing rates, which were implemented between the October 2014 and April 2015 investigations, have reduced the acute toxicity of LDP009 discharge. However, chronic toxicity of the mine water discharge has not changed significantly since August 2014. This is supportive of the chronic toxicity being attributable in the underground mine water.

From the water quality results for the LDP009 discharges, the majority of dissolved metals analysed were found to be below the ANZECC (2000a) DGVs, indicating that metals are unlikely to be the cause of the observed toxicity. An ionic imbalance is a potential cause of the variability in toxicity testing results observed, which may result from the composition and concentration of anions and cations. Toxicity associated with ionic imbalance occurs when the concentration and/or ratio of ions is not within the physiological tolerance range of test organisms. Generally, chronic toxicity end points such as growth and reproduction are more sensitive to the energy expending requirements of osmoregulation associated with ionic imbalances than the acute toxicity end point of survival.

During the response to submissions phase of the Springvale Mine Extension (SSD-5594) the EPA identified the potential for ionic imbalance (Whyte 2014b) from comparisons between Angus Place Colliery and Springvale Mine underground mine water. The conclusions of EPA indicated that low hardness (as $CaCO_3$), calcium, magnesium and potassium could be a driver to the chronic toxicity observed at LDP009. Attention was also drawn to elevated concentrations of bicarbonate alkalinity and sodium in LDP009 discharges when compared with Angus Place Colliery mine water.

An Australian Coal Research Paper (ACARP Project C23010) was prepared in May 2016 which investigated the toxicity of saline solution with different ionic compositions on freshwater organisms. The objectives of the investigation were:

- To undertake acute toxicity tests to determine the tolerance of selected aquatic macroinvertebrates from representative catchments, to saline solutions representative of ionic compositions on mine water in the southern and western coalfields. A sample of artificial mine water was also assessed, which was representative of the Bowen Basin.
- To undertake acute and chronic tests on representative mine waters ionic compositions using a standard suit of laboratory reared taxa (specific to the regions assessed) to compute levels of ecosystem protection afforded by different salinities.

A discussion of the influence of ionic composition on toxicity indicated that testing results can vary between organisms and can be complicated by anion or cation parameters in isolated versus a ratios of parameters. Generally, the investigation found that potassium ion, bicarbonate ion, manganese ion, chloride ion and sulfate ion are all drivers to toxicity from ionic composition with potassium ion being the greatest influence and sulfate ion being the least. Further discussion of salinity thresholds from the ACARP paper are included in Section 6.6.2.

When considering the parameters that were out of balance in comparisons undertaken between Springvale Mine and Angus Place Colliery water, the ionic composition influences on chronic toxicity are supported by the outcomes of the ACARP paper.

5.7 Groundwater environment

5.7.1 Local groundwater elevations

There are currently 12 monitoring bores located within the MPPS site and 15 monitoring bores located within the SCSS. The details of these monitoring bores are presented in Appendix E. Groundwater elevation data has been collected on either a quarterly or monthly basis since 2000 at MPPS and since 2013 for the SCSS. A discussion of monitoring data from each primary groundwater source is been provided in the following sections.

Alluvium groundwater

Two bores are present within the alluvium as part of the MPPS groundwater monitoring network. Groundwater bores are also present as part of Centennial Coal's network to the west of the Project near the confluence of Neubecks Creek and Wangcol Creek.

Groundwater levels from MPPS monitoring indicate groundwater level varied between 1.3 m below ground level (m bgl) to 2.1 m bgl. Centennial Coal's monitoring network indicated over the last two years a groundwater depth of 1 m bgl to 1.3 m bgl around the Neubecks Creek confluence.

Figure 5-23 presents the alluvial groundwater levels over the last two years of monitoring.

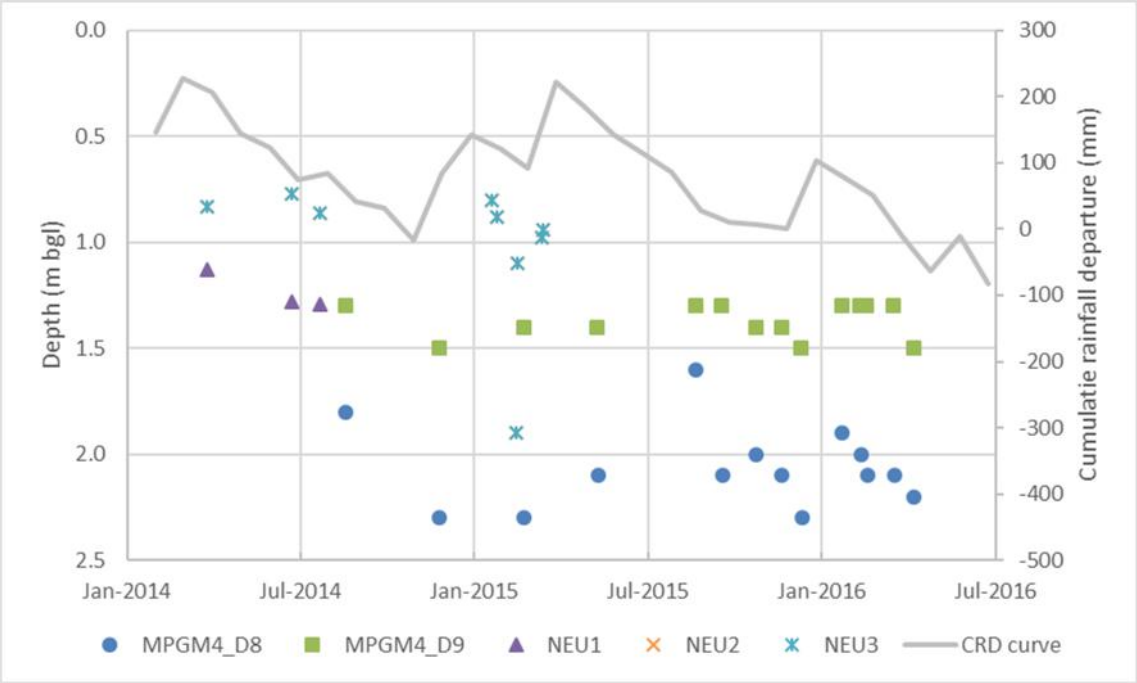


Figure 5-23 Alluvial groundwater levels

The groundwater level trends vary across each of the monitoring locations. The NEU series of bores tend to represent consistent trends being in close proximity to each other whereas the MPPS monitoring locations (MPGM4_D8 and MPGM4_D9) are somewhat similar to monthly rainfall patterns.

Lidsdale Seam

The monitoring bore MPGM4_D1 is representative of the groundwater above the Lidsdale Seam as the majority of MPPS elevations interface with the Lidsdale Seam rather than the Lithgow Seam which interfaces with the SCSS operations.

Figure 5-24 presents the depth to groundwater from monitoring bore MPGM4_D1 over the last two years.

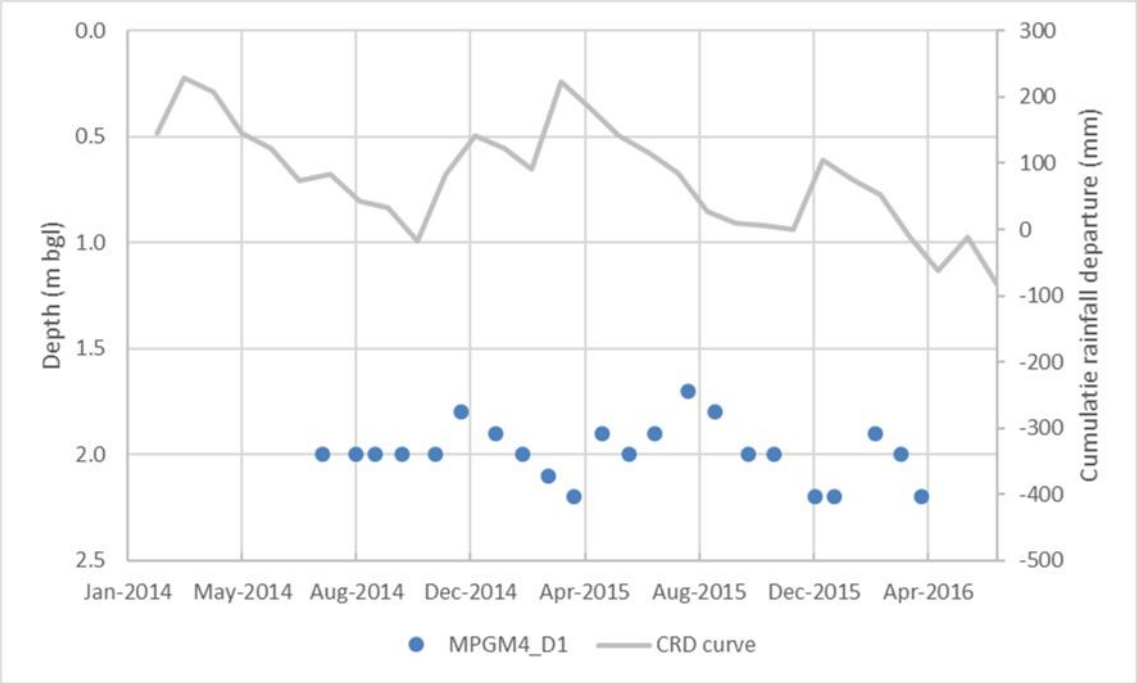


Figure 5-24 Groundwater levels above the Lidsdale Seam

Figure 5-24 indicates a good correlation to rainfall and groundwater level at MPGM4_D1. Typically water at this point is between 2 m bgl to 2.5 m bgl with a general trend following the CRD curve. This exemplifies the high connectivity between the surface and groundwater within SCSS and parts of the MPPS site.

Lithgow Seam

Groundwater levels above the Lithgow Seam are comprehensively monitored within the SCSS as a majority of the site has at some stage historically interfaced with the seam through open cut mining activities. One MPPS monitoring bore is located between the site and the SCSS monitors groundwater levels above the Lithgow Seam.

Figure 5-25 presents monitored groundwater levels above the Lithgow Seam since 2013.

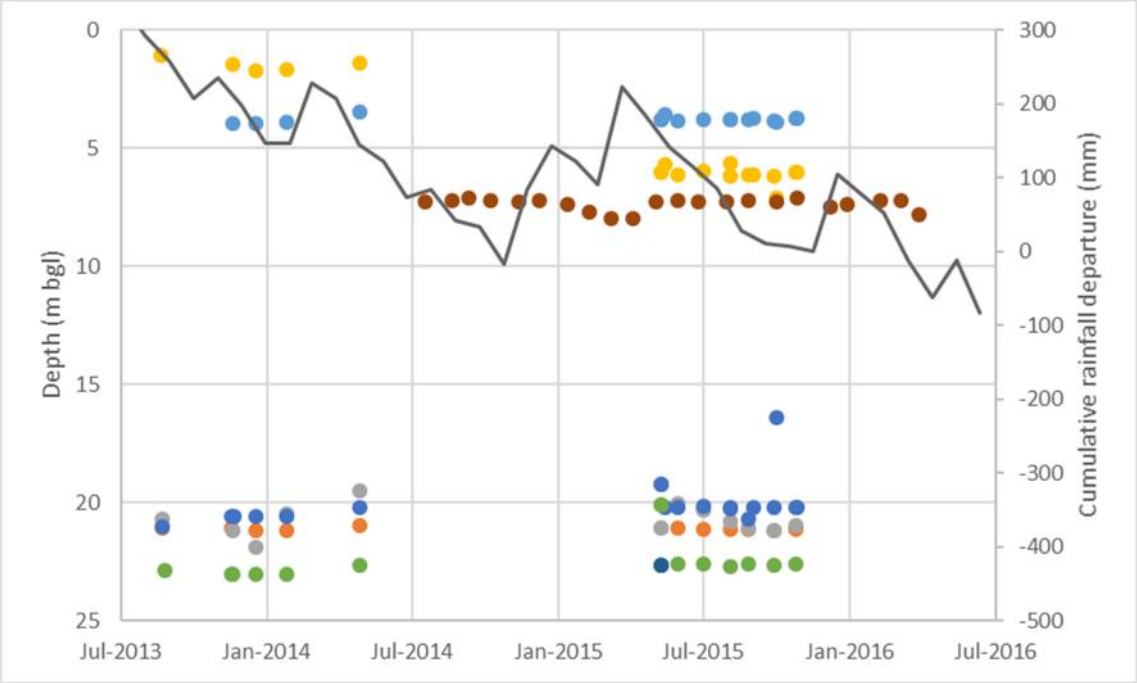


Figure 5-25 Groundwater levels above the Lithgow Seam

Figure 5-25 indicates that groundwater levels within the Lithgow Seam show some response to rainfall however less than that shown within groundwater above the Lidsdale Seam. Groundwater monitoring locations surrounding the existing surface water storages of DML Dam and Cooks Dam at the SCSS are somewhat influenced by volume within these two dams, as they are located within historical open cut areas and lie above backfill material. This is the case for bores BH1, BH6, and BH8.

Groundwater bores BH8, BH9 and BH10 are located to the south of the SCSS where the depth to the Lithgow Seam is greater.

Groundwater contours above the Lithgow Seam has been mapped over MPPS and the SCSS, with the piezometric map provided in Figure 5-26. Indicative groundwater level with respect to MPPS and SCSS site features are presented in Figure 5-27.



Paper Size A4

0 0.075 0.15 0.3 0.45 0.6

Kilometers

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

N

LEGEND

- Project application area
- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- Groundwater Level (1m interval)
- Cross sections
- Centennial Coal borehole
- EnergyAustralia borehole
- Watercourse - Non Perennial
- Watercourse - Perennial

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Piezometer contours for groundwater above the Lithgow Seam

Figure 5-26

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Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial: Site location, boundaries, pipeline, imagery, 2016. Created by: tmorton

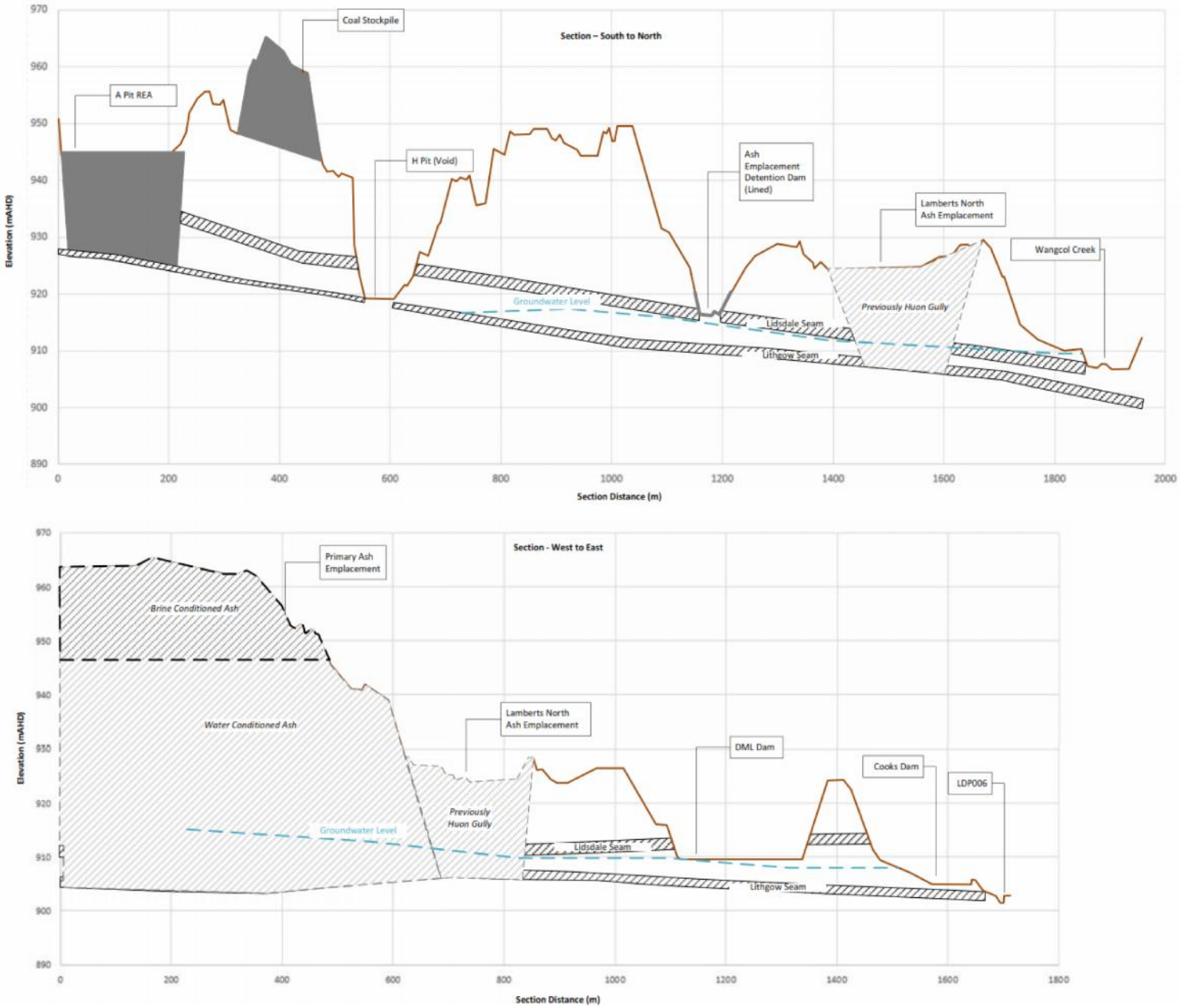


Figure 5-27 Groundwater level cross sections

5.7.2 Local groundwater quality

The groundwater within the MPPS site and surrounding area is typically of a poor quality due to the historical land uses of mining and backfilling with waste material and coal reject. Many emplacement areas have been constructed at the floor of the Lithgow Seam, allowing for some connectivity with groundwater. The two key activities influencing and characterising the groundwater environment are the historical mining including coal REAs and the existing ash emplacement.

Generally, a more complete water quality parameter dataset was available within MPPS bores compared with the SCSS.

Historical mine workings

Historical mining within the SCSS and the surrounding areas has had a long-term influence on groundwater quality. The groundwater environment specific to the SCSS is dominated by geochemical influences of the seams that have been exposed. Much of the historical open cut workings have been backfilled with overburden material, with some existing remanent voids being utilised as REAs and potential landfill areas.

Figure 5-28 presents MPPS and the SCSS operations with respect to historical open cut and underground mining within the area. Mining activities typically where targeting the Lidsdale and Lithgow coal seams.

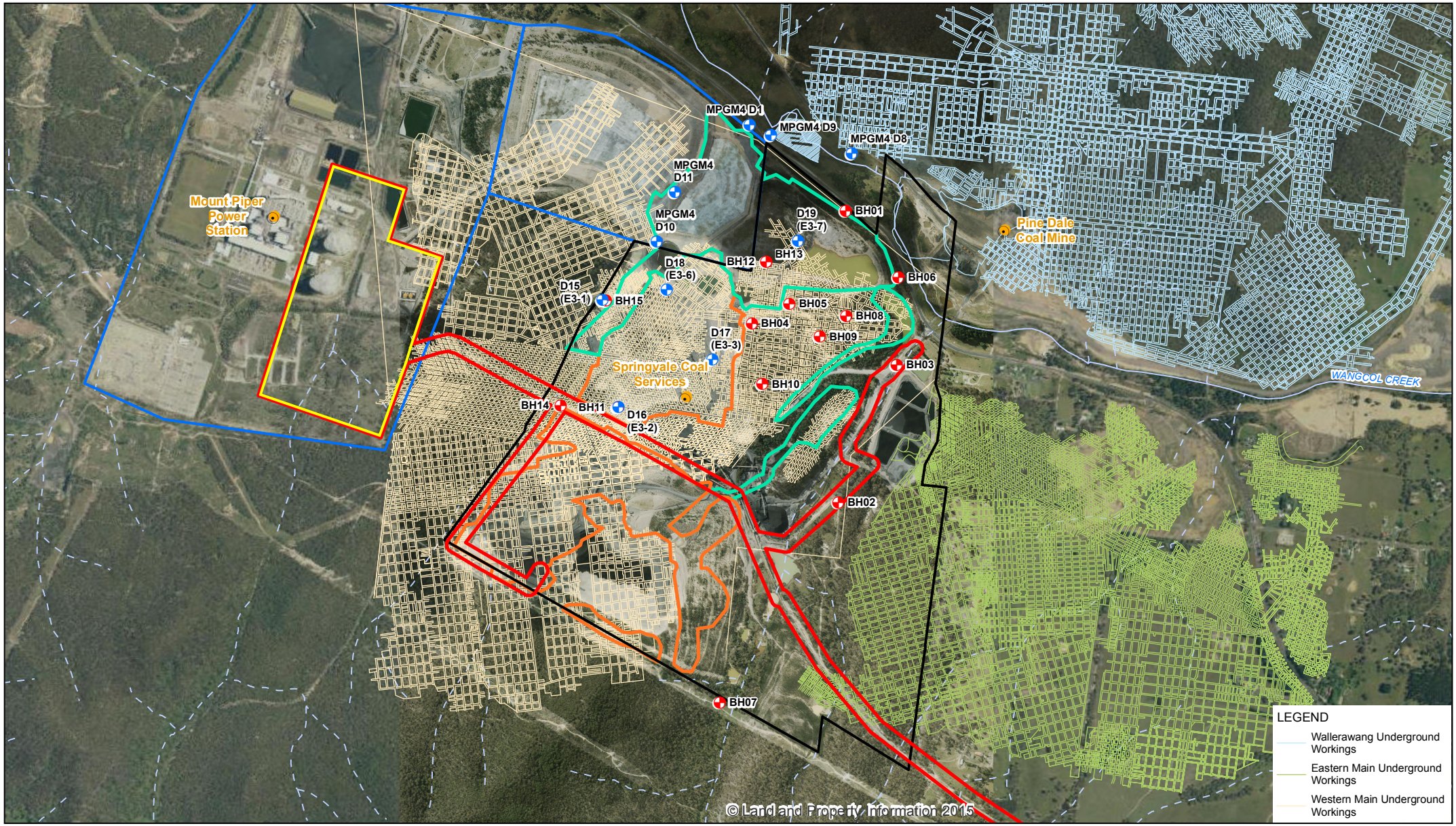
Groundwater quality typically representing a previous mining impact are elevated parameters of sulfate, boron, iron, manganese, nickel and zinc (Connell Wagner, 2007).

Groundwater quality of bores located within historical mine workings have been summarised in Table 5-23. Data presented is the average from at least three rounds of groundwater quality sampling from 2010 to 2013 (RPS, 2013b).

Table 5-23 Average groundwater quality concentrations within historical mining areas

Parameter	Units	BH1	BH4	BH5	BH6	BH8	BH9	BH11
Physicochemical parameters								
pH*	pH units	5.9	–	–	6.4	6.3	–	–
EC	µS/cm	1,418	284	283	958	2,452	2,365	577
Anions								
Chloride	mg/L	132	12	24	126	310	312	23
Sulfate	mg/L	1,180	38	73	902	1,940	1,970	336
Metals								
Boron	mg/L	0.46	0.07	<0.05	0.54	2.03	1.86	<0.05
Iron (dissolved)	mg/L	8.61	0.34	0.17	2.6	<0.05	9.27	1.66
Manganese (dissolved)	mg/L	7.46	0.752	0.55	4.28	<0.001	9.88	0.056
Nickel	mg/L	0.37	0.036	0.016	0.261	0.407	0.607	0.002
Zinc	mg/L	0.28	0.036	0.019	0.863	8.71	0.503	0.008

* Data from recent field monitoring undertaken in 2015.



Paper Size A4

0 0.075 0.15 0.3 0.45 0.6

Kilometers

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

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LEGEND

- Project application area
- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- Centennial Coal borehole
- EnergyAustralia borehole
- Lamberts Gully
- Western Main
- Watercourse - Non Perennial
- Watercourse - Perennial

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Historical mining activities within MPPS and SCSS

Figure 5-28

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Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial: Site location; boundaries; workings; monitoring, imagery, 2016. Created by: tmorton

Results of Table 5-23 indicate a variable groundwater quality with elevated concentrations of boron, nickel and zinc, which are typical indicators for the water quality of the historical workings. Bores BH4, BH5, BH11 are less influenced by factors that are driving BH1, BH6, BH8 and BH9. Bores BH8 and BH9 are likely representative of water quality within DML Dam at the SCSS, with the bores directly influenced by water levels within the dam through backfill material.

It should be noted that groundwater is reused in washing of coal at the SCSS. It is likely that through the reuse of groundwater, concentrations of some parameters have increased in concentration as coal reject is emplaced and some water from the washing process re-enters the groundwater at a slightly elevated concentration compared to when it was first extracted. It is expected that reject emplacement will result in a loss of water to the groundwater environment initially; however, this will reduce as emplacement material settles.

A Piper diagram, provided in Figure 5-29, supports the lack of distinction between water types from all groundwater monitoring locations assessed. Groundwater qualities represent a well-mixed aquifer, defined above the Lithgow Seam and generally suggests the dominance of sulfate.

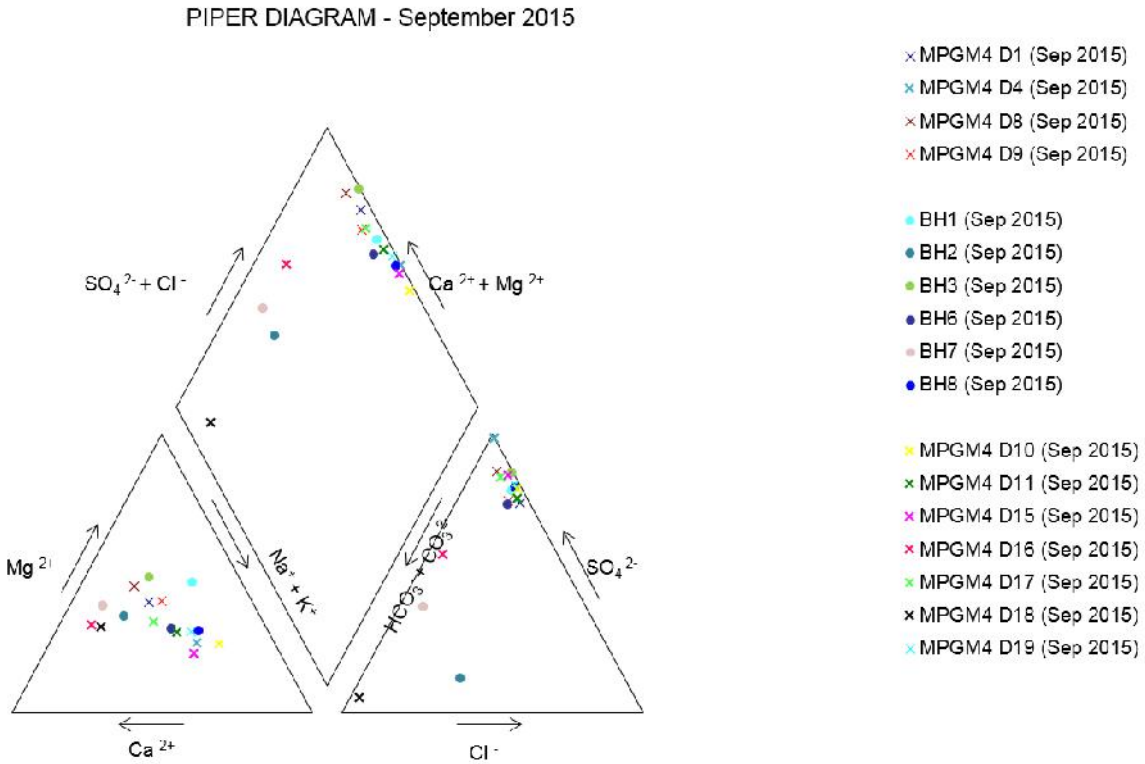


Figure 5-29 Piper diagram of all groundwater monitoring locations for data sampled (September 2015)

At the SCSS, surface and groundwater quality is linked through interactions between historical mine workings and some surface water storages as discussed in Section 5.7.3. Investigations into the improvements and management of potential source contaminants is ongoing at the SCSS. This involves the development of a hydrogeological model and modifications in water management practices. These works are being undertaken as part of the operations at the SCSS and do not form part of this Project.

Ash emplacement

MPPS groundwater monitoring includes a series of bores to manage groundwater contamination risk from ash emplacement. To assess the existing conditions of the ash emplacement, groundwater quality was reviewed for all bores located around the ash emplacement as well as the SCSS groundwater monitoring locations to determine the presence of chloride, which is a key indicator parameter for migration of leachate from emplaced brine conditioned ash.

Groundwater quality of bores surrounding the existing ash emplacement has been summarised in Table 5-24. Data presented is the average from 28 monitoring rounds between 2014 and 2016.

Table 5-24 Average groundwater quality concentrations surrounding the existing ash emplacement

Parameter	Units	MPGM4_D10	MPGM4_D11	MPGM4_D1	MPGM4_D19
Physicochemical parameters					
pH	pH units	5.7	6.2	6.1	6.4
EC	µS/cm	7,352	5,914	3,933	3,939
Anions					
Chloride	mg/L	698	577	368	298
Sulfate	mg/L	3,745	3,066	1,981	2,038
Metals					
Boron	mg/L	3.63	2.70	2.16	1.44
Iron (dissolved)	mg/L	11.5	59.1	32.8	0.16
Manganese (dissolved)	mg/L	8.97	15.2	15.6	0.399
Nickel	mg/L	0.943	0.472	0.95	0.241
Zinc	mg/L	1.35	0.067	0.102	0.376
Other					
Fluoride	mg/L	0.940	0.13	0.098	0.099

Whilst the statistics of three bores presently monitored around the ash dam indicate elevated parameters of EC, chloride, dissolved iron and sulfate, specific association with the brine conditioned ash activities are unconfirmed. Studies undertaken from 2007 and 2012 indicate that much of the existing elevated parameters are due to mine spoil and historical mining activities that are elevating groundwater quality. Connell Wagner (2007) indicated that sulfate, boron, iron, manganese, nickel and zinc are elevated due to the local mineralisation within underground goaf areas. Connell Wagner (2007) indicate that bores MPGM4_D10 and MPGM4_D11 are influenced by water from these goaf areas. Historically, the quality of water extracted from MPGM4_D10 has been poor.

It is expected that bore MPGM4_D1 is observing elevated concentrations in some water quality parameters due to the removal of the Huon Gully Dam (also referred to as the Groundwater Collection Basin). With the removal of the basin, groundwater level is generally elevated with infilling that has occurred and underground goaf water has become an influencing factor on bore MPGM4_D1 which is likely intercepting the Lidsdale Seam at approximately 910 m AHD.

As the EC of water is a key water quality parameter for this Project, a plot of average EC levels across all monitored groundwater bores within MPPS and SCSS was undertaken. Figure 5-30 presents the interpolated contours from the average EC for the MPPS and SCSS operations.

MPPS have undertaken the installation of additional groundwater bores in the first quarter of 2016 to assess potential groundwater quality changes within areas around the ash emplacement. This work is ongoing and any future works are to be undertaken as part of the operations of MPPS and do not form part of this Project.

5.7.3 Surface and groundwater connectivity

Historical mine workings

RPS (2013a) identified that mining in the MPPS and SCSS operational areas has been extensive. Historical mine workings exist under the SCSS (Western Main), partially under MPPS (Huon Colliery), to the east (Eastern Main) and to the north (Wallerawang Colliery No 1 and 3). More specifically within the SCSS the following areas interface with historical mining activities:

- Existing washery is located on the floor of a historical open cut mine.
- The majority of the REA is located within a historical open cut mine.
- Co-disposal area is located on the floor of the Lithgow Seam.

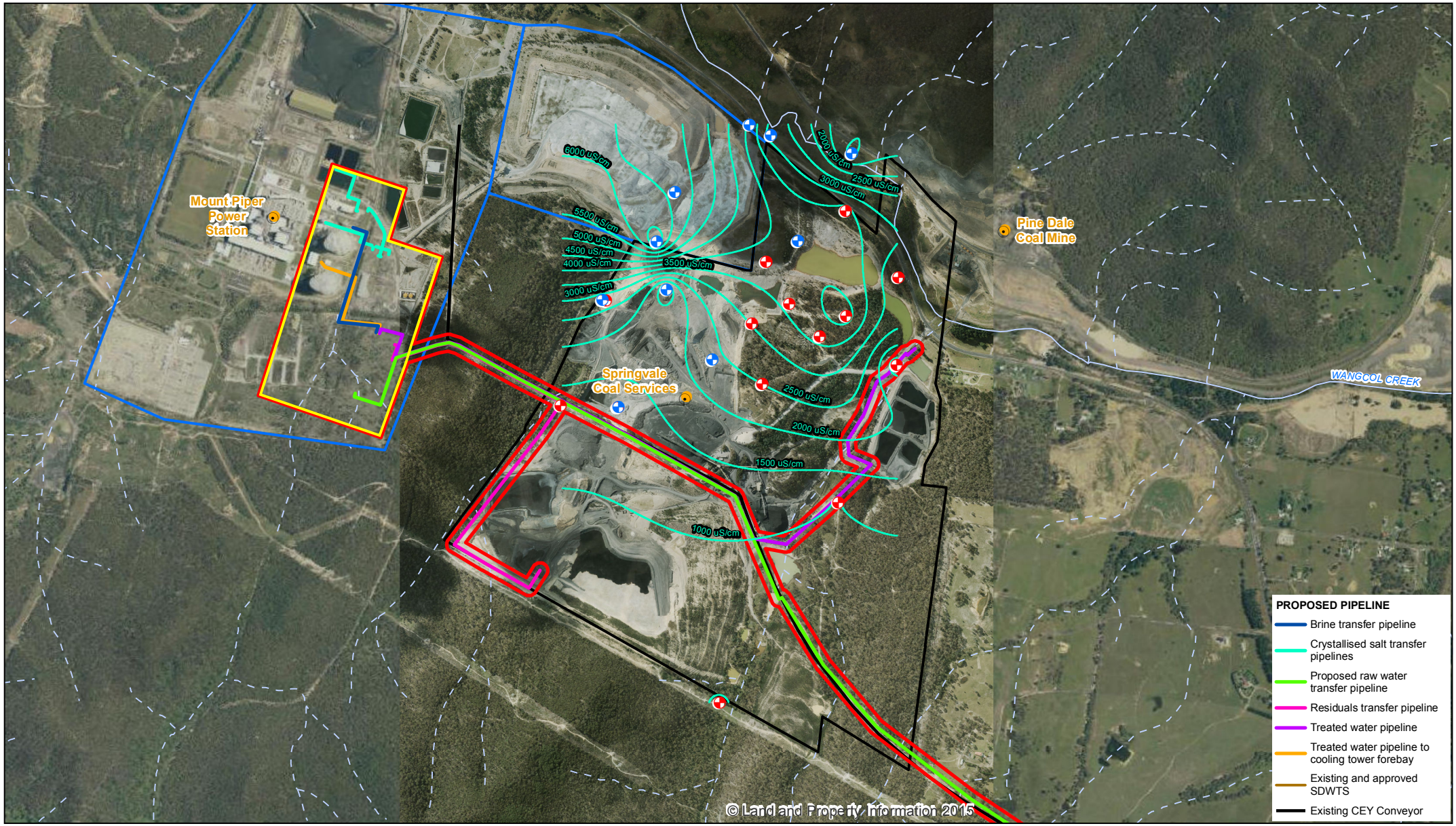
Many voids left by open cut mining have been filled by rejects at the SCSS, filled by ash at MPPS or remain open. Areas of higher permeability are likely to occur where backfilling has been undertaken.

Shallow groundwater flow is generally towards the north-east and Wangcol Creek. The likelihood of groundwater interfacing with Wangcol Creek is high; however, this is dependent upon the relationship between groundwater level and water level within the creek. RPS (2013a) have identified that, based on elevation information of Wangcol Creek and the Lidsdale Seam floor, the likelihood is that groundwater contributing to Wangcol Creek from the historical mining areas is more likely to be as a result of groundwater within or above the Lidsdale Seam.

Groundwater recharge is likely to be occurring through the SCSS operations from water intercepted by remanent open cut voids, ash emplacement areas and REAs. SKM (2010) suggest that due to interconnectivity and permeability of the surface, groundwater tables may rise between 1 m and 3 m in a few hours of rainfall.

Ash emplacement

The ash emplacement at MPPS has been in operation since the establishment of the power station. Historically, ash and water conditioned ash was co-disposed of within the ash emplacement, with operational decisions and site conditions determining how the ash was conditioned prior emplacement. Following the modifications and expansion of the ash emplacement, the management of ash changed such that only water conditioned ash could be emplacement at levels below approximately 946 m AHD. This change in management allowed for the buffer of some 39 m of brine conditioned ash from the base of the emplacement. Following the most recent development approval to modifications of the ash emplacement, the control levels for the placement of brine conditioned ash are set to 946 m AHD for Lamberts north emplacement (current) and 956 m AHD for Lamberts south emplacement (future).



Paper Size A4

0 0.075 0.15 0.3 0.45 0.6 0.75

Kilometers

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

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LEGEND

- Project application area
- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- Centennial Coal borehole
- EnergyAustralia borehole
- Aveage electrical conductivity
- Watercourse - Non Perennial
- Watercourse - Perennial

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Average groundwater eletrical conductivity across MPPS and SCSS

Figure 5-30

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Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial: Site location, boundaries, pipeline, imagery, 2016. Created by: tmorton

The use of water conditioned ash, not only below areas of brine conditioned ash placement, but also on the final surface, is undertaken such that brine conditioned ash is encapsulated. Surface water storages that manage the capture of brine from the disposal area are all lined.

The hydraulic conductivity of the ash is predicted at 0.1 m/day (CDM Smith, 2012) and constituents from the ash are likely to be immobilised within the pores of the ash as it is placed in layers of 500 mm and compacted to 98% to 99% of the original placement density. Leaching of the ash is unlikely as rainfall infiltration is low due to compaction.

The development of Lamberts north required the infilling of the Huon Pond (also referred to as the Groundwater Collection Basin). This required the placement of material to aid in both the foundation and the ongoing drainage of the Huon Gully. Typically, groundwater connectivity between Huon Gully and Wangcol Creek has been minimal (Merrick and Tammetta, 1999).

CDM Smith (2012) discuss the basis for the Lamberts north emplacement design as typically having the base of the ash emplacement 5 m above the shallow groundwater table that is above the Lithgow Seam floor.

The likely sources of elevated chloride concentrations have been investigated by CDM Smith (2012) within up-gradient MPPS bores and concluded that a potential source could be the completed coal REA A Pit at the SCSS.

5.8 Downstream water users

From the assessment of the existing environment, the downstream water receptors include:

- Users of surface water downstream of the Project.
- Users of groundwater downstream of the Project.

5.8.1 Surface water users

As discussed in Section 3.1, land use surrounding the Project includes rural residential, grazing land, coal mining, power generation, commercial forestry, recreation activities and nature conservation. Water to supply these various activities is drawn from a range of sources, including extraction from watercourses. The major surface resource in the region surrounding the Project Application Area is the Coxs River.

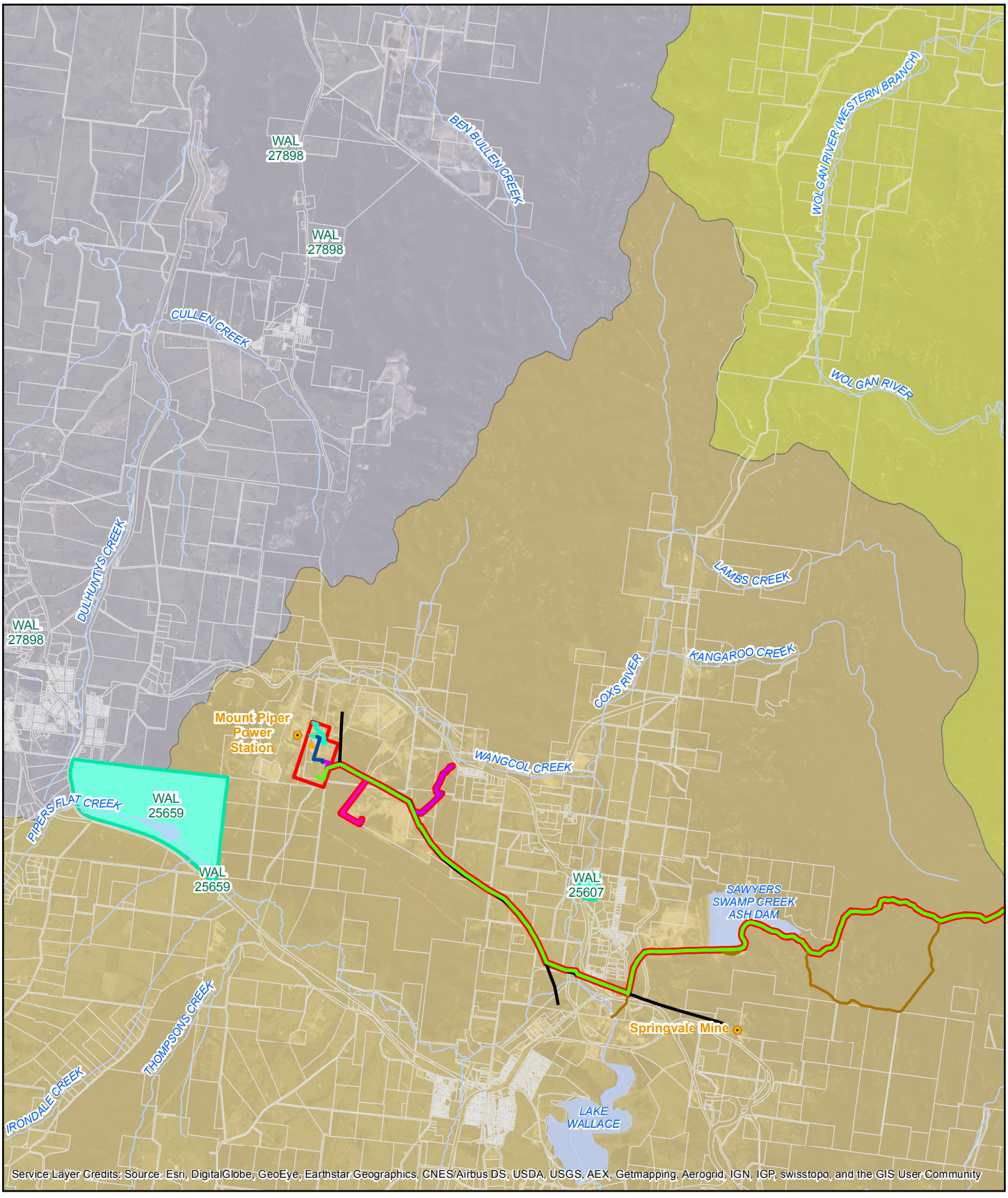
Surface water use in the Coxs River catchment also includes supply for power generation activities at MPPS. Water required for the operation of the power station is currently supplied by three reservoirs, Lake Wallace, Thompsons Creek Reservoir and Lake Lyell. Water is also sourced from the Fish River water supply scheme as required to supplement supply to the power stations.

The Coxs River ultimately flows into Lake Burragorang which is impounded by Warragamba Dam. This dam is the primary reservoir for drinking water in Sydney, supplying more than 3.7 million people living in Sydney and the lower Blue Mountains. WaterNSW is responsible for the management of the drinking water catchment, including the Coxs River catchment, to ensure a reliable supply of raw water of suitable quality.

Licensed surface water users were identified by searching the NSW Water Register (DPI-Water, 2016a) within the Wangcol Creek and Coxs River catchments that may potentially be impacted by the Project. Based on the search of allotments, two WALs were identified for surface water user. The locations of surface water extraction use WAL 25607 and WAL 25659 are provided in Figure 5-31.

5.8.2 Groundwater users

Licensed groundwater users were identified by searching the NSW groundwater bore database (DPI-Water, 2016b) within a 7.5 km radius of the proposed WTP site. The search identified 121 bores, with the majority registered as monitoring bores (47 bores) and stock and/or domestic use (47 bores). The remaining bores were registered for mining or dewatering, irrigation and industrial use. There were nine bores with an unknown use. Details of the registered bores are provided in Appendix E and locations are shown in Figure 5-32.



LEGEND

- Project application area
- Water Access
- Turon Crudine River Water Source
- Hawkesbury and Lower Nepean Rivers Water Source
- Upper Nepean and Upstream Warragamba Water Source
- Brine transfer pipeline
- Crystallised salt transfer pipelines
- Proposed raw water transfer pipeline
- Residuals transfer pipeline
- Treated water pipeline
- Treated water pipeline to cooling tower forebay
- Existing and approved SDWTS
- Existing CEY Conveyor
- Waterbody
- Waterway

Paper Size A4

0 305 610 1,220 1,830 2,440

Metres

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

N

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Springvale Water Treatment Project
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Job Number 21-25109
Revision 0
Date 10 Aug 2016

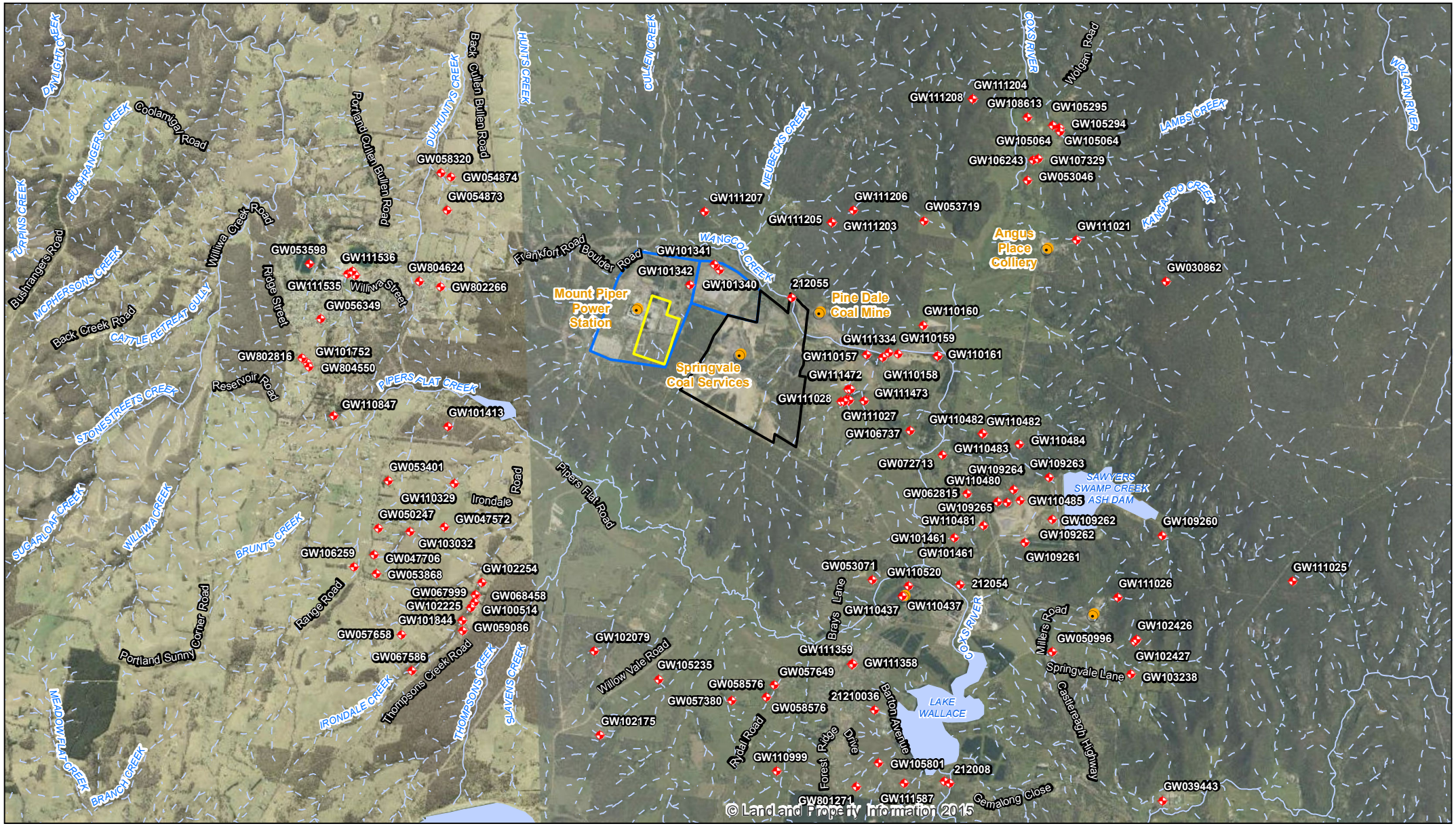
Licensed surface water users Figure 5-31

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Data source: LPI: DTDB/Imagery, 2012, 2015. Created by: tmorton



Paper Size A4

0 0.35 0.7 1.4 2.1 2.8

Kilometers

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

N

LEGEND

- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- Licensed Groundwater Bore
- Waterbody
- Watercourse - Non Perennial
- Watercourse - Perennial

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Water Resources Impact Assessment

Job Number 21-25109
Revision 0
Date 10 Aug 2016

Licensed groundwater bores Figure 5-32

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Data source: LPI: DTDB/Imagery, 2012, 2015. Created by: tmorton

6. Impact assessment

6.1 Proposed water strategy

6.1.1 Overview

The Project involves the development of a water transfer system from the existing dewatering facilities on the Newnes Plateau to MPPS; a new WTP at MPPS to treat water to a standard suitable for industrial reuse or environmental release; and the establishment of a new LDP to discharge any excess treated water to Wangcol Creek. The Project includes the construction of the following assets:

- Transfer systems:
  - Raw water transfer system – Transfer pipeline from the existing gravity tank on the Newnes Plateau to the proposed WTP site at MPPS.
  - Treated water transfer system – Transfer pipelines and associated pumping facilities from the WTP to the cooling water forebays at MPPS for reuse and to Wangcol Creek for discharge via the proposed LDP.
  - Residuals transfer system – Transfer pipeline and associated pumping facilities from the WTP to the SCSS for placement within the existing REA.
  - Brine transfer system – Transfer pipeline and associated pumping facilities from the WTP to the blowdown system at MPPS for treatment.
  - Crystallised salt transfer system – Transfer pipelines and associated pumping facilities from the brine concentrators to the crystalliser unit and from the crystalliser unit to salt ponds, cooling water forebays or demineralisation plant at MPPS.
- WTP:
  - Buffer ponds.
  - Solids removal pre-treatment process.
  - RO desalinisation process.
  - Residuals removal.
  - Brine removal.
- Crystalliser unit:
  - Salt crystalliser unit.
  - Salt ponds.
- Extension or upgrade of existing access tracks, such that the overall system allows patrol and maintenance access along the full length of the pipelines.

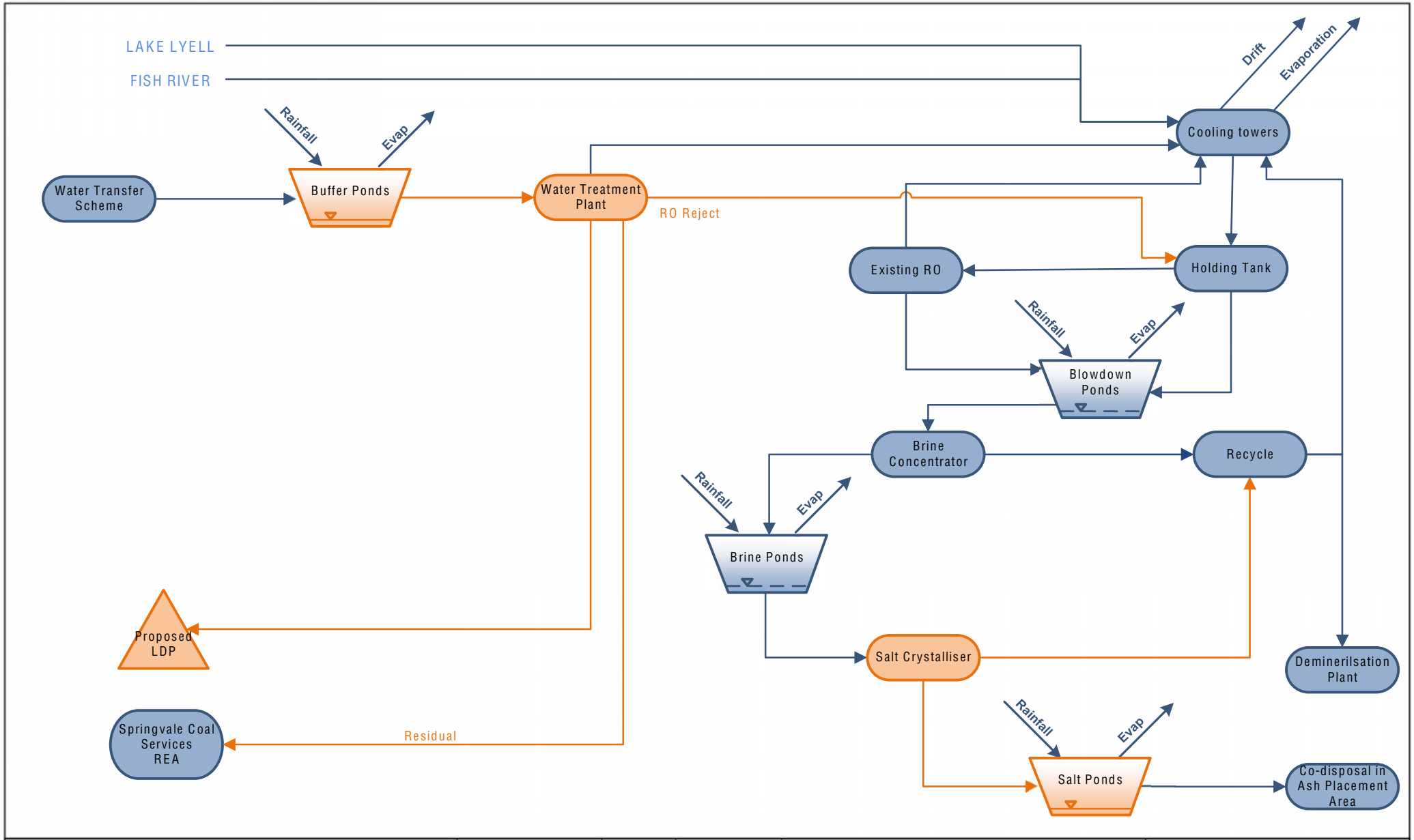
A schematic of the overall water cycle for the proposed WTP and MPPS cooling water system is provided in Figure 6-1.

6.1.2 Pipelines

A plan with the layout of all proposed pipelines is provided in Figure 6-2.

Raw water transfer pipeline

The raw water transfer pipeline from the existing gravity tank on the Newnes Plateau to the WTP site has an indicative length of 14.6 km. This length is based on the pipeline following the northern route across the escarpment area with a proposed pipe diameter of 450 mm.



LEGEND

- Surface water transfer
- Proposed water transfer
- Storage

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LOCATION	SCS
SEAM	N/A
DRAWN	SM
CHECKED	LH
APPROVED	SG
SCALE	NTS

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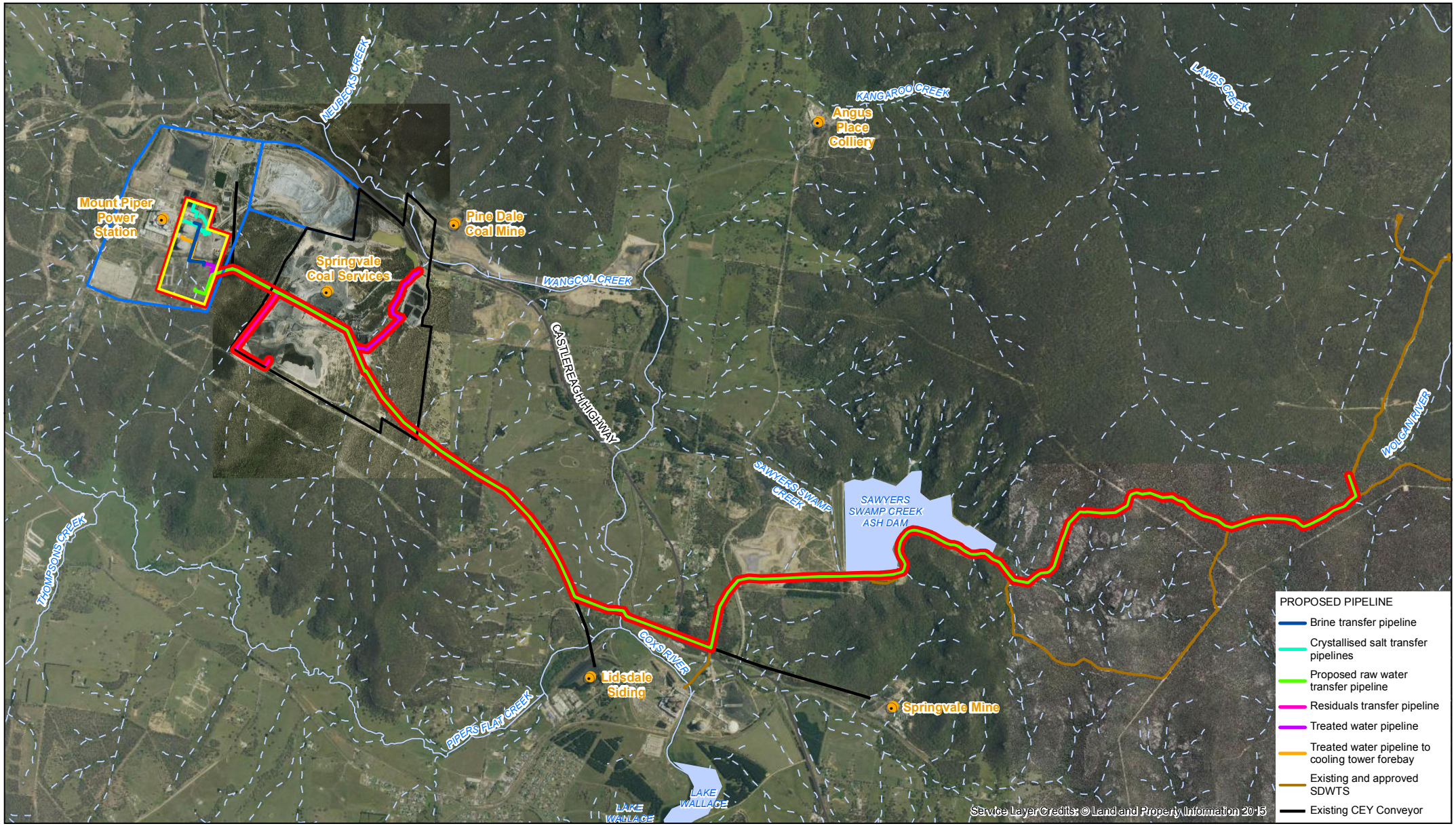
Water Cycle for WTP and Mt Piper Power Station

Centennial Coal
EnergyAustralia

DATE Jun 2016

Figure 6-1

\\ghdnet\ghd\AU\Newcastle\Projects\21\25109\Visio\2125109_MPPS Water Cycle Schematic.vsdx



Paper Size A4

0 0.2 0.4 0.8 1.2 1.6

Kilometers

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

N

LEGEND

- Project application area
- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- Principal Road
- Waterbody
- Watercourse - Non Perennial
- Watercourse - Perennial

Springvale Coal
Springvale Water Treatment Project
Water Resources Impact Assessment

Job Number 21-25109
Revision 0
Date 10 Aug 2016

Proposed pipeline routes

Figure 6-2

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Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial: Site location, boundaries, pipeline, imagery, 2016. Created by: tmorton

The pipeline components will include:

- Air valves and vent stacks as required for compliant hydraulic operation of the pipeline.
- Scour valves to facilitate drainage of the pipeline at specific locations.
- Intermediate in-line valves for practical sectional isolation during maintenance or emergency.

The pipeline will be capable of transferring water from the gravity tank to the WTP inlet at a variable speed up to a maximum flow rate of 417 L/s (36 ML/day).

Treated water transfer pipeline and discharge structure

Treated water transfer pipeline

A treated water transfer pipeline is proposed to allow the transfer of treated water from the WTP to the SCSS for discharge to Wangcol Creek via the proposed LDP. The pipeline would only be used during periods when MPPS is operating at reduced capacity or during MPPS shut-down periods.

The flow rate will be governed by the WTP throughput and the make-up water demand at MPPS. Velocity limitations or provision of means for energy dissipation will be applied on the pipeline discharge end to match the design of the new LDP structure.

Some areas of the pipeline will be required to be directionally drilled below existing infrastructure or waterways, as shown in Figure 6-3. This will be undertaken as a method of mitigating potential impacts.

Discharge point

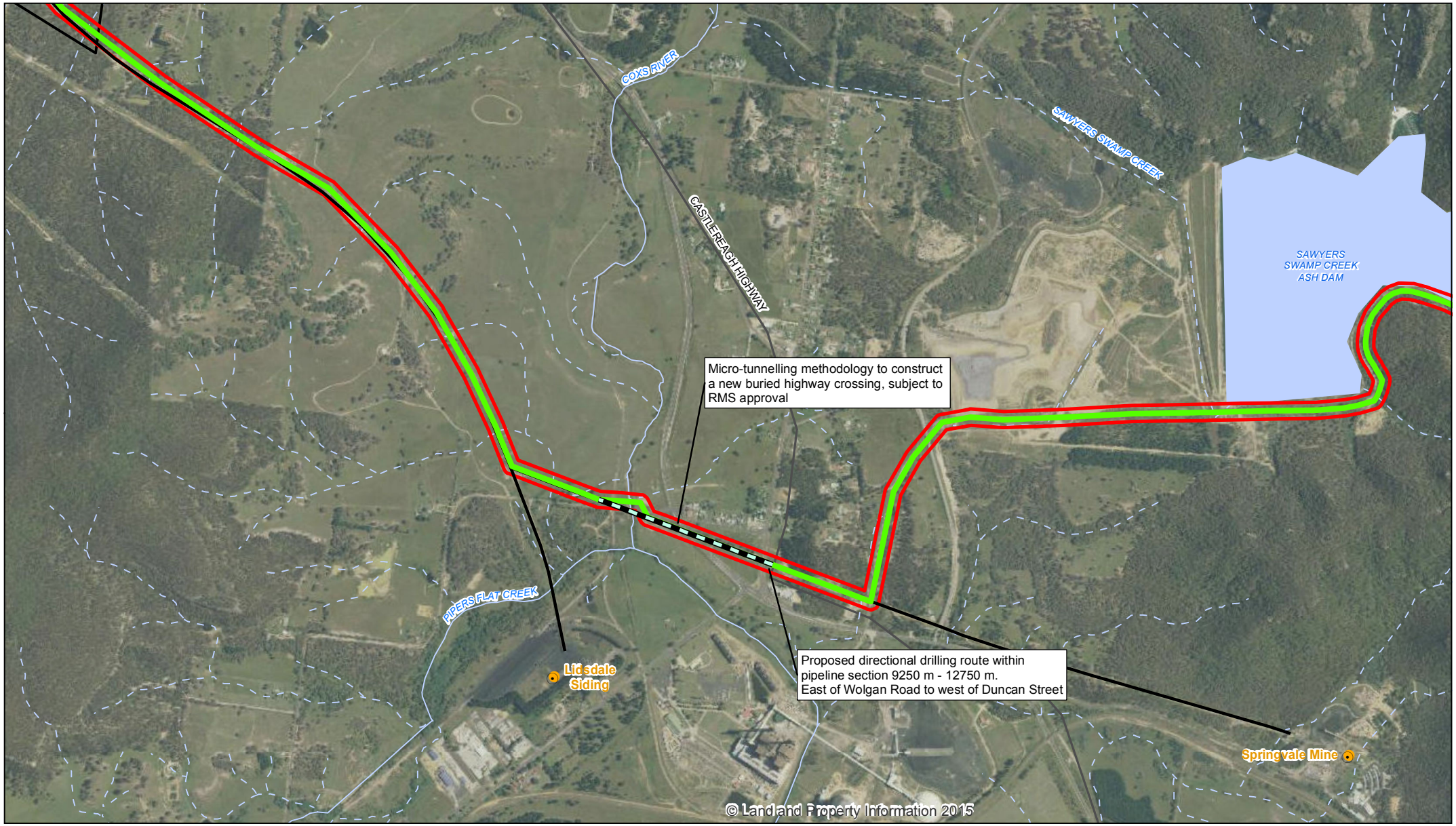
A new LDP structure shall be designed and constructed in the vicinity of the existing LDP006 structure at the SCSS. The new structure will service as an operating licence monitoring point for the Project.

The existing LDP006 structure is a concrete box arrangement incorporating a pipeline intake and V-notch weir outlet assembly. The existing structure is designed for 5 ML/day water discharge which flows into culverts under the Castlereagh Highway and into Wangcol Creek.

The new structure will be designed to be similar in principal to the existing LDP006 structure. The structure shall include:

- Concrete box structure.
- Connection to the treated water pipeline.
- Pipeline isolation valve.
- Instrumentation for monitoring water quality.
- An outlet weir assembly and water level instrumentation for monitoring water discharge volumes.

The discharge point structure will be connected to the existing open channel downstream of the current LDP006 structure. This open channel shall be upgraded for the increased capacity of flow from the discharge structures to its interface with Wangcol Creek.



Paper Size A4

0 0.075 0.15 0.3 0.45 0.6

Kilometers

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

N

LEGEND

- Project application area
- Springvale Coal Services Development Consent
- Proposed raw water transfer pipeline
- Proposed directional drilling
- Existing CEY Conveyor
- Principal Road
- Waterbody
- Watercourse - Non Perennial
- Watercourse - Perennial

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Sections of pipeline to be under bored

Figure 6-3

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Data source: LPI: DTDB/Imagery, 2012, 2015. Created by: tmorton

An overview plan of the works required for the proposed discharge point are provided in Figure 6-4. The works shown in Figure 6-4 include:

- Cleanout of debris and vegetation around Castlereagh Highway downstream of the existing LDP006 at SCSS. RMS have committed to do this (separate to the Project) by August 2016.
- Construction of additional discharge infrastructure adjacent to the existing SCSS LDP006 discharge concrete spillway. Works will be undertaken within the Western Coal Services Project boundary.
- Potential expansion of the existing culvert below Castlereagh Highway.
- Excavation of earth on the northern side of Castlereagh Highway to form an open channel to Wangcol Creek. The open channel would be constructed such that it is stable with vegetated banks and channel inverts are equal with the existing Wangcol Creek invert.
- Rock armouring of the interface between the open channel and Wangcol Creek to both mitigate energy and to remediate existing headcut instabilities historically formed around discharges from SCSS to Wangcol Creek.

Residuals transfer pipeline

The residuals transfer pipeline from the WTP to the existing REA at SCSS has an indicative length of 1.8 km. The pipeline will be terminated as an open end pipe arranged as a distribution header which will allow the water to discharge at multiple points with low velocity and low volumetric flow to avoid localised erosion within the REA.

The pipeline will be capable of transferring residuals at a flow rate of 30 L/s in batch flow periods. The typical transfer rate to the REA from the WTP is expected to be approximately 0.43 ML/day.

6.1.3 Water treatment plant

The new WTP is proposed to be located adjacent to the MPPS to the south and east of the existing operations. The WTP would be located entirely within an area previously disturbed and used for stockpiling during construction of MPPS and has existing vehicle access. The salt crystalliser unit is proposed to be located within close proximity to the brine concentrator units within the existing MPPS operations.

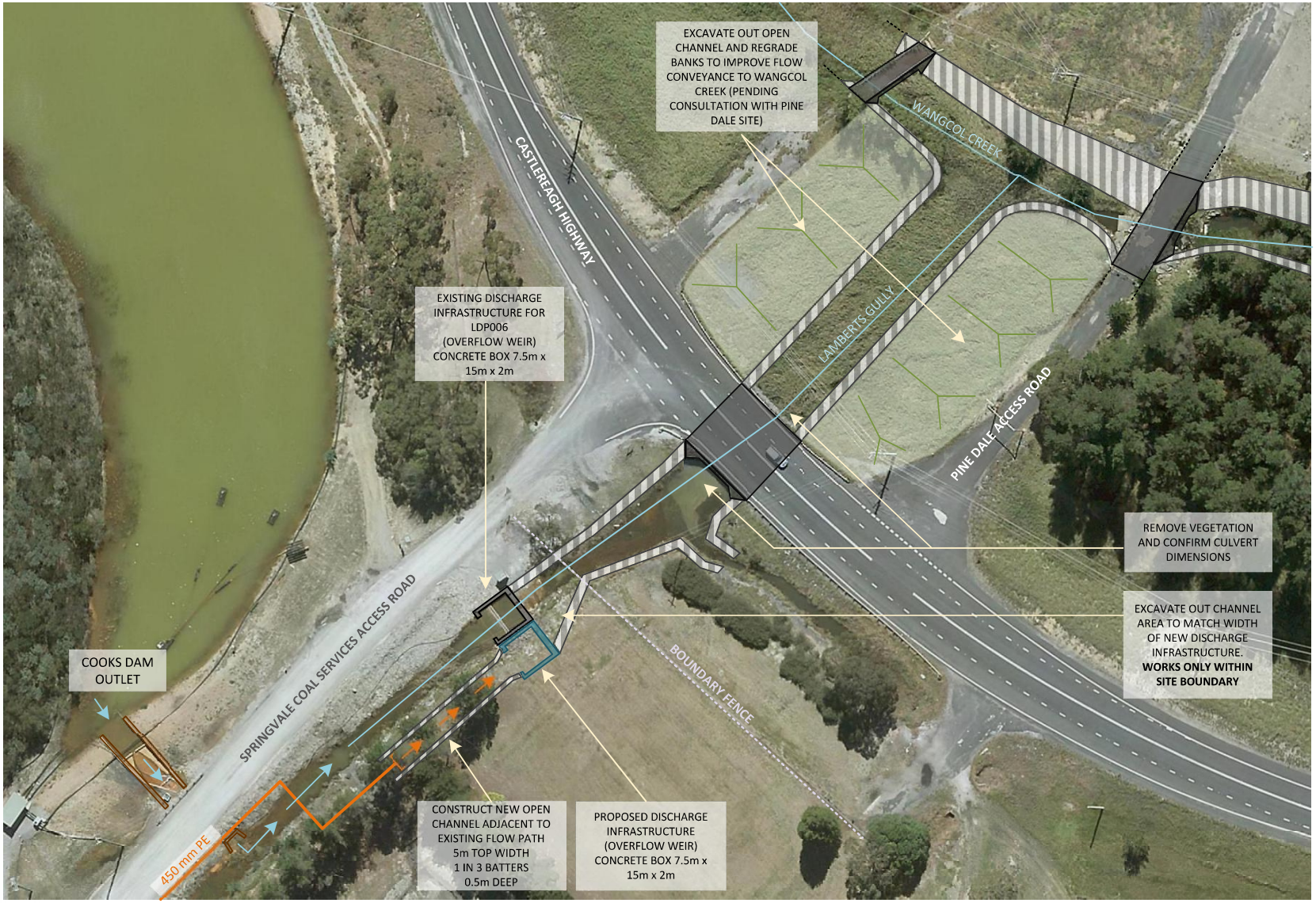
Pre-treatment

Raw water will enter buffer ponds via a cascading aerator for initial oxidation and buffering of minor flow and quality fluctuations. The ponds will have a capacity of 72 ML, configured as two 36 ML ponds.

The pre-treatment process involves solids removal via a lamella clarifier to remove suspended solids. Clarified effluent would then be directed to the water treatment process with residuals (thickened solids) transferred to the REA at the SCSS.

Desalinisation

Clarified effluent from the pre-treatment process will be treated using RO desalinisation processes to remove dissolved salts from the water. Some pre-treated water will bypass the RO process for downstream blending with the RO permeate to enable optimisation of the RO process.



LDP006 Flow Direction
Proposed LDP Flow Direction
Proposed Pipeline Alignment
Existing Waterway Crossing Structures

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LOCATION	SCS
SEAM	NA
DRAWN	SM
CHECKED	LH
APPROVED	SG
SCALE	NTS

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Water Resources Impact Assessment

Proposed discharge infrastructure

Centennial Coal
EnergyAustralia

DATE Jun 2016

Figure 6-4

\\ghdnet\ghd\AU\Newcastle\Projects\21\25109\Visio\2125109_Proposed Discharge Infrastructure.vsdx

Treated water will be directed to the cooling water forebays for reuse within the cooling water system as make-up water. During periods when MPPS the volume of treated water exceeds the make-up water demand at MPPS, the excess treated water will be transferred to the proposed LDP at the SCSS for discharge to Wangcol Creek.

The RO reject by-product or brine stream will be directed to the existing MPPS blowdown system for further treatment and processing.

The WTP has considered in its design a functional availability of at least 90% of days (allowable down period of up to 36.5 days/year of a non-consecutive period).

Figure 6-5 presents the proposed layout of the WTP.

Brine management

The brine by-product from the RO process will be directed to the existing MPPS blowdown system, for further treatment and processing described in Section 5.1.1. The existing brine concentrators will be upgraded to facilitate a seed recycle stream to enable the units to manage the increased salt load from the new WTP.

Concentrated brine slurry from the brine concentrators will be transferred to a new mixed salt crystalliser unit, which will further increase the salt concentration of the slurry. The crystallised salt slurry would be stored in new salt ponds. The ponds will have a capacity of 40 ML, configured as two 20 ML ponds. From the salt ponds, the slurry will be co-disposed with the ash in accordance with existing operations. Distillate from the crystalliser unit would be directed to the existing cooling water forebays or the demineralisation plant.

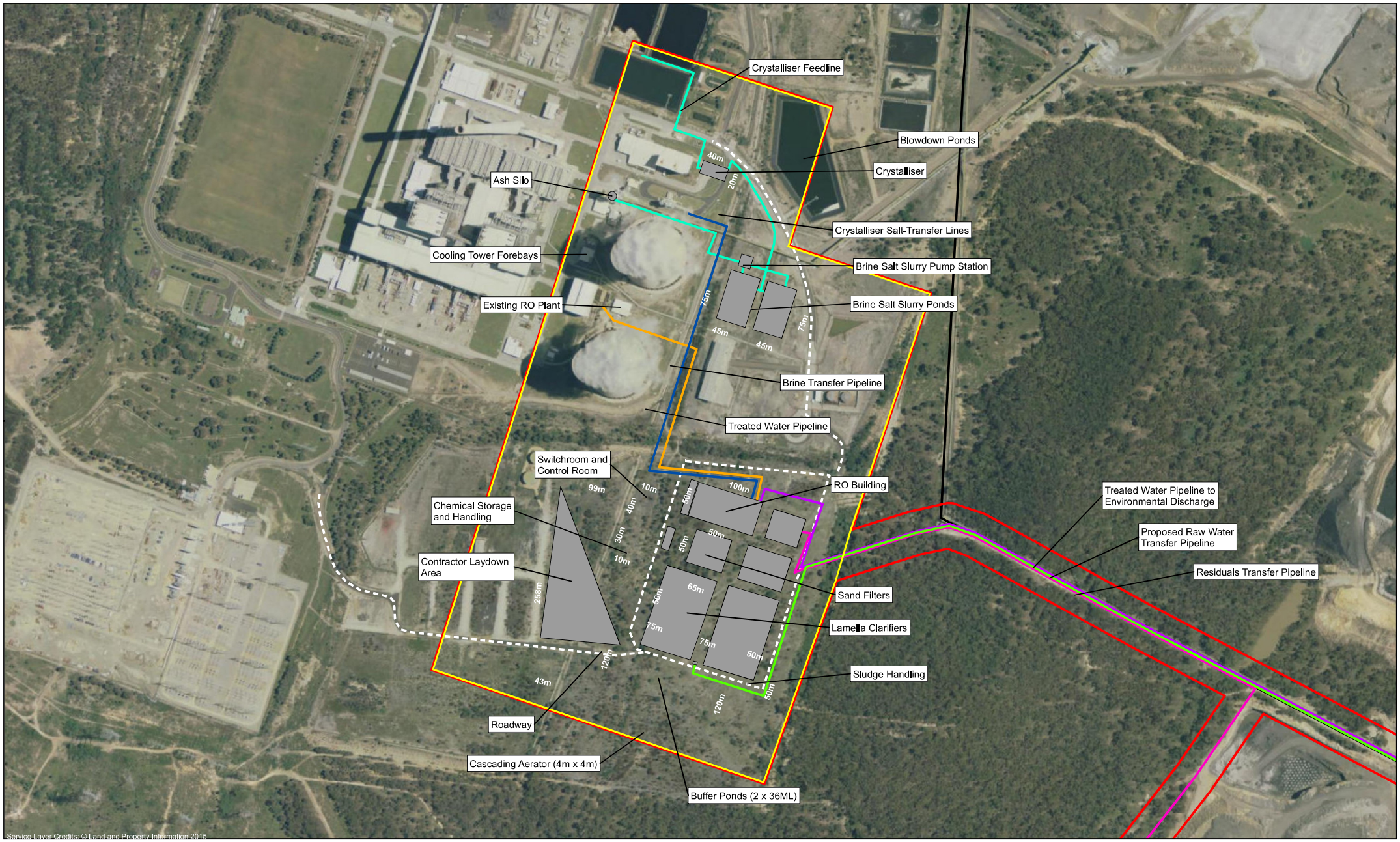
6.1.4 Project staging

The following points form the key stages for the implementation of the infrastructure proposed as part of the Project:

- The civil works relating to the pipeline, treatment plant pad, surface water storages and LDP infrastructure are expected to be undertaken concurrently as part of preliminary works.
- The construction of the water transfer system (pipelines and associated infrastructure) is expected to be undertaken over a 12-month period. The construction of the WTP is expected to be undertaken concurrently with the construction of the water transfer system over an 18-month period.
- A period of six months will be adopted for WTP commissioning where treatment efficiencies and water quality testing will be undertaken. This period is to be confirmed through consultation with EPA along with documentation and testing requirements.
- The construction of the crystalliser is expected to be undertaken following the construction of the WTP over a period of 12 months.

6.2 Water and salt balance assessment

As discussed in Section 4.2, the water balance model was developed to represent the water cycle under proposed conditions based on the water management strategy presented in Section 6.1. Annual transfers and monthly average time series results from the water and salt balance model are presented in the following sections for the do nothing scenario (50% power generation requirement) and Scenario 3 (50% power generation requirement). Results for the remaining proposed scenarios modelled are presented in Appendix B. Note that results are indicative only as water demands at MPPS vary daily with power generation requirements.



Paper Size A3

0 25 50 100 150 200

Metres

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

N

LEGEND

- Project application area
- Proposed water treatment site
- Brine transfer pipeline
- Crystallised salt transfer pipelines
- Proposed raw water transfer pipeline
- Residuals transfer pipeline
- Treated water pipeline
- Treated water pipeline to cooling tower forebay
- Existing CEY conveyor
- WTP Layout

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Water Resources Impact Assessment

Job Number	21-25109
Revision	0
Date	10 Aug 2016

Proposed water treatment plant site

Figure 6-5

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It should be noted that the groundwater inflows into the active underground workings of Angus Place Colliery and Springvale Mine, which are transferred to the SDWTS, are predicted to vary over time, as shown in Figure 4-3. The results are presented for the proposed conditions are based on the predicted conditions in 2030. This year was chosen as it is when groundwater inflows, and the inflows to the SDWTS, are predicted to peak (refer Section 4.2.8) and the Coxs River catchment system will be the most different compared to the existing conditions.

Slight differences in some components of the modelling output between the existing conditions in 2016 and the proposed conditions in 2030 are attributed to 2016 being a leap year (i.e. 366 days available) and 2030 not being a leap year (i.e. 365 years available). Therefore, an extra day of simulation is represented in the results for existing conditions compared to proposed conditions.

6.2.1 Water balance results

Annual results

The predicted annual values for each of the water transfers for the Project in 2030 are shown in Figure 6-6. The predicted values for each of the water transfers within the Coxs River catchment for proposed conditions in 2030 are provided in Figure 6-7 and Figure 6-8 for the do nothing scenario (50% power generation requirement) and Scenario 3 (50% power generation requirement) respectively. The results present the average annual transfers between the elements of the water cycle as well as an indication of the range of values expected due to possible variations in rainfall.

Wangcol Creek catchment

A summary of the average annual inputs and outputs for the water balance for the Wangcol Creek catchment under proposed conditions in 2030 for all scenarios is presented in Table 6-1.

As shown in Table 6-1, the Project was predicted to result in an increase in the discharge from Wangcol Creek into the Coxs River due to discharges from the proposed LDP for scenarios 1 (0% power generation requirement), 2 (25% power generation requirement) and 3 (50% power generation requirement) and discharges from LDP006 for all of the proposed Project scenarios.

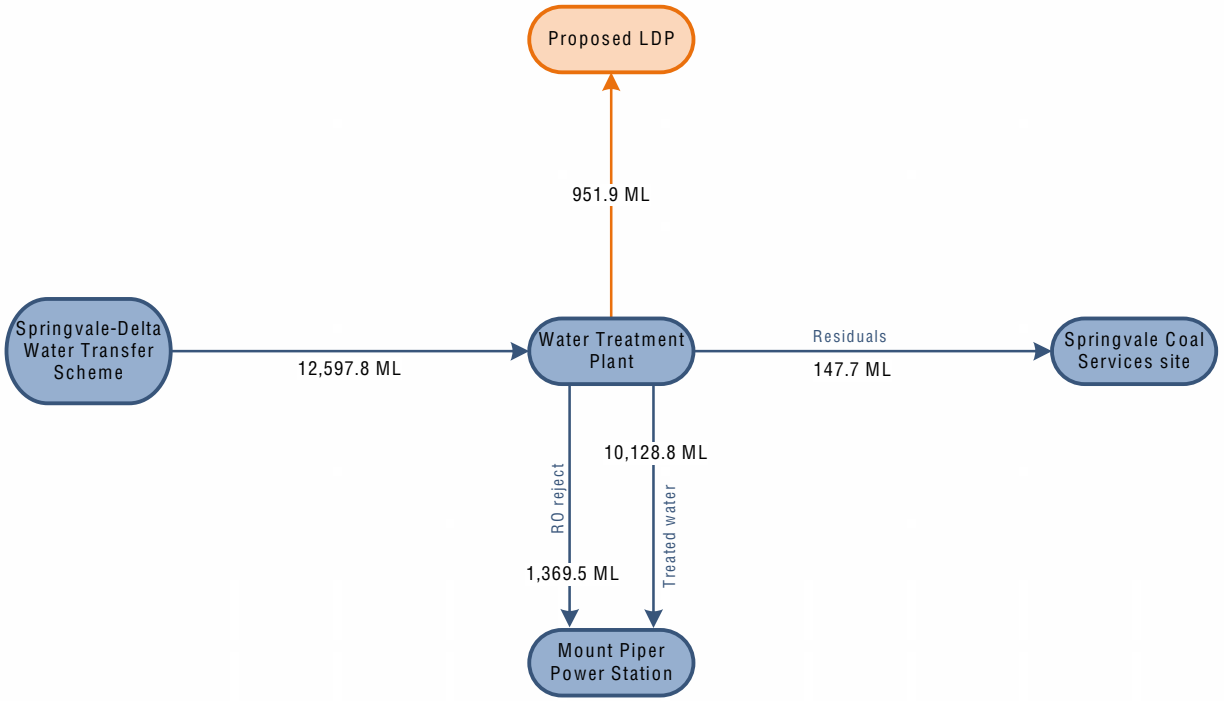
For scenarios 1, 2 and 3, excess treated water from the Project that is not used within the MPPS cooling water system was discharged via the proposed LDP to Wangcol Creek. Discharges were modelled to range between an average of 952 ML/year for Scenario 3 to 11,081 ML/year for Scenario 1.

The increase in LDP006 discharge from the SCSS was associated with the transfer of residual material from the Project to the existing REA at the SCSS at a rate of 0.43 ML/day. This transfer was predicted to increase discharges to Wangcol Creek by approximately 67.2 ML/year on average, compared to the do nothing scenario.

The total annual flow from Wangcol Creek to the Coxs River was modelled to range between approximately 2,961 ML/year for scenarios 4 and 5 and approximately 14,042 ML/year Scenario 1 on average, compared to a flow of approximately 2,894 ML/year on average for the do nothing scenario. The contribution of discharges from the Project via the proposed LDP to the total flow within Wangcol Creek was predicted to vary between approximately 24% (Scenario 3) and 79% (Scenario 1).

Coxs River catchment

A summary of the average annual inputs and outputs for the water balance for the Coxs River catchment under proposed conditions in 2030 for all scenarios is presented in Table 6-2.



LEGEND

Surface water transfer

Proposed transfer

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LOCATION	Coxs River
SEAM	N/A
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

Springvale Water Treatment Project
Water Resources Impact Assessment

Annual water transfers
Proposed conditions (2030)
Water Treatment Plant

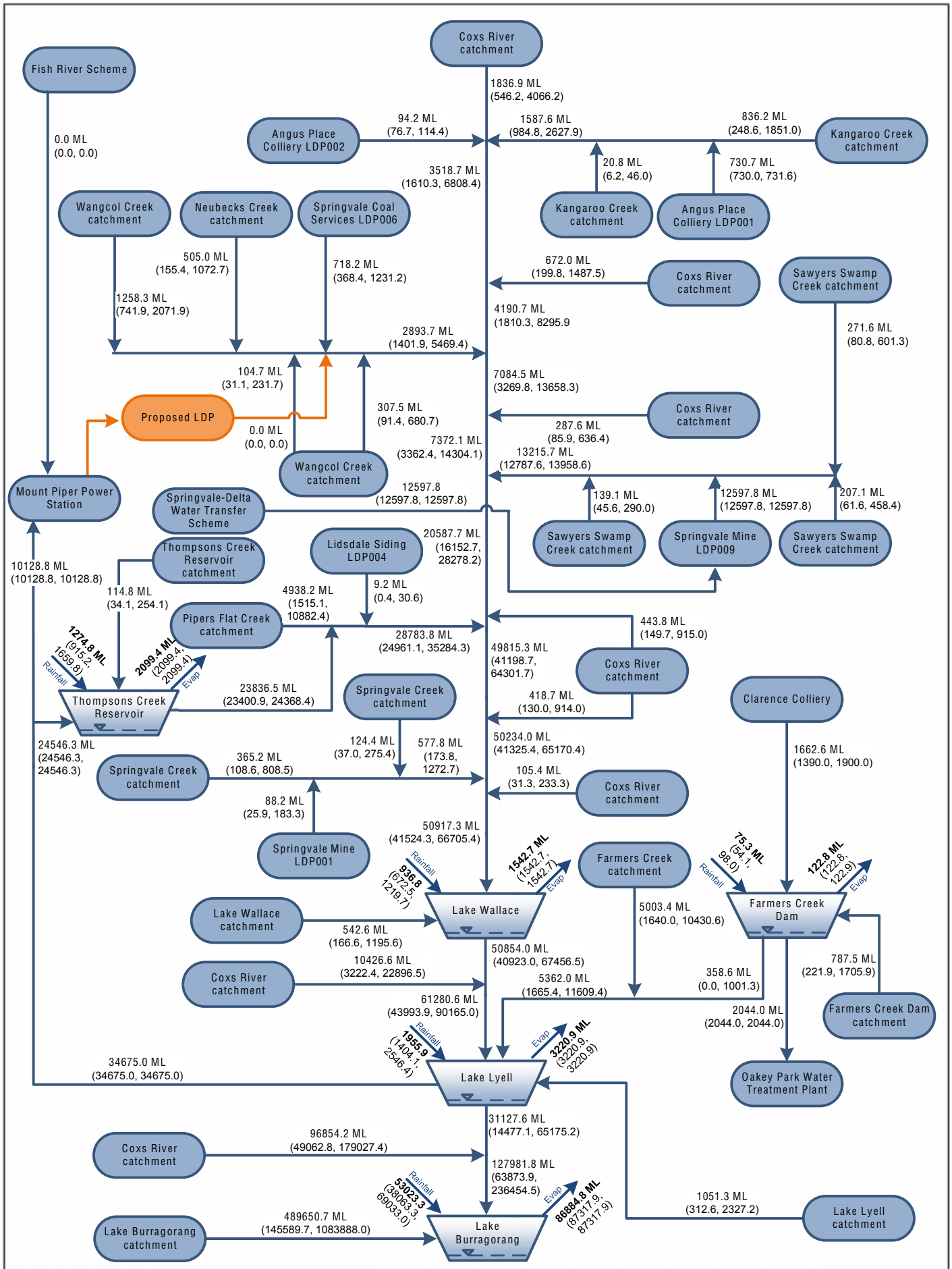
Centennial Coal

EnergyAustralia

DATE Aug 2016

Figure 6-6

G:\21\25109\Visio\2125109_WTP Water Cycle Schematic.vsdx



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LOCATION	Coxs River
SEAM	NA
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

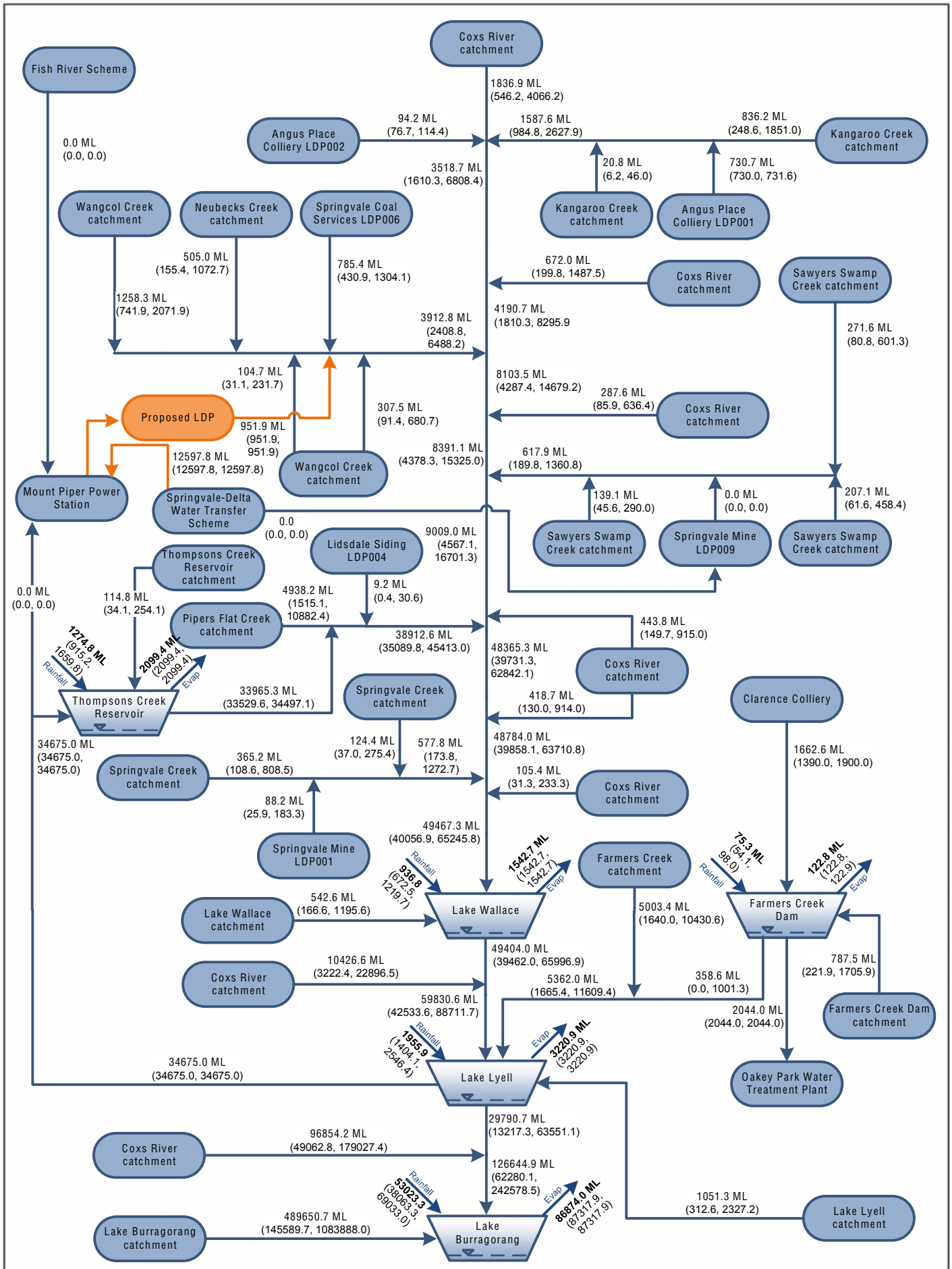
Springvale Water Treatment Project
Water Resources Impact Assessment

Annual water transfers
Proposed conditions (2030)
Do nothing scenario

Centennial Coal
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DATE Aug 2016

Figure 6-7



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LOCATION	Coxs River
SEAM	NA
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

Springvale Water Treatment Project
Water Resources Impact Assessment

Annual water transfers
Proposed conditions (2030)
Scenario 3

Centennial Coal
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Figure 6-8

Table 6-1 Summary of average water inputs and outputs for Wangcol Creek catchment under proposed conditions in 2030

	Scenario 1 (ML/year)	Scenario 2 (ML/year)	Scenario 3 (ML/year)	Scenario 4 (ML/year)	Scenario 5 (ML/year)	Do nothing scenario (ML/year)
	0% power generation	25% power generation	50% power generation	75% power generation	100% power generation	50% power generation
INPUTS						
Catchment runoff	2,175.5	2,175.6	2,175.6	2,175.6	2,175.6	2,175.6
LDP discharge from SCSS (LDP006)	785.4	785.4	785.4	785.4	785.4	718.2
Proposed LDP discharge	11,080.6	6,016.2	951.9	0.0	0.0	N/A
TOTAL INPUTS (rounded)	14,042	8,977	3,913	2,961	2,961	2,894
OUTPUTS						
Contribution to Coxs River	14,041.6	8,977.2	3,912.8	2,960.9	2,960.9	2,893.7
TOTAL OUTPUTS (rounded)	14,042	8,977	3,913	2,961	2,961	2,894
BALANCE						
Inputs – outputs	0	0	0	0	0	0

Table 6-2 Summary of average water inputs and outputs for Coxs River catchment under proposed conditions in 2030

	Scenario 1 (ML/year)	Scenario 2 (ML/year)	Scenario 3 (ML/year)	Scenario 4 (ML/year)	Scenario 5 (ML/year)	Do nothing scenario[a] (ML/year)
	0% power generation	25% power generation	50% power generation	75% power generation	100% power generation	50% power generation
INPUTS						
Direct rainfall onto storages and catchment runoff	131,865.8	131,865.8	131,865.8	131,865.8	131,865.8	131,865.8
Supply from Fish River water supply scheme to MPPS	0.0	0.0	0.0	0.0	155.5	0.0
Transfer from Clarence Colliery to Farmers Creek Dam	1,662.6	1,662.6	1,662.6	1,662.6	1,662.6	1,662.6
LDP discharge from Angus Place Colliery (LDP001)	730.7	730.7	730.7	730.7	730.7	730.7
LDP discharge from Angus Place Colliery (LDP002)	94.2	94.2	94.2	94.2	94.2	94.2
LDP discharge from Lidsdale Siding (LDP004)	9.2	9.2	9.2	9.2	9.2	9.2
LDP discharge from SCSS (LDP006)	785.4	785.4	785.4	785.4	785.4	718.2
LDP discharge from Springvale Mine (LDP001)	88.2	88.2	88.2	88.2	88.2	88.2

	Scenario 1 (ML/year)	Scenario 2 (ML/year)	Scenario 3 (ML/year)	Scenario 4 (ML/year)	Scenario 5 (ML/year)	Do nothing scenario[a] (ML/year)
	0% power generation	25% power generation	50% power generation	75% power generation	100% power generation	50% power generation
LDP discharge from Springvale Mine (LDP009)	0.0	0.0	0.0	0.0	0.0	12,597.8
Proposed LDP discharge	11,080.6	6,016.2	951.9	0.0	0.0	N/A
TOTAL INPUTS (rounded)	146,317	141,252	136,188	135,236	135,392	147,767
OUTPUTS						
Evaporation	6,985.9	6,985.9	6,985.9	6,985.9	6,985.9	6,985.9
Additional make-up water used at MPPS[b]	0.0	0.0	0.0	4,112.4	9,332.4	10,128.8
Oakey Park WTP use	2,044.0	2,044.0	2,044.0	2,044.0	2,044.0	2,044.0
Contribution to Lake Burragorang	137,094.7	131,625.3	126,644.9	121,718.1	116,370.4	127,981.8
TOTAL OUTPUTS (rounded)	146,125	140,655	135,675	134,860	134,733	147,141
CHANGE IN STORAGE						
Farmers Creek Dam	0.0	0.0	0.0	0.0	0.0	0.0
Lake Lyell	192.2	597.2	513.2	377.6	661.4	626.3
Lake Wallace	0.0	-0.1	0.0	0.0	0.0	0.0

	Scenario 1 (ML/year)	Scenario 2 (ML/year)	Scenario 3 (ML/year)	Scenario 4 (ML/year)	Scenario 5 (ML/year)	Do nothing scenario[a] (ML/year)
	0% power generation	25% power generation	50% power generation	75% power generation	100% power generation	50% power generation
Thompsons Creek Reservoir	-0.1	-0.1	-0.1	-2.0	-2.4	0.0
TOTAL CHANGE IN STORAGE (rounded)	192	597	513	376	659	626
BALANCE						
Inputs – outputs – change in storage	0	0	0	0	0	0

[a] In the do nothing scenario, inputs from the SDWTS are discharged to Sawyers Swamp Creek via Springvale Mine's LDP009.

[b] Additional make-up water required in addition to the supply from the Project.

As with existing conditions, the largest source of water into the Coxs River catchment was associated with rainfall onto surface water storages and catchment runoff, which accounted for approximately 131,866 ML/year on average, equating to between 90% (do nothing scenario) and 98% (Scenario 4) of the total inflows to the system. The second largest input was modelled to be associated with the discharges from the proposed LDP for scenarios 1 and 2; transfers from Clarence Colliery into the catchment for scenarios 3, 4 and 5; and discharges from LDP009 for the do nothing scenario.

Shortfalls in water supply to the MPPS cooling water system from the Project and Lake Lyell was modelled to be supplied by the Fish River water supply scheme in Scenario 5 (100% power generation requirement). The total average volume extracted from the Fish River water supply scheme was predicted to be 156 ML/year on average. The 10th percentile and 90th percentile values were found to be 0 ML/year, indicating that the average value is significantly skewed by prolonged dry periods.

The volume of make-up water used by MPPS in the cooling water system, in addition to the water supplied by the Project, varied with scenario modelled. No additional water was required for scenarios 1, 2 and 3, with all make-up water at MPPS supplied by the Project. A volume of 4,122 ML/year was modelled to be supplied from the Coxs River in Scenario 4, which increased to 9,332 ML/year for Scenario 5 supplied from the Coxs River and Fish River sources.

Under the proposed conditions, the total annual flow within the Coxs River upstream of Lake Burragorang varied with the power generation requirement at MPPS modelled, with additional flow available for lower power generation scenarios. Flow was estimated to range from approximately 116,370 ML/year for Scenario 5 to 137,095 ML/year for Scenario 1 on average. For the do nothing scenario, with a 50% power generation requirement and all water within the SDWTS modelled to be discharged via LDP009, the flow within the Coxs River was predicted to be approximately 127,982 ML/year on average.

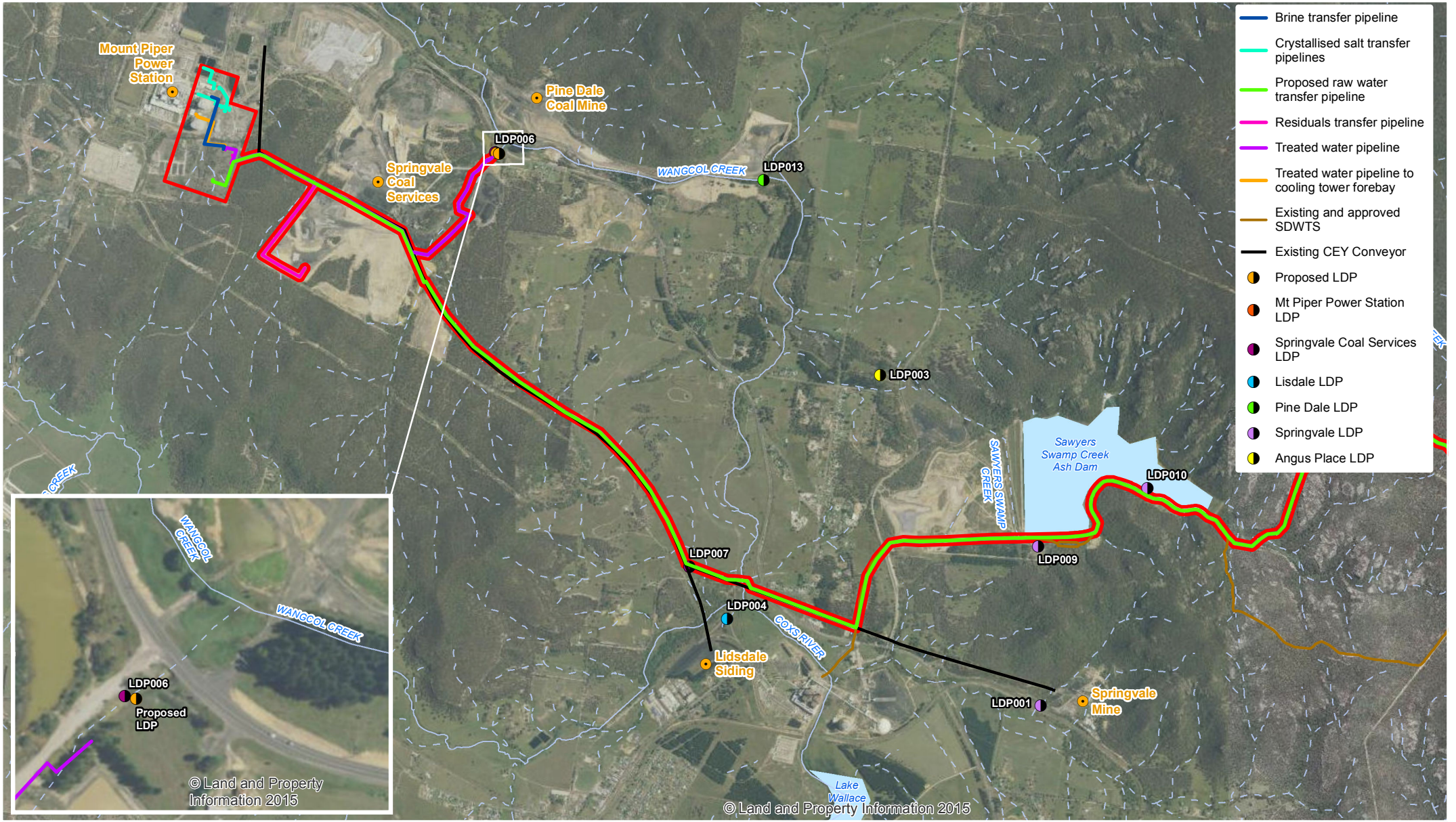
Site-based discharges from Angus Place Colliery, Lidsdale Siding, the SCSS and Springvale Mine as well as Project discharges from the proposed LDP were estimated to contribute between approximately 1,708 ML/year, for scenarios 4 and 5, and approximately 12,788 ML/year, for Scenario 1, to the Coxs River catchment on average. This equates to between 1%, for scenarios 4 and 5, and 9%, for Scenario 1, of the total annual inflow to the Coxs River catchment.

The change in storage modelled for Lake Lyell was approximately 2% of the total capacity for all scenarios. It should be noted that a simple linear correlation cannot be inferred between scenarios modelled and the change in storage presented in Table 6-2. This is due to the complex relationship between the power generation requirement at MPPS, the operation of Lake Lyell and Thompsons Creek Reservoir and discharges via LDP009 and the proposed LDP. Further detail on the annual transfers between modelled components is provided within Appendix B.

Time series results

Monthly average time series results of flow are presented for the do nothing scenario (50% power generation requirement) and Scenario 3 (50% power generation requirement) for the following locations in the Coxs River catchment, as shown in Figure 6-9 and Figure 6-10:

- Proposed LDP discharge.
- Wangcol Creek at the confluence with the discharge from the proposed LDP and LDP006 from the SCSS.



Paper Size A4

0 125250 500 750 1,000

Metres

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

N

LEGEND

- Project application area
- Site location
- Modelling Points of Interest
- Watercourse - Non Perennial
- Watercourse - Perennial
- Reservoir

Springvale Coal
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Water Resources Impact Assessment

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Revision 0
Date 09 Aug 2016

Project Area Extent
Regional Modelling Locations

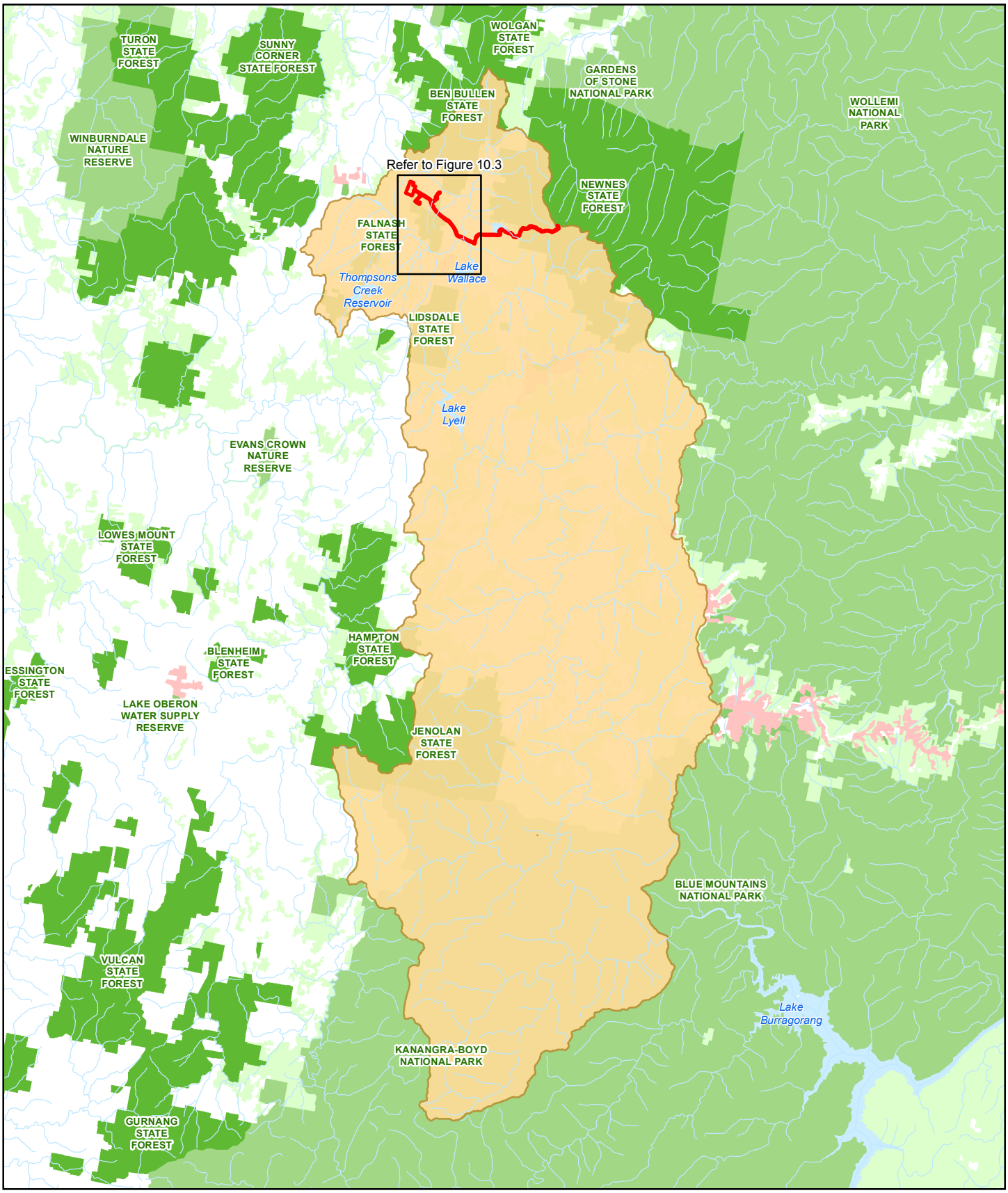
Figure 6-9

G:\22\0105001\GIS\Maps\Deliverables\Western\Springvale\2125109\WRIA\10_3\2125109_WRIA036_FlowLocationsSh2_0.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

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Data source: LPI: DTDB/Imagery, 2012, 2015; Centennial: Site location, boundaries, monitoring, alignment, imagery, 2016. Created by: tmorton



LEGEND

- Project application area
- Coxs River Catchment
- Modelling Points of Interest
- Existing Rail
- Dual Carriageway
- Principal Road
- Secondary Road
- Minor Road
- Waterway
- Reservoir
- GA_Lakes
- Waterbody
- Built up area
- Recreation area
- Nature Conservation
- State Forest
- Forest or shrub

Paper Size A4

0 1,8503,700 7,400 11,100 14,800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Springvale Coal
Springvale Water Treatment Project
Water Resources Impact Assessment

Regional Extent
Regional Modelling Locations

Job Number 21-25109
Revision 0
Date 09 Aug 2016

Figure 6-10

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

G:\22\0105001\GIS\Maps\Deliverables\Western\Springvale\2125109\WRIA\10_3\2125109_WRIA035_FlowLocationsSh1_0.mxd

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Data source: Commonwealth of Australia (Geoscience Australia); 250K Topographic Data Series, 2006; Centennial: Boundaries, monitoring, 2016. Created by: tmorton

- Wangcol Creek at the confluence with the Coxs River.
- LDP009 discharges from the SDWTS to Sawyers Swamp Creek.
- Sawyers Swamp Creek at the confluence with the Coxs River.
- Coxs River at the inflow to Lake Wallace.
- Coxs River at the inflow to Lake Lyell.
- Coxs River at the inflow to Lake Burragorang.

A seasonal pattern can be seen in the time series results, corresponding to the pattern found in the rainfall and evaporation data used as inputs into the water and salt balance model, as discussed in Section 3.3. Time series information for scenarios 1, 2, 4 and 5 are provided in Appendix B.

Do nothing scenario

For the do nothing scenario, it was assumed in the water balance model that the Project would not be developed. As such, there were no discharges predicted for the proposed LDP.

The modelled flow of Wangcol Creek at the confluence with the discharge from the SCSS via LDP006 is presented in Figure 6-11. Site-based discharges from the SCSS as well as upstream catchment runoff in Wangcol Creek were estimated to be an average of approximately 4 ML/day to 12 ML/day. The flow ranged between approximately 2 ML/day (10th percentile) and 35 ML/day (90th percentile) due to the variation in rainfall contributing to catchment runoff.

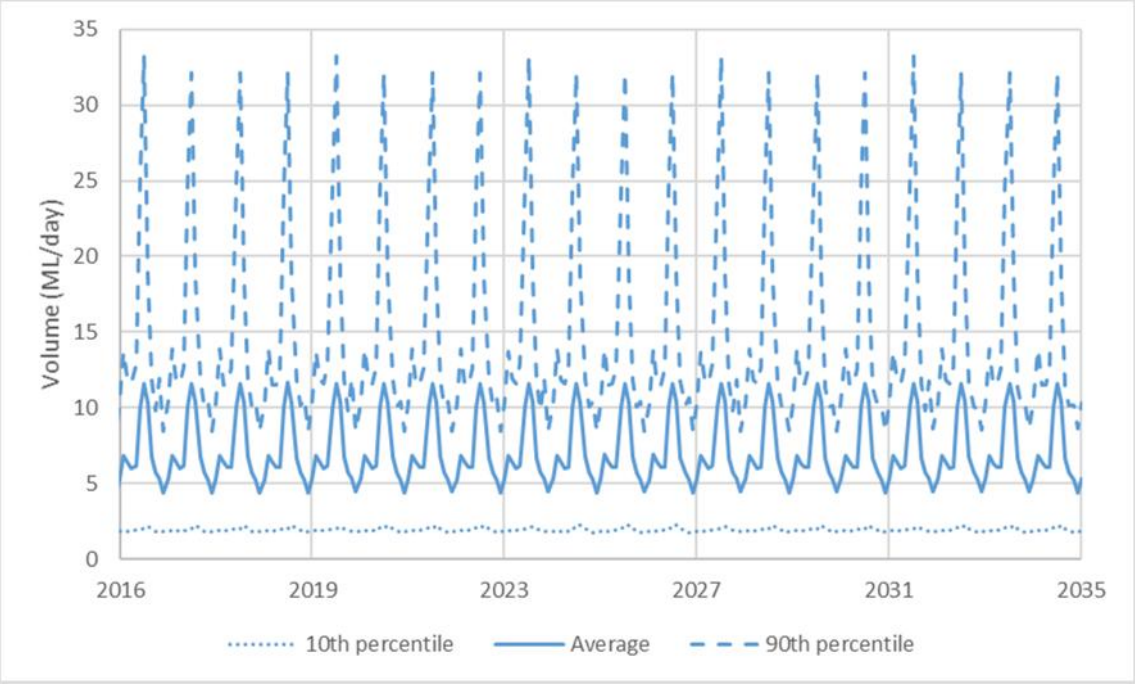


Figure 6-11 Do nothing scenario – Predicted flow of Wangcol Creek at LDPs

Wangcol Creek flow at the confluence with the Coxs River is shown in Figure 6-12. Catchment runoff downstream of LDP006 discharges from the SCSS provides up to an additional 1 ML/day to Wangcol Creek on average.

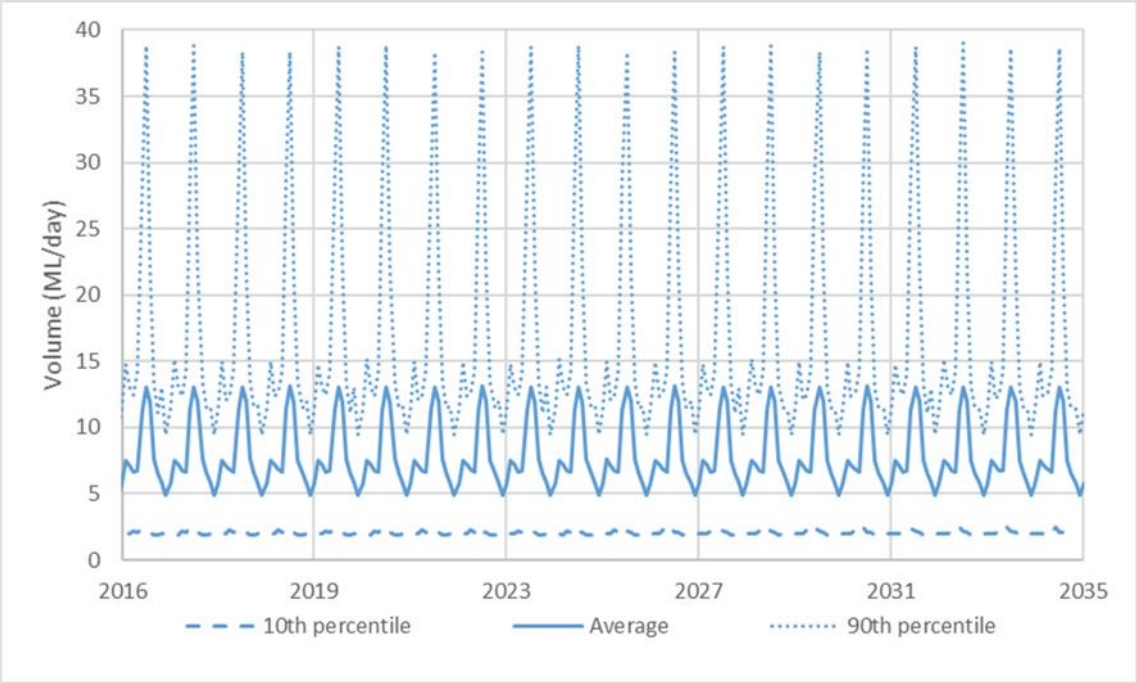


Figure 6-12 Do nothing scenario – Predicted flow of Wangcol Creek at the confluence with the Coxs River

The predicted time series of discharge from LDP009 at Springvale Mine into Sawyers Swamp Creek is provided in Figure 6-13. The discharge is defined by the groundwater inflows into the active underground workings of Angus Place Colliery and Springvale Mine that are transferred to the SDWTS and discharged via LDP009 for the do nothing scenario. The LDP009 discharge was modelled to peak at approximately 36 ML/day in December 2029.

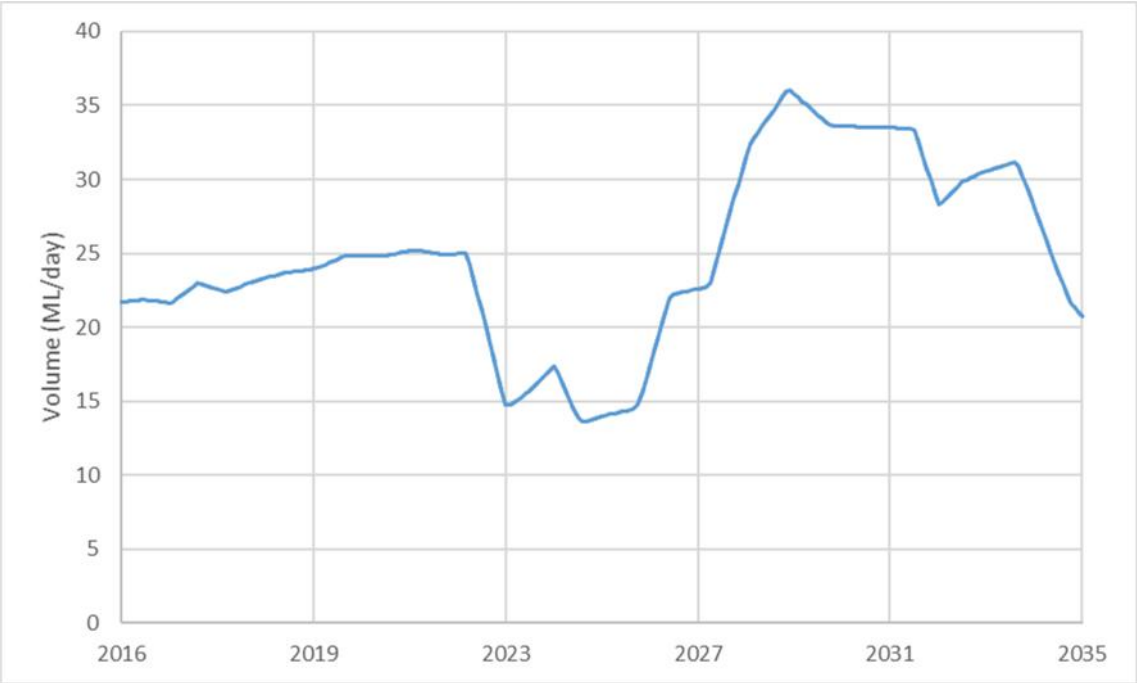


Figure 6-13 Do nothing scenario – Predicted LDP009 discharge to Sawyers Swamp Creek

Figure 6-14 presents the modelled flow of Sawyers Swamp Creek at the confluence with the Coxs River, which is dominated by the predicted discharge of mine water via LDP009, with slight variability due to catchment runoff. The peak flow within Sawyers Swamp Creek was estimated to be an average of 38 ML/day, ranging between 35 ML/day (10th percentile) and 43 ML/day (90th percentile).

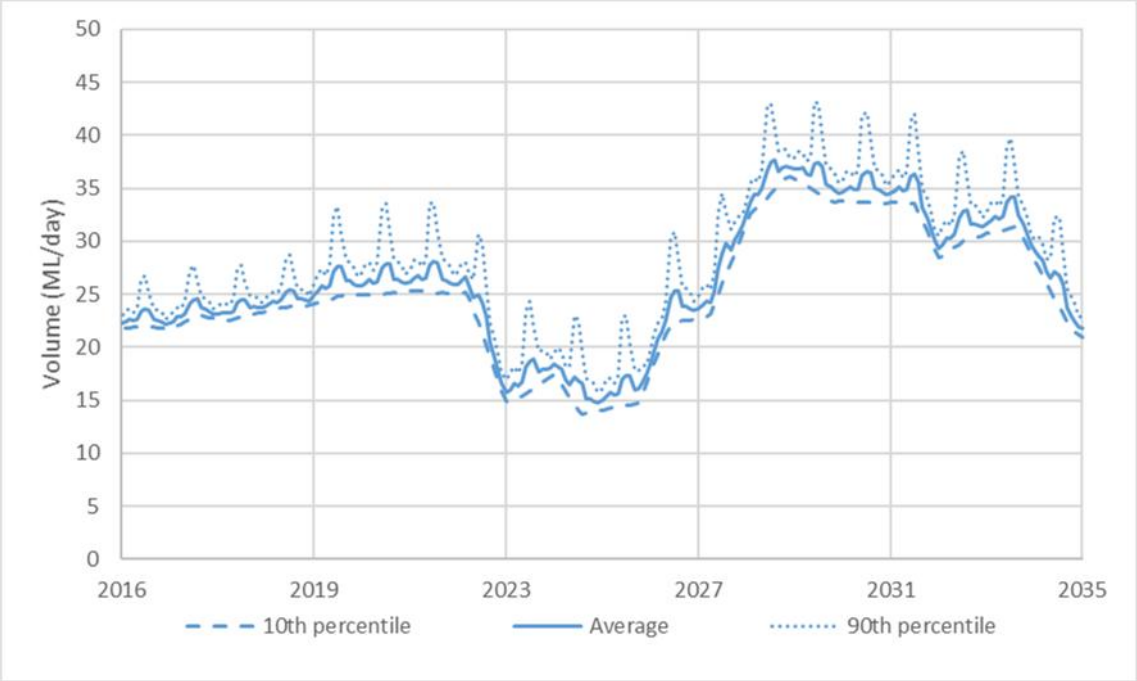


Figure 6-14 Do nothing scenario – Predicted flow of Sawyers Swamp Creek at the confluence with the Coxs River

The modelled inflow to Lake Wallace is presented in Figure 6-15. The flow is dominated by catchment runoff, with a small variation over time due to the SDWTS discharges to the Coxs River catchment via LDP009. The average inflow to the lake was found to vary between approximately 86 ML/day to 172 ML/day. The flow ranged between approximately 67 ML/day (10th percentile) and 305 ML/day (90th percentile) due to the variation in rainfall contributing to catchment runoff.

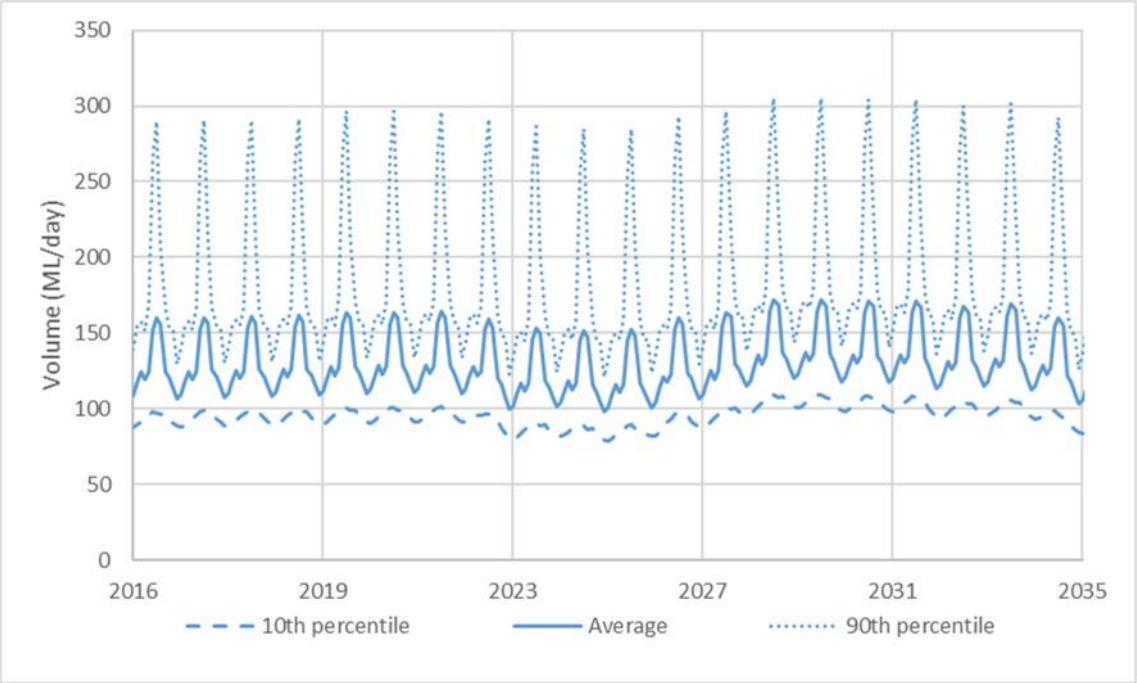


Figure 6-15 Do nothing scenario – Predicted flow from Coxs River to Lake Wallace

Inflows to Lake Lyell were predicted to range between approximately 98 ML/day and 227 ML/day on average, as shown in Figure 6-16. The flow was modelled to range between 64 ML/day (10th percentile) and 474 ML/day (90th percentile) due to the variation in rainfall contributing to catchment runoff.

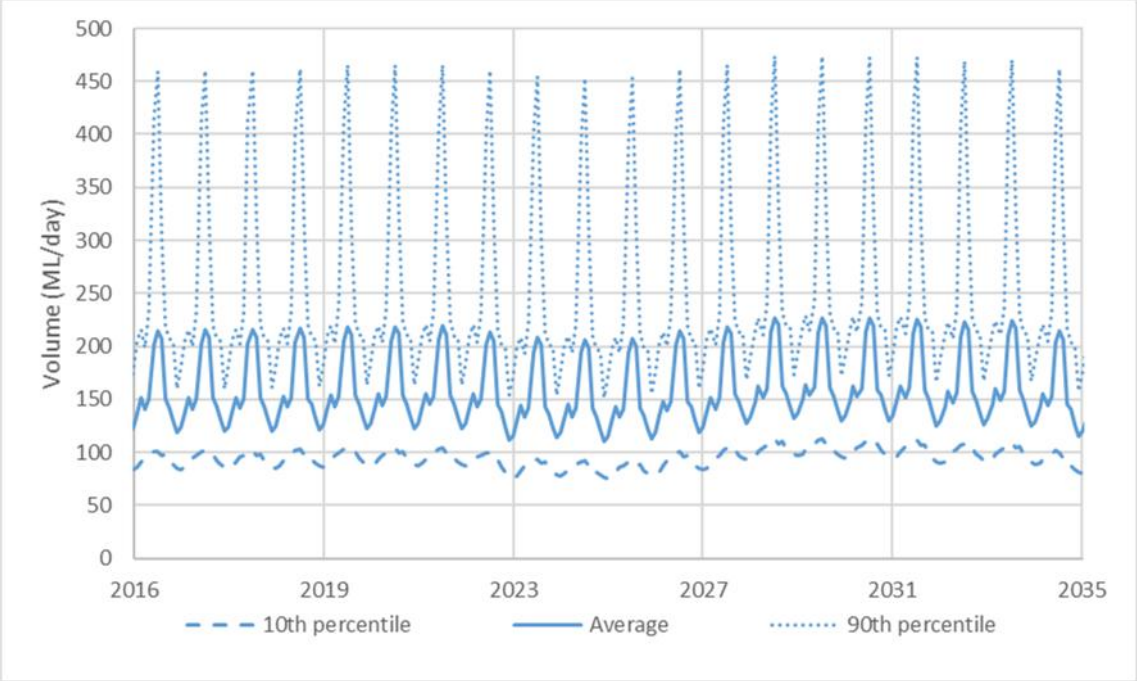


Figure 6-16 Do nothing scenario – Predicted flow from Coxs River to Lake Lyell

Figure 6-17 provides the modelled flow from the Coxs River catchment into Lake Burragorang, which was found to vary between approximately 158 ML/day and 574 ML/day on average. The flow ranged from approximately 68 ML/day (10th percentile) and 1,339 ML/day (90th percentile) due to the variation in rainfall contributing to catchment runoff.

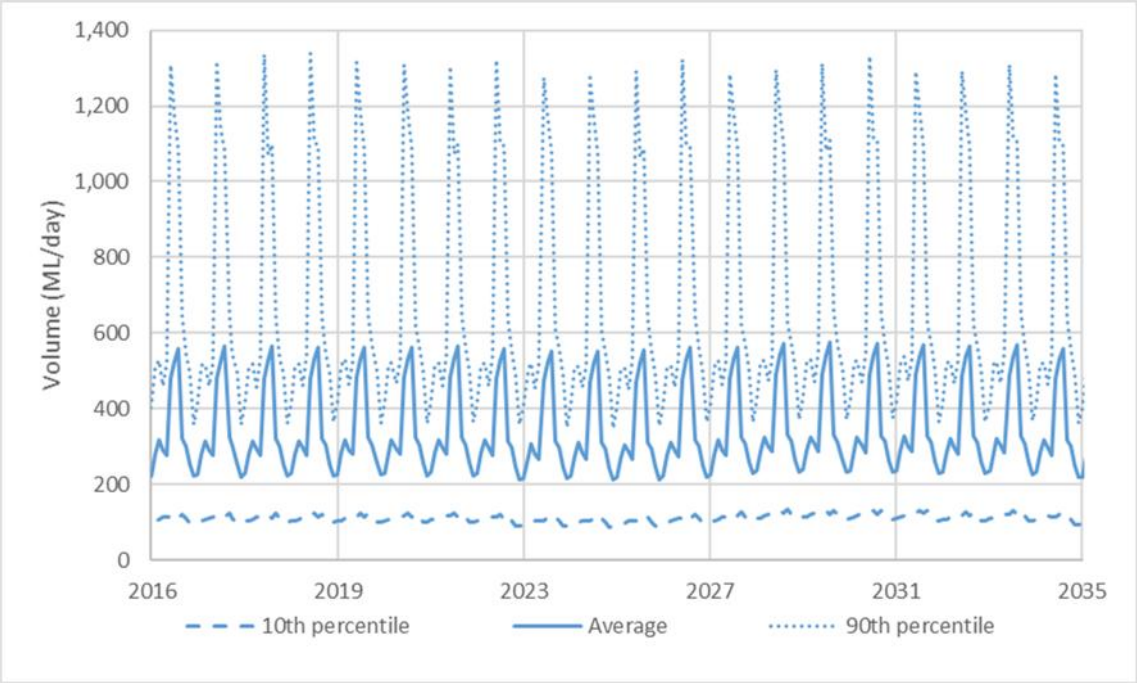


Figure 6-17 Do nothing scenario – Predicted flow from Coxs River to Lake Burragorang

Scenario 3

The predicted discharge from the Project via the proposed LDP is presented in Figure 6-18. For Scenario 3, the 50% power generation requirement modelled at MPPS results in the majority of water transferred to the SDWTS used within the cooling water system. Proposed LDP discharges of excess treated water were predicted to occur from January 2029 to September 2032, peaking at approximately 3.9 ML/day in December 2029. As discussed, the results are indicative only as water demands at MPPS vary daily with power generation requirements.

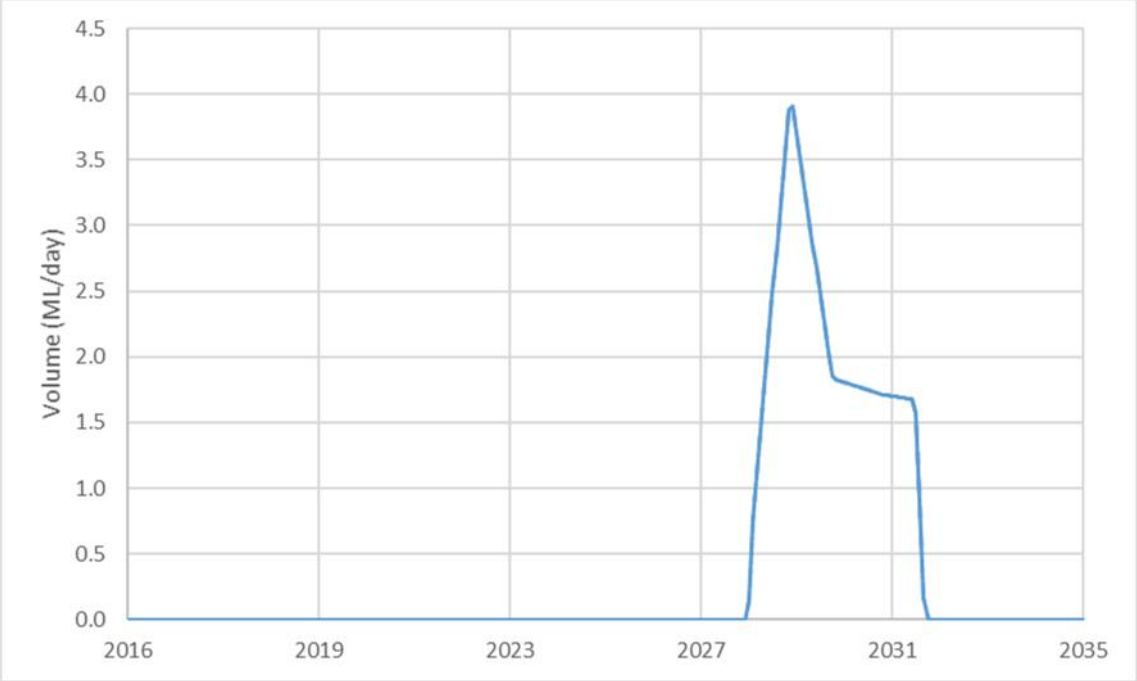


Figure 6-18 Scenario 3 – Predicted proposed LDP discharge

Proposed Project discharges resulted in an increase of up to 3.9 ML/day in the flow of Wangcol Creek at the confluence with LDP006 and the proposed LDP, as shown in Figure 6-19, and at the confluence with the Coxs River, as shown in Figure 6-20, compared to the do nothing scenario.

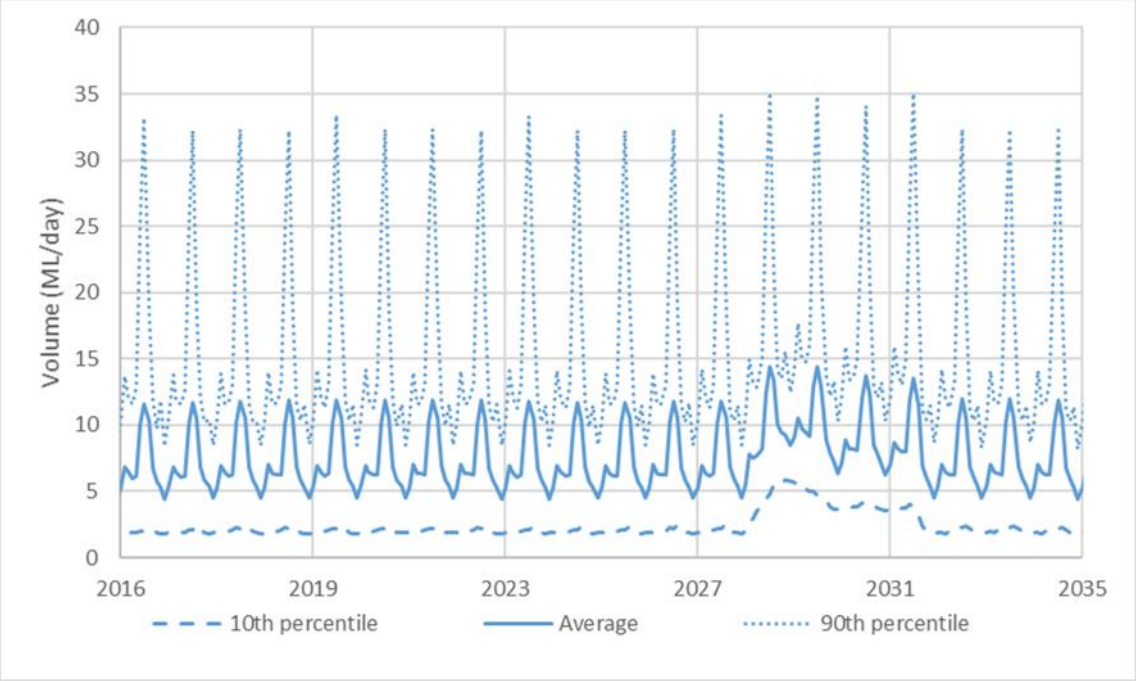


Figure 6-19 Scenario 3 – Predicted flow of Wangcol Creek at LDPs

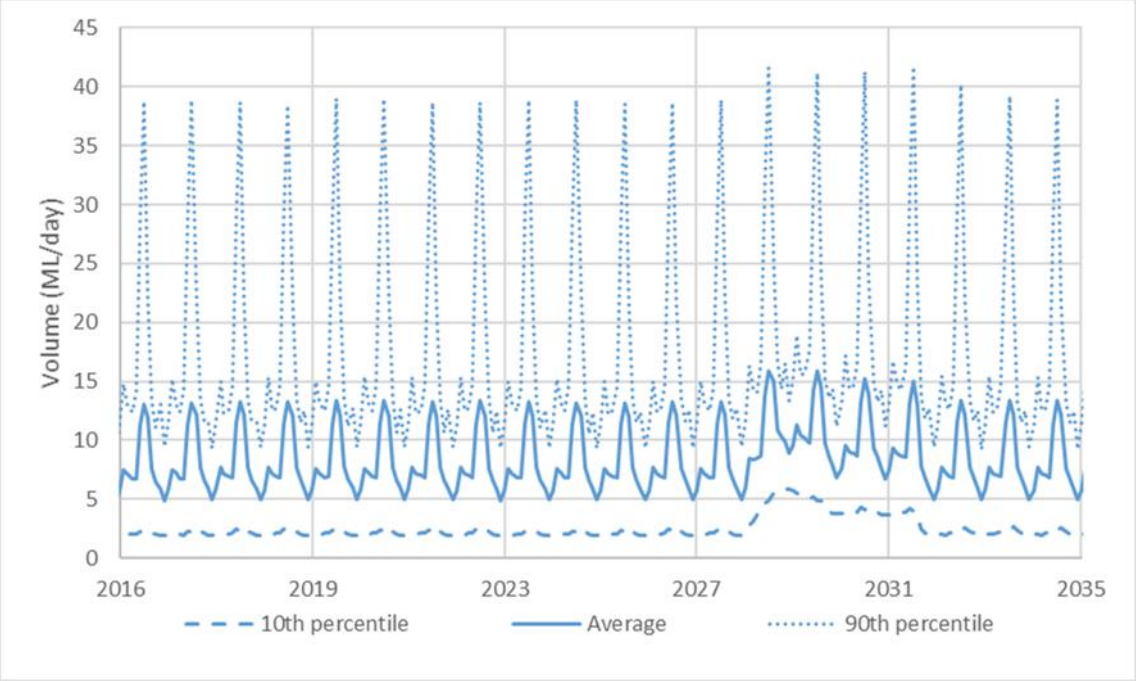


Figure 6-20 Scenario 3 – Predicted flow of Wangcol Creek at the confluence with the Coxs River

Predicted LDP009 discharge, provided in Figure 6-21, ceased from 30 June 2017 when the Project was modelled to commence. Under proposed conditions, LDP009 discharge to Sawyers Swamp Creek was estimated to peak at 23 ML/day in June 2017.

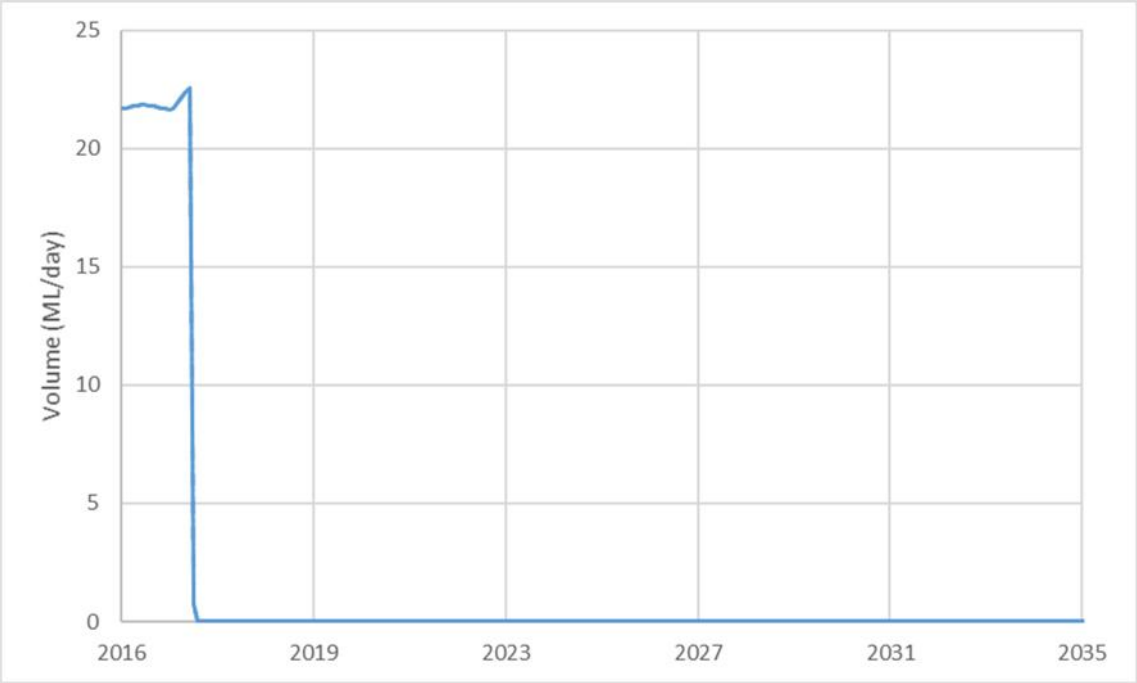


Figure 6-21 Scenario 3 – Predicted LDP009 discharge to Sawyers Swamp Creek

The flow of Sawyers Swamp Creek at the confluence with the Coxs River is presented in Figure 6-22. Following the commencement of the Project in June 2017 and the subsequent cessation of discharges via LDP009, flow within Sawyers Swamp Creek was modelled to reduce to between 0.5 ML/day and 1.7 ML/day on average. Flow was predicted to increase slightly after 2020 following the rehabilitation of Sawyers Swamp Creek Ash Dam, with additional catchment runoff contributing to the creek. After 2020, the flow was estimated to be an average of approximately 0.9 ML/day to 3.2 ML/day. The flow ranged between approximately 0.1 ML/day (10th percentile) and 8.7 ML/day (90th percentile) due to the variation in rainfall contributing to catchment runoff.

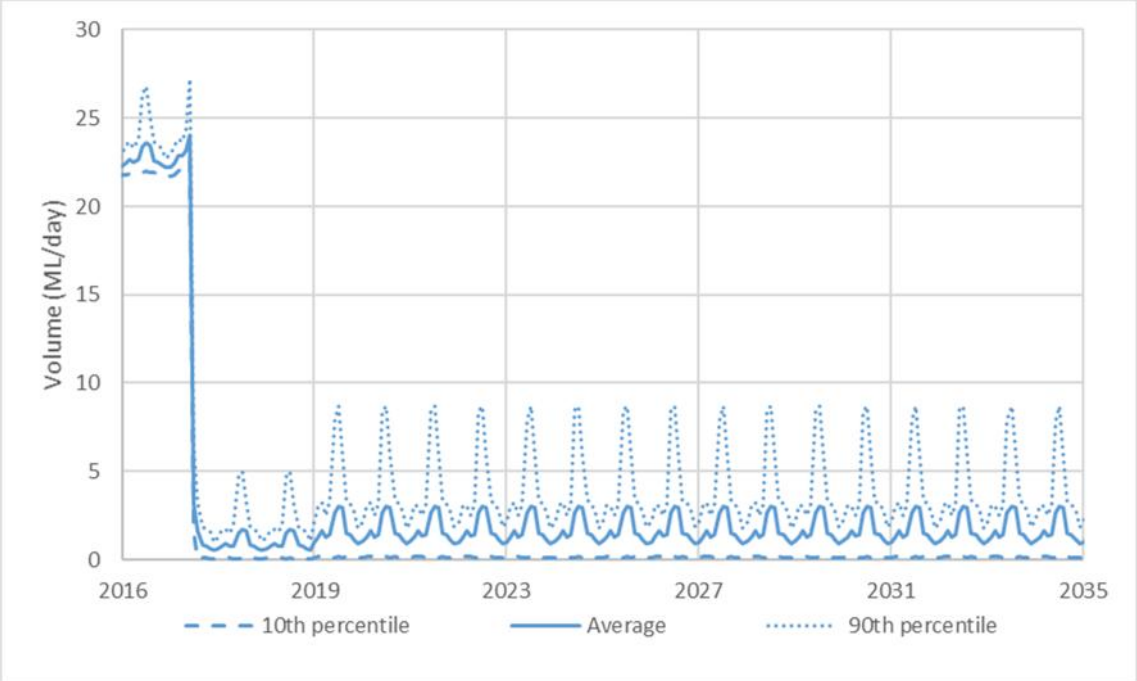


Figure 6-22 Scenario 3 – Predicted flow of Sawyers Swamp Creek at the confluence with the Coxs River

Figure 6-23 presents the modelled inflow to Lake Wallace. As with the do nothing scenario, the flow is dominated by catchment runoff, however a small variation in volume is seen over time due to discharges via the proposed LDP and the rehabilitation of Sawyers Swamp Creek Ash Dam. Compared to the do nothing scenario, the inflow to Lake Wallace was slightly reduced, due to the cessation of discharges from LDP009 following the commencement of the Project. The average inflow to Lake Wallace was found to vary between approximately 85 ML/day and 168 ML/day. The flow ranged between approximately 67 ML/day (10th percentile) and 301 ML/day (90th percentile) due to the variation in rainfall contributing to catchment runoff.

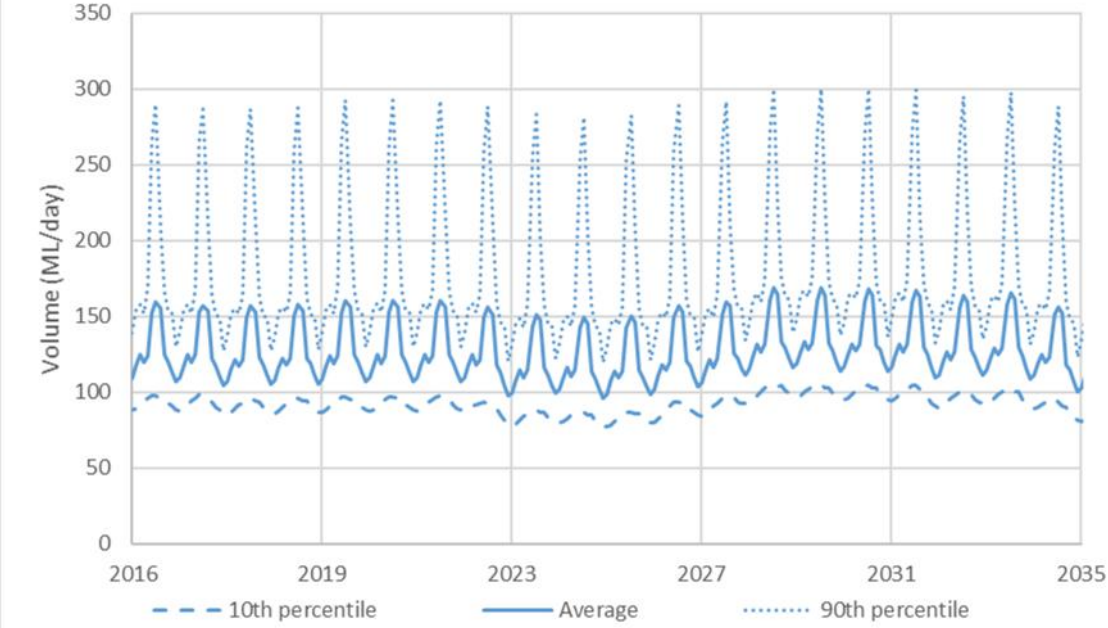


Figure 6-23 Scenario 3 – Predicted flow from Coxs River to Lake Wallace

Inflows to Lake Lyell were predicted to range between approximately 97 ML/day and 223 ML/day on average, as shown in Figure 6-24. The flow was modelled to range between 63 ML/day (10th percentile) and 470 ML/day (90th percentile) due to the variation in rainfall contributing to catchment runoff. Flows are slightly decreased compared to the do nothing scenario, due to the absence of LDP009 discharges within the Coxs River catchment after the commencement of the Project.

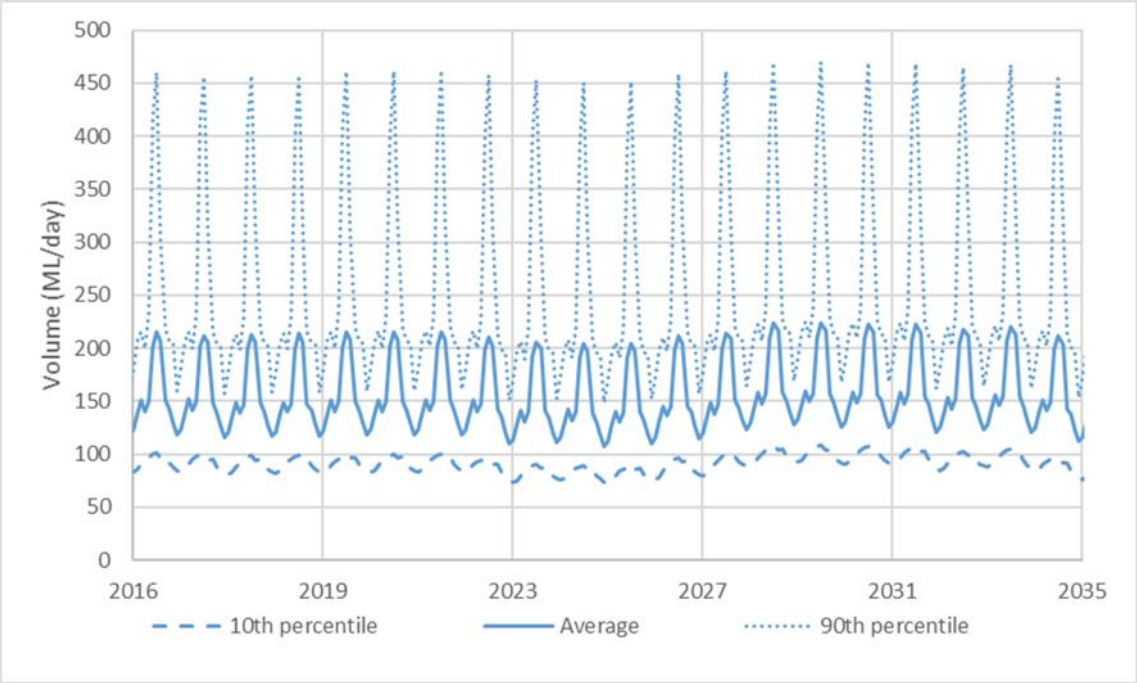


Figure 6-24 Scenario 3 – Predicted flow from Coxs River to Lake Lyell

Figure 6-25 provides the modelled flow from the Coxs River catchment into Lake Burragorang, which was found to vary between approximately 158 ML/day and 570 ML/day on average. The flow ranged from approximately 70 ML/day (10th percentile) and 1,336 ML/day (90th percentile) due to the variation in rainfall contributing to catchment runoff. The cessation of LDP009 discharges associated with the Project resulted in a slight decrease in the upper ranges of Coxs River flow into Lake Burragorang.

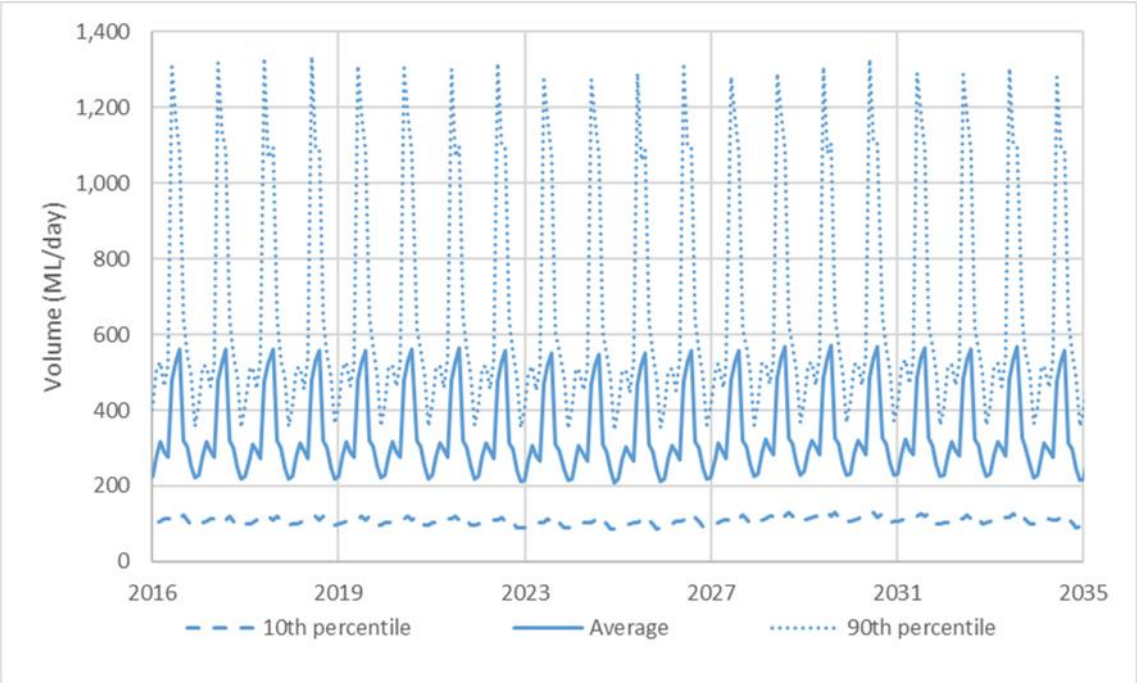


Figure 6-25 Scenario 3 – Predicted discharge from Coxs River to Lake Burragorang

6.2.2 Salt balance results

Annual results

The predicted annual values for each of the salt transfers for the Project in 2030 are shown in Figure 6-26. The predicted values for each of the salt transfers within the Coxs River catchment for proposed conditions in 2030 are provided in Figure 6-27 and Figure 6-28 for the do nothing scenario (50% power generation requirement) and Scenario 3 (50% power generation requirement) respectively. The results present the average annual salt transfers between the elements of the water cycle as well as an indication of the range of values expected due to possible variations in rainfall and the predicted average salt concentrations.

Wangcol Creek catchment

A summary of the average annual inputs and outputs for the salt balance for the Wangcol Creek catchment under proposed conditions in 2030 for all scenarios is presented in Table 6-3.

Similar to the water balance results for proposed conditions, the Project was predicted to result in an increase in the salt load of discharges from Wangcol Creek into the Coxs River due to discharges from the proposed LDP for scenarios 1, 2 and 3 and discharges from LDP006 for all of the proposed Project scenarios.

Discharges of excess treated water to Wangcol Creek from the Project via the proposed LDP were modelled to range between an average of 288 t/year for Scenario 3 to 3,312 t/year for Scenario 1. The increase in LDP006 discharge associated with the disposal of residual material from the Project within the REA at the SCSS was found to be approximately 153 t/year on average, compared to the do nothing scenario.

The salt load associated with the discharge from Wangcol Creek was modelled to contribute from approximately 1,930 t/year for scenarios 4 and 5 to approximately 5,242 t/year for Scenario 1 into the Coxs River on average. For the do nothing scenario, the salt load associated with Wangcol Creek flow was estimated to be 1,777 t/year on average. The contribution of discharges from the Project via the proposed LDP to the total salt load within Wangcol Creek was predicted to vary between approximately 13% (Scenario 3) and 63% (Scenario 1).

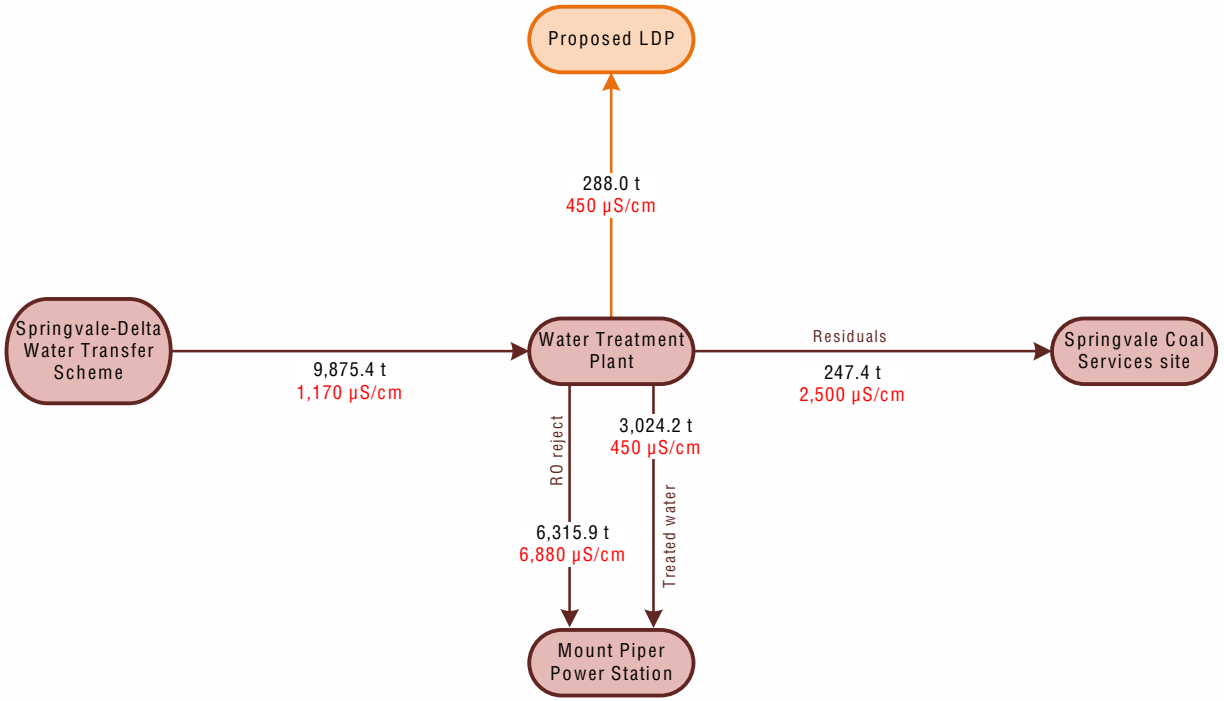
Coxs River catchment

A summary of the average annual inputs and outputs for the salt balance for the Coxs River catchment under proposed conditions in 2030 for all scenarios is presented in Table 6-4.

As shown in Table 6-4, the sources and sinks for the salt balance were broadly similar to the water balance. The largest source of salt into the Coxs River catchment under proposed conditions was associated with rainfall onto surface water storages and catchment runoff, which accounted for 9,506 t/year on average, equating to between 44% (do nothing scenario) and 80% (scenarios 4 and 5) of the total salt input to the system. The average salinity of the total contribution of rainfall and runoff to the catchment was estimated to be approximately 108 µS/cm.

Similar to the water balance results, the second largest input of salt to the system was modelled to be associated with proposed LDP discharges to Wangcol Creek for scenarios 1 and 2; transfers from Clarence Colliery into the catchment for scenarios 3, 4 and 5; and discharges from LDP009 for the do nothing scenario.

The salt load associated with the supply of water from the Fish River water supply scheme to MPPS in Scenario 5 was modelled to input approximately 31 t/year of salt to the system on average.



LEGEND

Salt transfer

Proposed transfer

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LOCATION	Coxs River
SEAM	N/A
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

Springvale Water Treatment Project
Water Resources Impact Assessment

Annual salt transfers
Proposed conditions (2030)
Water Treatment Plant

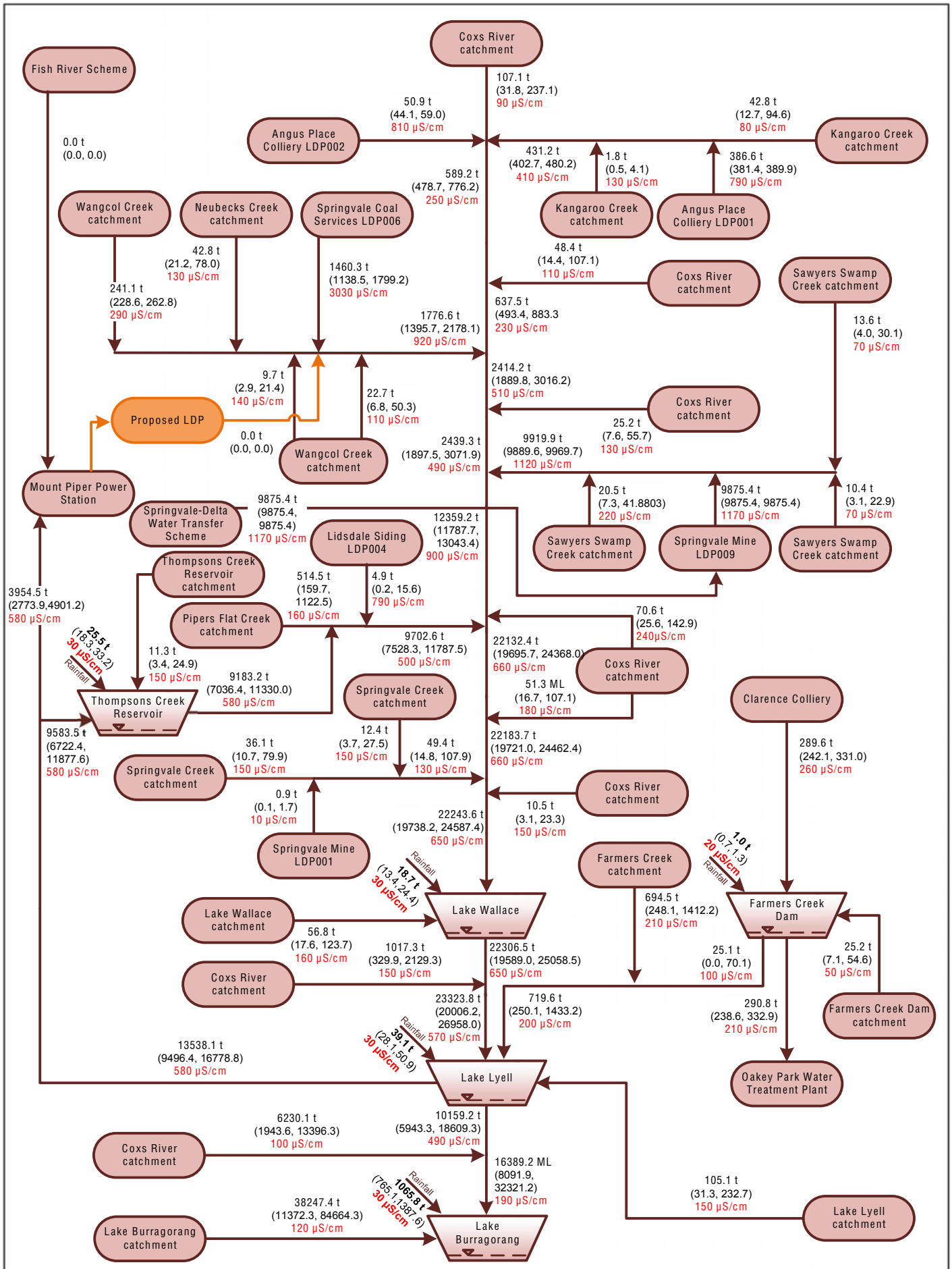
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EnergyAustralia

DATE Aug 2016

Figure 6-26

G:\21\25109\Visio\2125109_WTP Salt Cycle Schematic.vsdx



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LOCATION	Coxs River
SEAM	NA
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

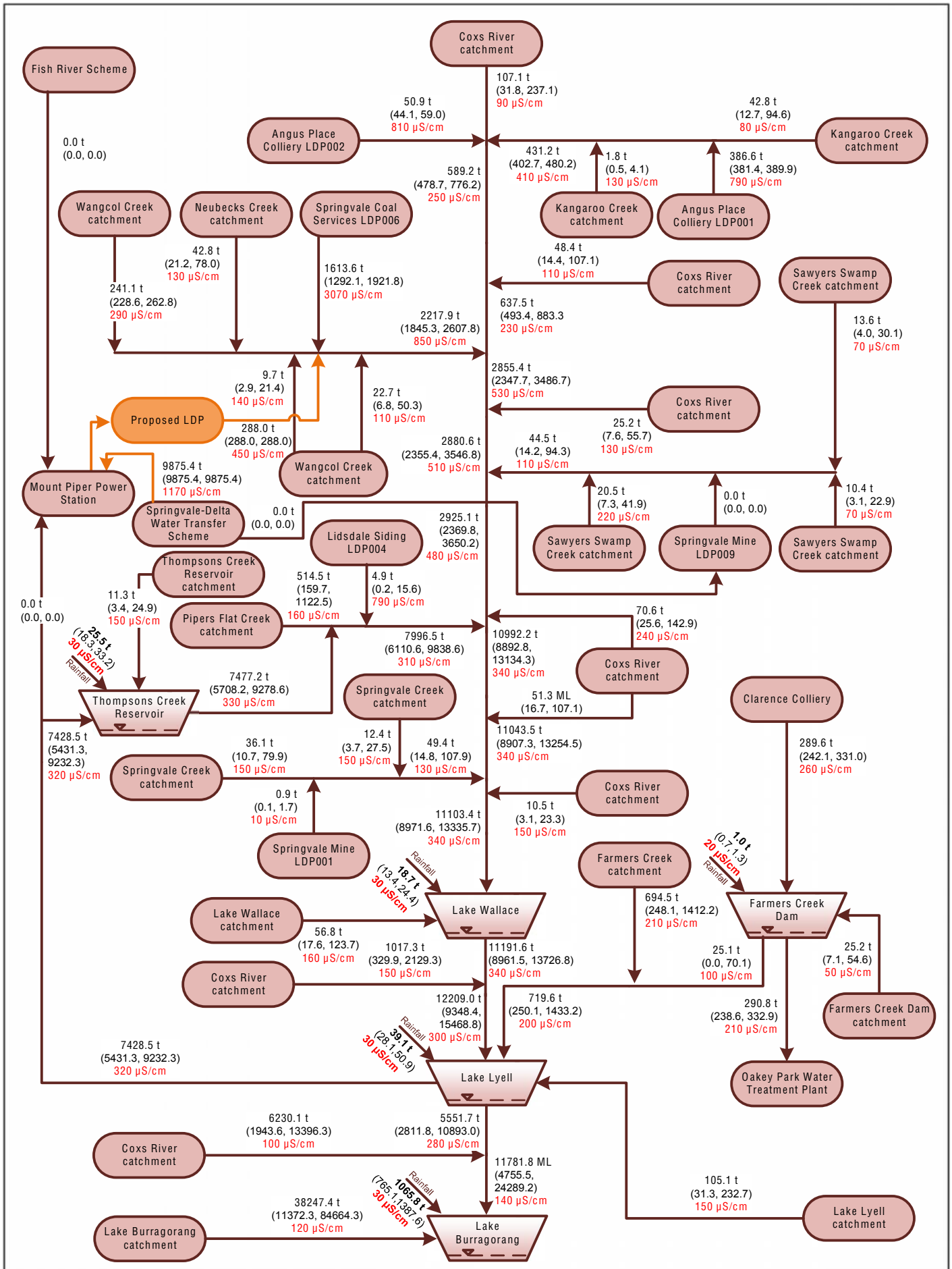
Springvale Water Treatment Project
Water Resources Impact Assessment

Annual salt transfers
Proposed conditions (2030)
Do nothing scenario

Centennial Coal
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DATE Aug 2016

Figure 6-27



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LOCATION	Coxs River
SEAM	NA
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

GHD

Springvale Water Treatment Project
Water Resources Impact Assessment

Annual salt transfers
Proposed conditions (2030)
Scenario 3

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Figure 6-28

Table 6-3 Summary of average salt inputs and outputs for Wangcol Creek catchment under proposed conditions in 2030

	Scenario 1 (t/year)	Scenario 2 (t/year)	Scenario 3 (t/year)	Scenario 4 (t/year)	Scenario 5 (t/year)	Do nothing (t/year)
	0% power generation	25% power generation	50% power generation	75% power generation	100% power generation	50% power generation
INPUTS						
Catchment runoff	316.3	316.3	316.3	316.3	316.3	316.3
LDP discharge from SCSS (LDP006)	1,613.6	1,613.6	1,613.6	1,613.6	1,613.6	1,460.3
Proposed LDP discharge	3,312.1	1,800.1	288.0	0.0	0.0	N/A
TOTAL INPUTS (rounded)	5,242	3,730	2,218	1,930	1,930	1,777
OUTPUTS						
Contribution to Coxs River	5,242.0	3,729.9	2,217.9	1,929.9	1,929.9	1,776.6
TOTAL OUTPUTS (rounded)	5,242	3,730	2,218	1,930	1,930	1,777
BALANCE						
Inputs – outputs	0	0	0	0	0	0

Table 6-4 Summary of average salt inputs and outputs for Coxs River catchment under proposed conditions in 2030

	Scenario 1 (t/year)	Scenario 2 (t/year)	Scenario 3 (t/year)	Scenario 4 (t/year)	Scenario 5 (t/year)	Do nothing scenario[a] (t/year)
	0% power generation	25% power generation	50% power generation	75% power generation	100% power generation	50% power generation
INPUTS						
Direct rainfall onto storages and catchment runoff	9,506.2	9,506.2	9,506.2	9,506.2	9,506.2	9,506.2
Supply from Fish River water supply scheme to MPPS	0.0	0.0	0.0	0.0	31.3	0.0
Transfer from Clarence Colliery to Farmers Creek Dam	289.6	289.6	289.6	289.6	289.6	289.6
LDP discharge from Angus Place Colliery (LDP001)	386.6	386.6	386.6	386.6	386.6	386.6
LDP discharge from Angus Place Colliery (LDP002)	50.9	50.9	50.9	50.9	50.9	50.9
LDP discharge from Lidsdale Siding (LDP004)	4.9	4.9	4.9	4.9	4.9	4.9
LDP discharge from SCSS (LDP006)	1,613.6	1,613.6	1,613.6	1,613.6	1,613.6	1,460.3
LDP discharge from Springvale Mine (LDP001)	0.9	0.9	0.9	0.9	0.9	0.9
LDP discharge from Springvale Mine (LDP009)	0.0	0.0	0.0	0.0	0.0	9,875.4
Proposed LDP discharge	3,312.1	1,800.1	288.0	0.0	0.0	N/A
TOTAL INPUTS (rounded)	15,165	13,653	12,141	11,853	11,884	21,575

	Scenario 1 (t/year)	Scenario 2 (t/year)	Scenario 3 (t/year)	Scenario 4 (t/year)	Scenario 5 (t/year)	Do nothing scenario[a] (t/year)
	0% power generation	25% power generation	50% power generation	75% power generation	100% power generation	50% power generation
OUTPUTS						
Additional make-up water used at MPPS[b]	0.0	0.0	0.0	879.5	2,006.1	3,954.5
Oakey Park WTP use	290.8	290.8	290.8	290.8	290.8	290.8
Contribution to Lake Burragorang	14,446.7	13,045.6	11,781.8	10,657.2	9,508.1	16,389.2
TOTAL OUTPUTS (rounded)	14,738	13,336	12,073	11,828	11,805	20,635
CHANGE IN STORAGE						
Farmers Creek Dam	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Lake Lyell	201.0	209.9	92.6	70.0	126.5	490.3
Lake Wallace	-23.9	-18.1	-12.7	-6.0	-5.9	12.6
Thompsons Creek Reservoir	250.0	124.3	-11.9	-39.0	-41.9	437.1
TOTAL CHANGE IN STORAGE (rounded)	427	316	68	25	79	940
BALANCE						
Inputs – outputs – change in storage	0	0	0	0	0	0

[a] In the do nothing scenario, inputs from the SDWTS are discharged to Sawyers Swamp Creek via Springvale Mine's LDP009.

[b] Additional make-up water required in addition to the supply from the Project.

The salt load associated with make-up water supplied to MPPS, in addition to the supply from the Project, varied with scenario modelled. No additional make-up water was required for scenarios 1, 2 and 3. MPPS was predicted to act as a sink for salt in the catchment for scenarios 4 and 5, with 880 t/year and 2,006 t/year supplied to the power station on average.

Under the proposed conditions, the total annual salt load of the Coxs River upstream of Lake Burragorang was estimated to range from approximately 9,508 t/year for Scenario 5 to 14,447 t/year for Scenario 1 on average. For the do nothing scenario, with a 50% power generation requirement and all salt associated with water within the SDWTS modelled to be discharged via LDP009, the salt load of the Coxs River was predicted to be approximately 16,389 t/year on average.

Site-based discharges from Angus Place Colliery, Lidsdale Siding, the SCSS and Springvale Mine as well as Project discharges from the proposed LDP were estimated to contribute between approximately 2,057 t/year, for scenarios 4 and 5, and approximately 5,369 t/year, for Scenario 1, to the Coxs River catchment on average. This equates to between 17%, for scenarios 4 and 5, and 35%, for Scenario 1, of the total annual salt load input to the Coxs River catchment. This is a reduction in salt load associated with mine water discharges compared to the do nothing scenario, which was predicted to discharge 11,779 t/year of salt on average, equating to 55% of the total salt load input to the catchment.

Time series results

Monthly average time series results of EC associated with flows are presented for the do nothing scenario (50% power generation requirement) and Scenario 3 (50% power generation requirement) in the following sections.

Do nothing scenario

For the do nothing scenario, it was assumed in the water balance model that the Project would not be developed. As such, there were no discharges predicted for the proposed LDP.

The predicted EC of Wangcol Creek at the confluence with the discharge from the SCSS via LDP006 is presented in Figure 6-29. Site-based discharges from the SCSS dominate the EC of Wangcol Creek at this location, with EC predicted to be an average of approximately 1,182 µS/cm and 1,594 µS/cm. The flow EC ranged between approximately 558 µS/cm (10th percentile) and 2,387 µS/cm (90th percentile) due to the variation in rainfall contributing to catchment runoff.

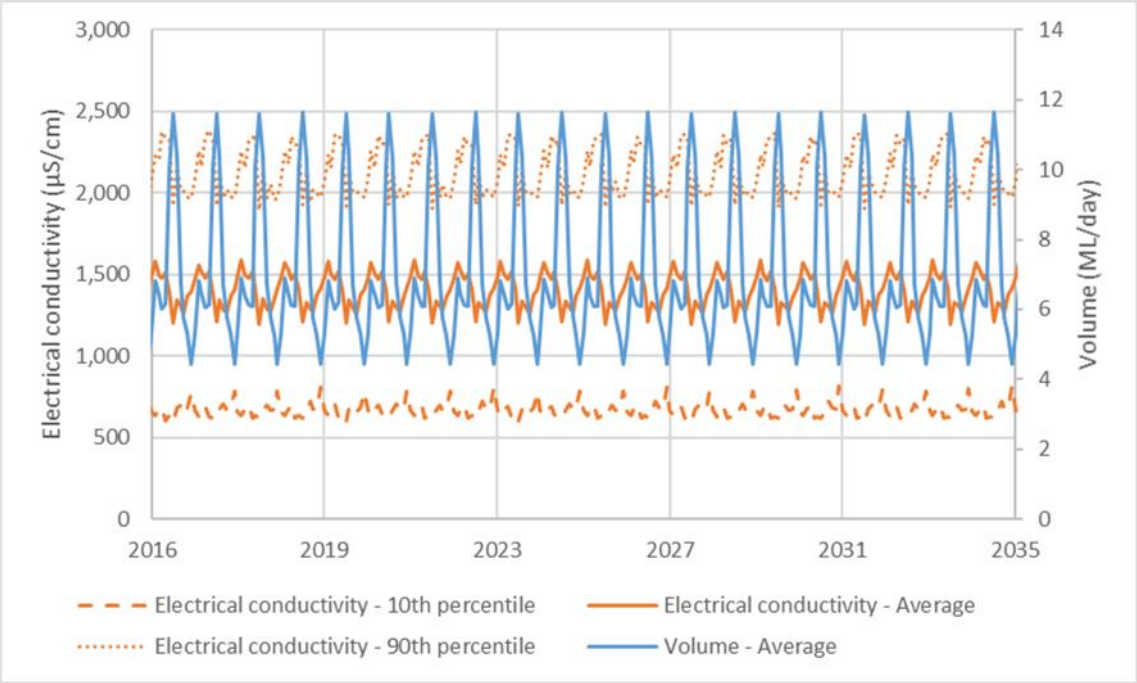


Figure 6-29 Do nothing scenario – Predicted EC of Wangcol Creek at LDPs

The EC of Wangcol Creek at the confluence with the Coxs River predicted by the salt balance model is shown in Figure 6-30. The relatively low EC of catchment runoff downstream of LDP006 discharges provides a slight dilution of the flow.

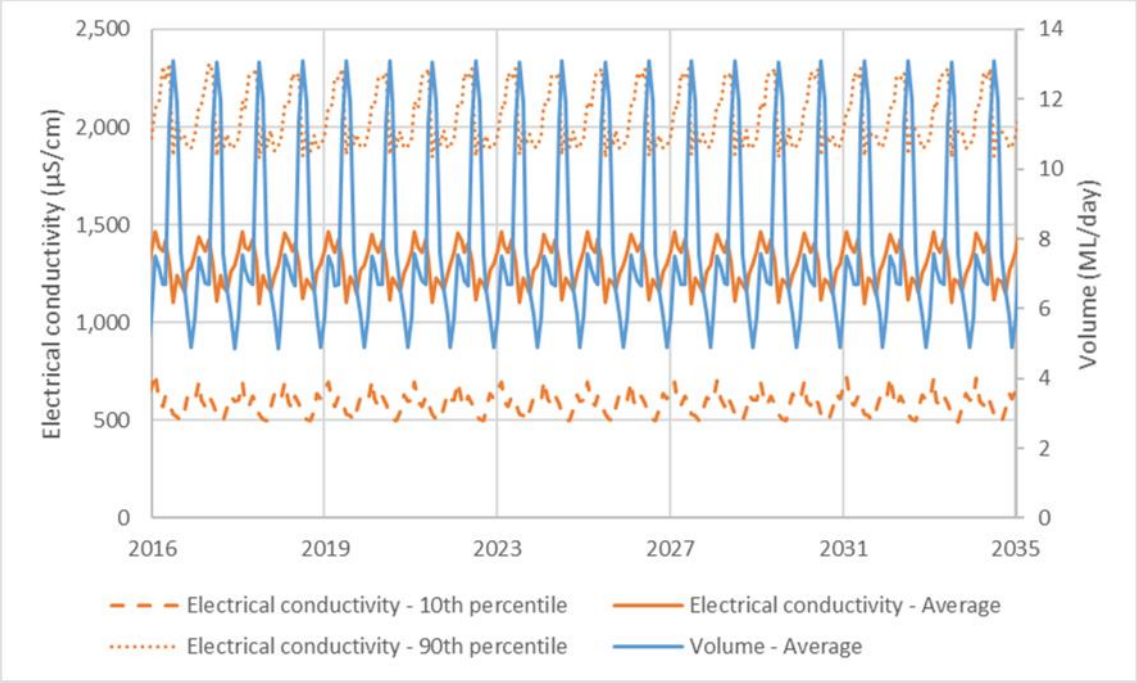


Figure 6-30 Do nothing scenario – Predicted EC of Wangcol Creek at the confluence with the Coxs River

Figure 6-31 provides the predicted EC of Springvale Mine's LDP009 discharge into Sawyers Swamp Creek. This discharge was modelled at a rate of 1,170 µS/cm.

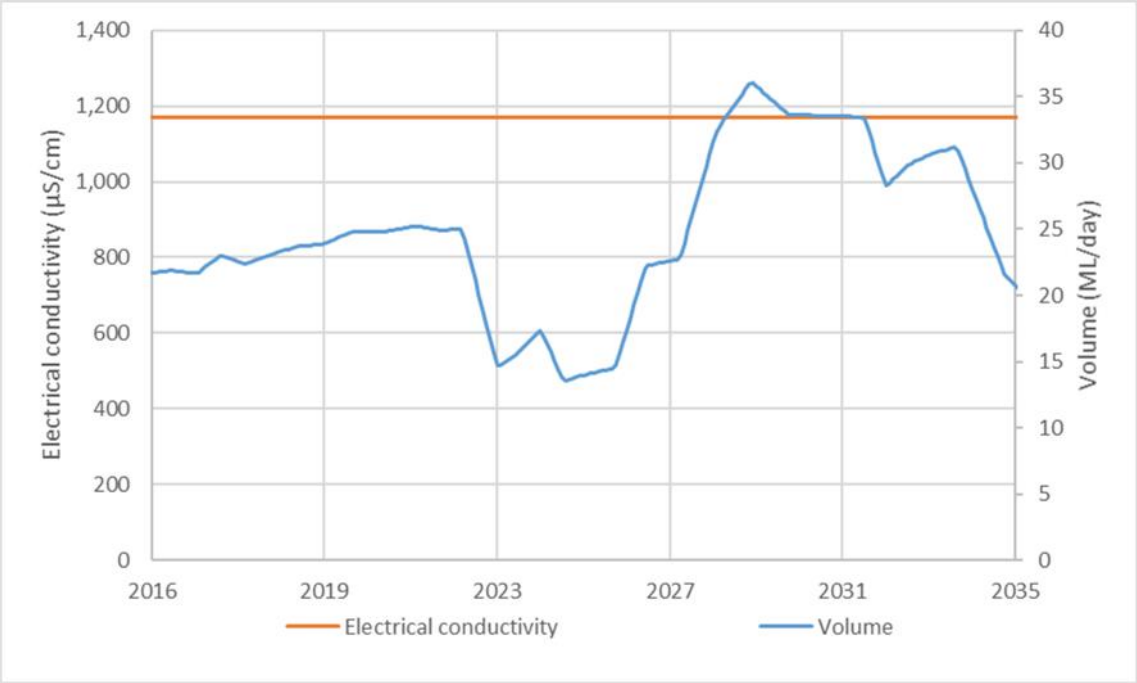


Figure 6-31 Do nothing scenario – Predicted EC of LDP009 discharge to Sawyers Swamp Creek

The modelled EC of Sawyers Swamp Creek to the Coxs River is presented in Figure 6-32. This flow is dominated by the discharge of mine water via LDP009, with slight dilution of the EC due to catchment runoff. The EC was estimated to be an average of between 952 µS/cm and 1,149 µS/cm.

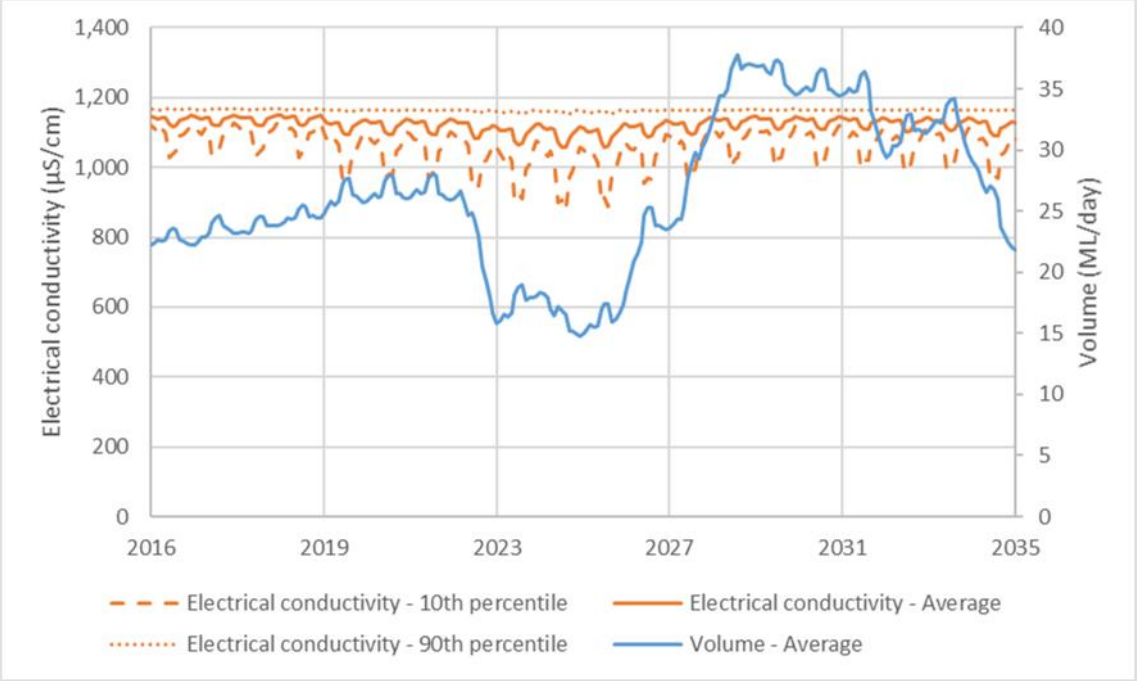


Figure 6-32 Do nothing scenario – Predicted EC of Sawyers Swamp Creek at the confluence with the Coxs River

The modelled EC of the inflow to Lake Wallace is shown in Figure 6-33. The EC is dominated by the relatively high EC of mine water discharges via LDP009, with the average EC found to vary between 435 µS/cm and 755 µS/cm. The flow ranged in EC between approximately 322 µS/cm (10th percentile) and 906 µS/cm (90th percentile) due to the variation in rainfall contributing to catchment runoff.

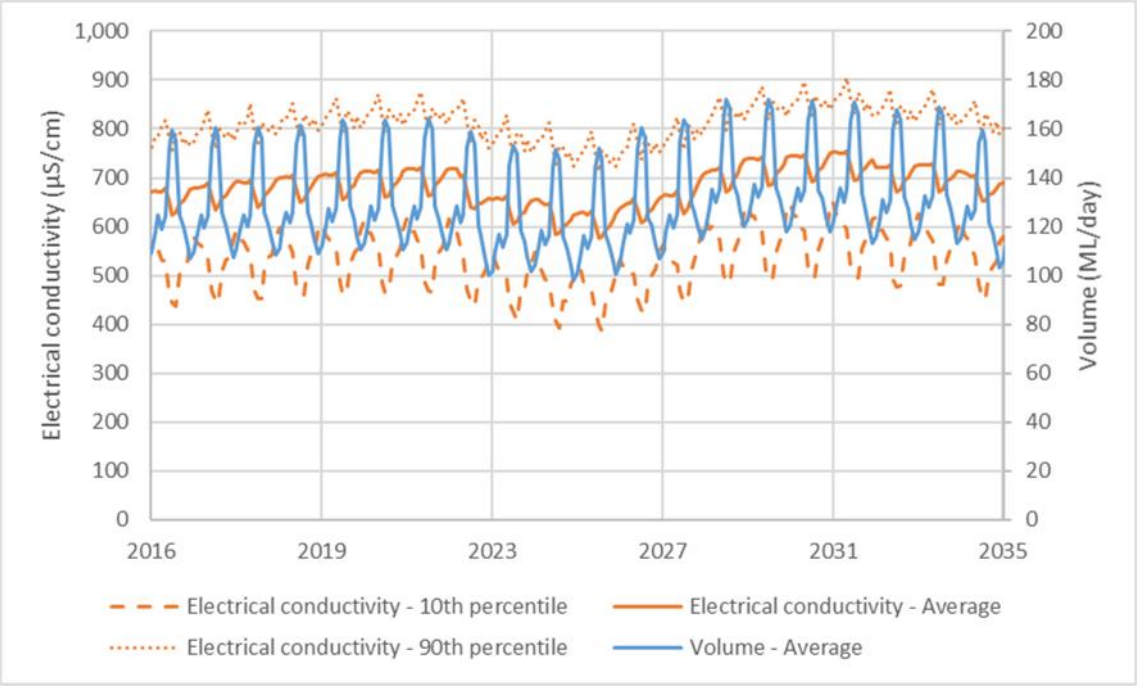


Figure 6-33 Do nothing scenario – Predicted EC of flow from the Coxs River to Lake Wallace

The EC of inflows to Lake Lyell was predicted to range between approximately 394 µS/cm and 705 µS/cm on average, as shown in Figure 6-34. The flow was modelled to range in EC between 238 µS/cm (10th percentile) and 861 µS/cm (90th percentile) due to the variation in rainfall contributing to catchment runoff.

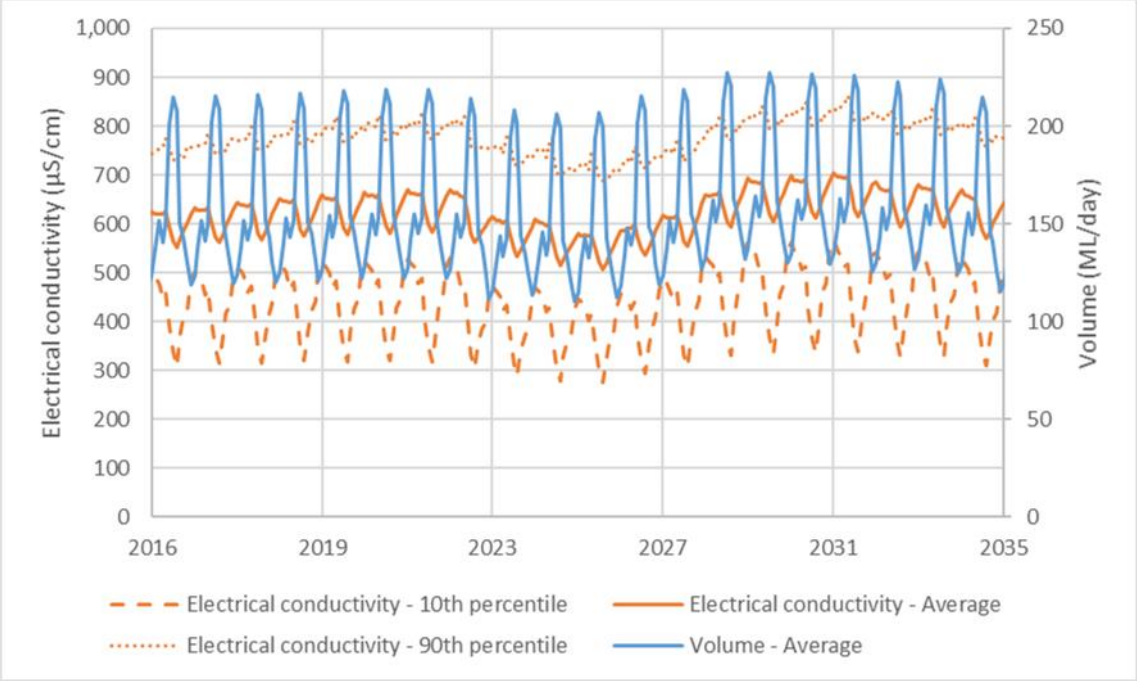


Figure 6-34 Do nothing scenario – Predicted EC of flow from the Coxs River to Lake Lyell

Figure 6-35 provides the modelled EC of flows from the Coxs River catchment into Lake Burragorang, which was found to vary between approximately 63 µS/cm and 201 µS/cm on average. The EC of the flow ranged from approximately 47 µS/cm (10th percentile) and 248 µS/cm (90th percentile) due to the variation in rainfall contributing to catchment runoff. The relatively low EC indicates that the flows into Lake Burragorang are heavily dominated by the large volume of catchment runoff compared to the higher EC of mine water discharges within the Coxs River catchment.

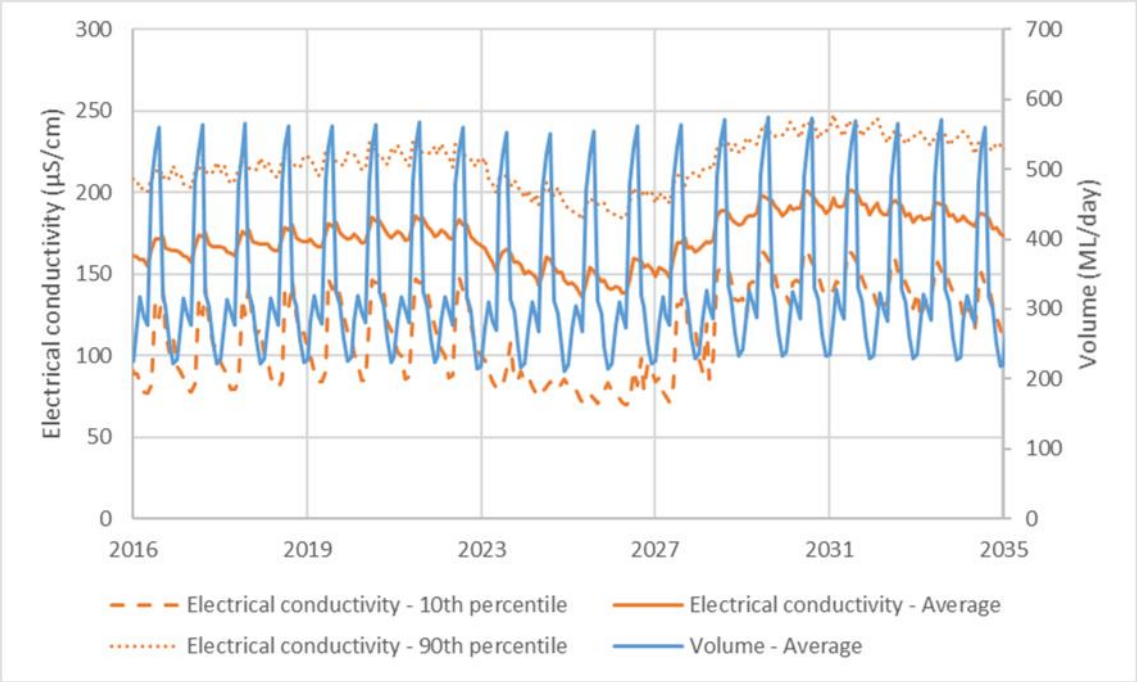


Figure 6-35 Do nothing scenario – Predicted EC of flow from the Coxs River to Lake Burragorang

Scenario 3

The EC of the predicted discharge from the Project via the proposed LDP is presented in Figure 6-36. For Scenario 3, the 50% power generation requirement modelled at MPPS results in the majority of water transferred to the SDWTS used within the cooling water system. The treated water was modelled to have a maximum EC of approximately 493 µS/cm.

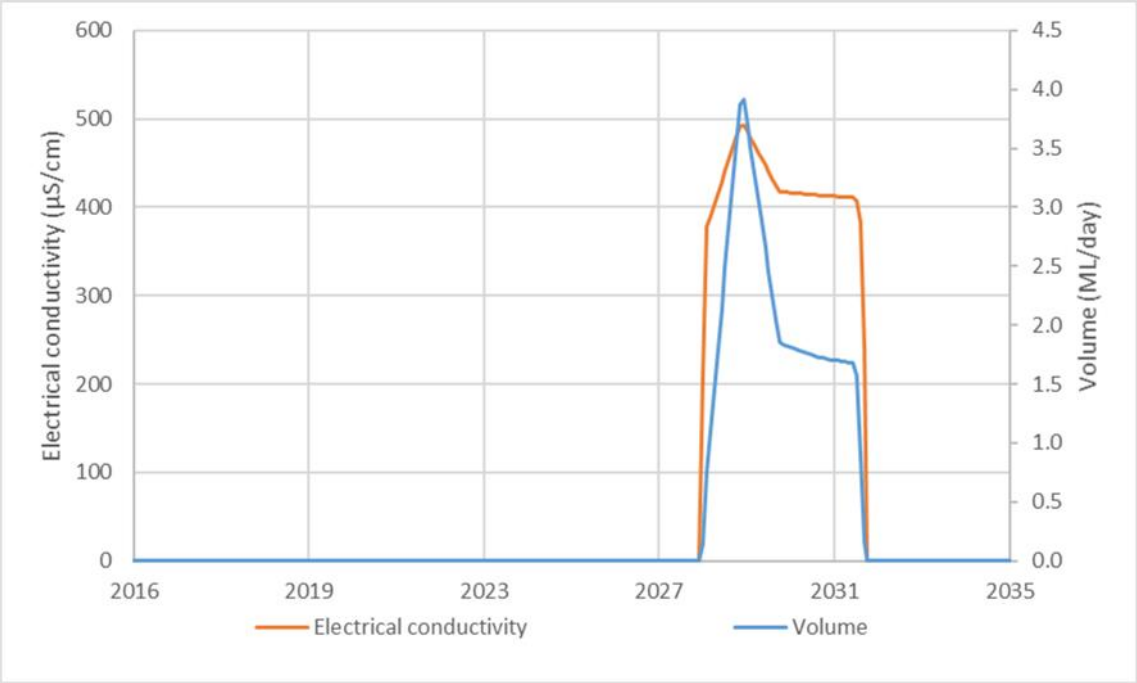


Figure 6-36 Scenario 3 – Predicted EC of proposed LDP discharge

The proposed Project discharges of up to 4 ML/day resulted in a decrease in the modelled EC of up to approximately 300 µS/cm in Wangcol Creek at the confluence with LDP006 and the proposed LDP, as shown in Figure 6-37, and at the confluence with the Coxs River, as shown in Figure 6-38, compared to the do nothing scenario.

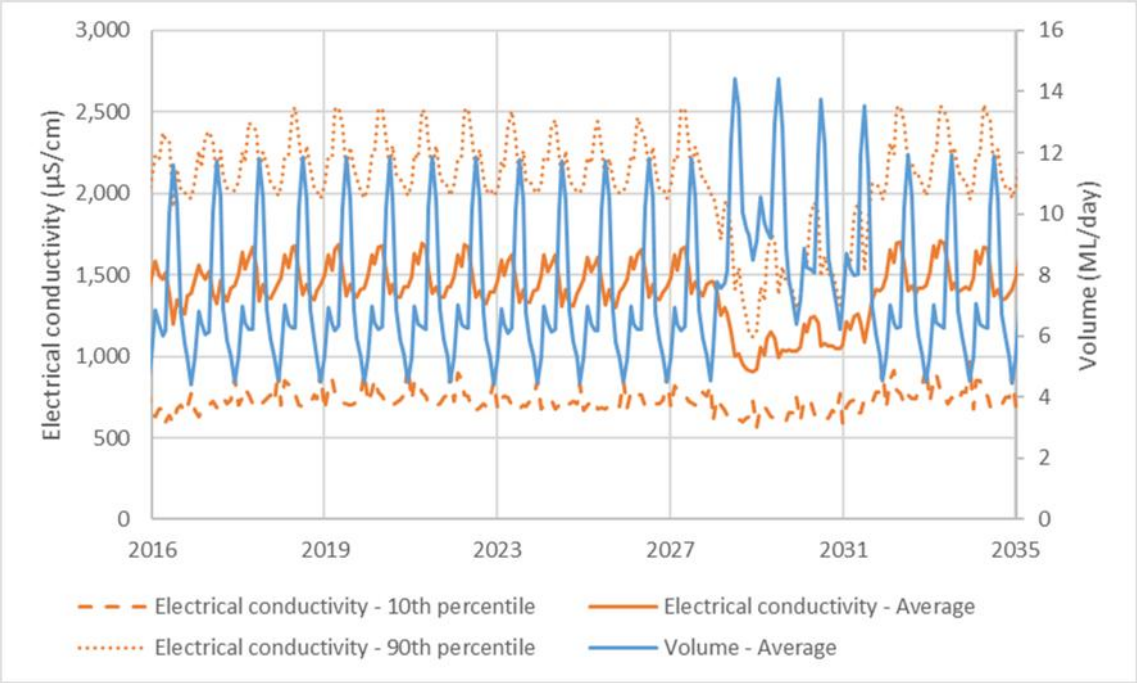


Figure 6-37 Scenario 3 – Predicted EC of Wangcol Creek at LDPs

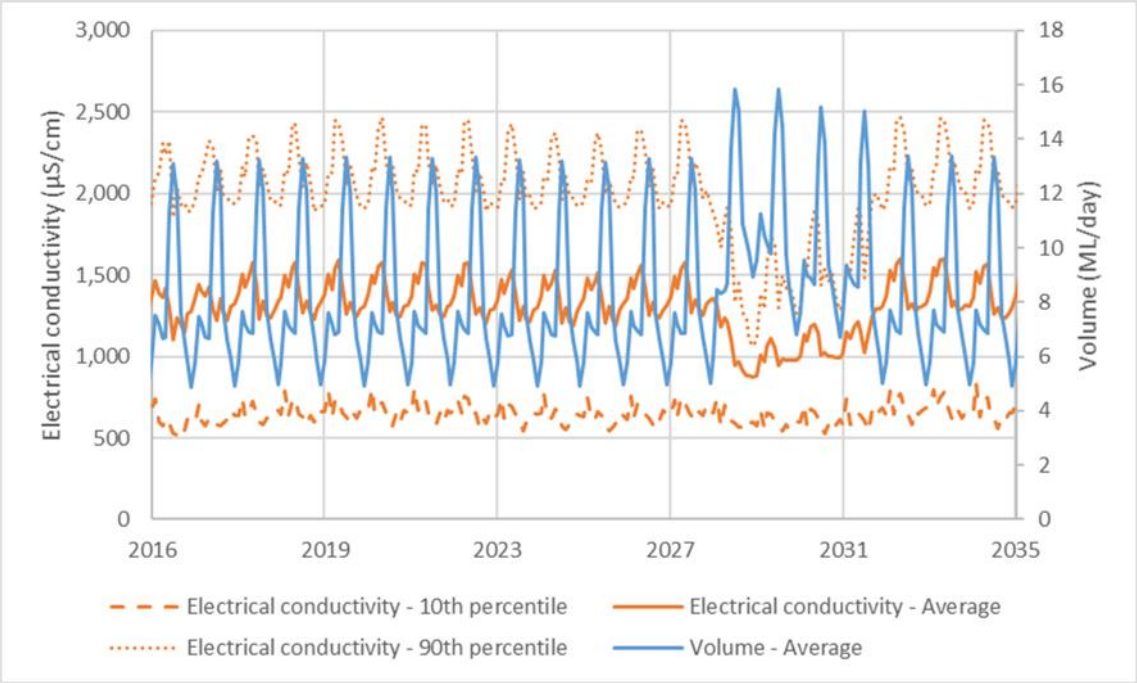


Figure 6-38 Scenario 3 – Predicted EC of Wangcol Creek at the confluence with the Coxs River

Predicted LDP009 discharge, modelled with an EC of 1,170 µS/cm, ceased from June 2017 when the Project was assumed to commence, as shown in Figure 6-39.

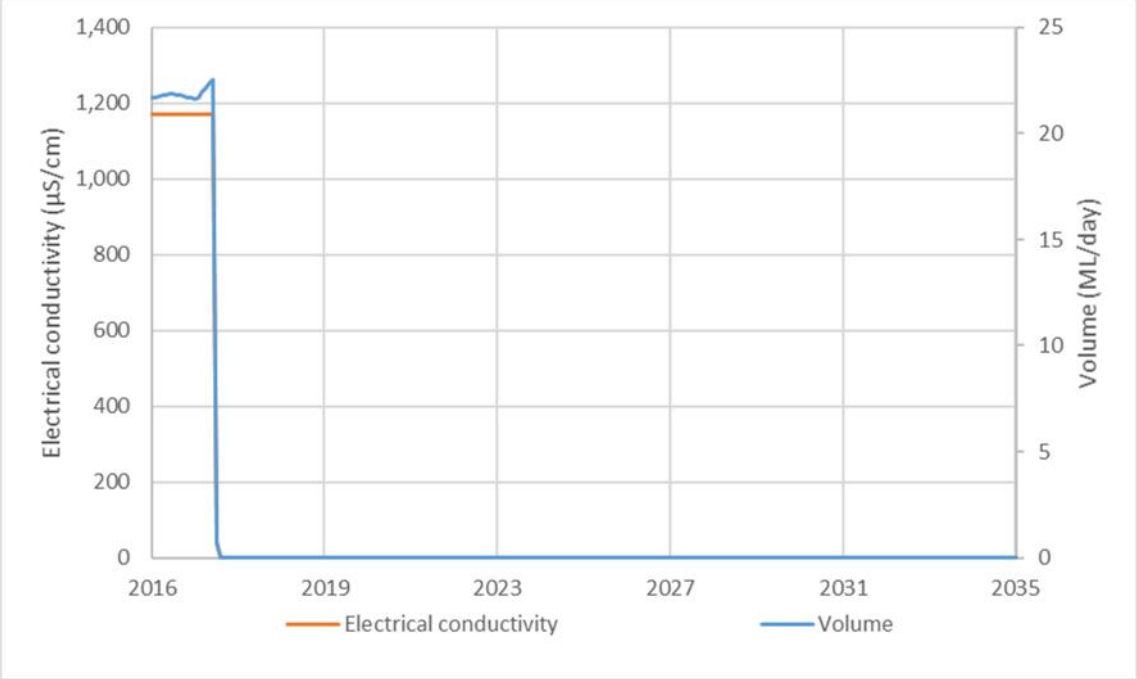


Figure 6-39 Scenario 3 – Predicted EC of LDP009 discharge to Sawyers Swamp Creek

The modelled EC of Sawyers Swamp Creek at the confluence with the Coxs River is presented in Figure 6-40. Following the commencement of the Project in June 2017 and the subsequent cessation of discharges via LDP009, the EC of Sawyers Swamp Creek was modelled to reduce to between 111 µS/cm and 120 µS/cm on average. After the rehabilitation of Sawyers Swamp Creek Ash Dam in 2020, the flow within Sawyers Swamp Creek was estimated to have an EC of approximately 95 µS/cm to 103 µS/cm on average.

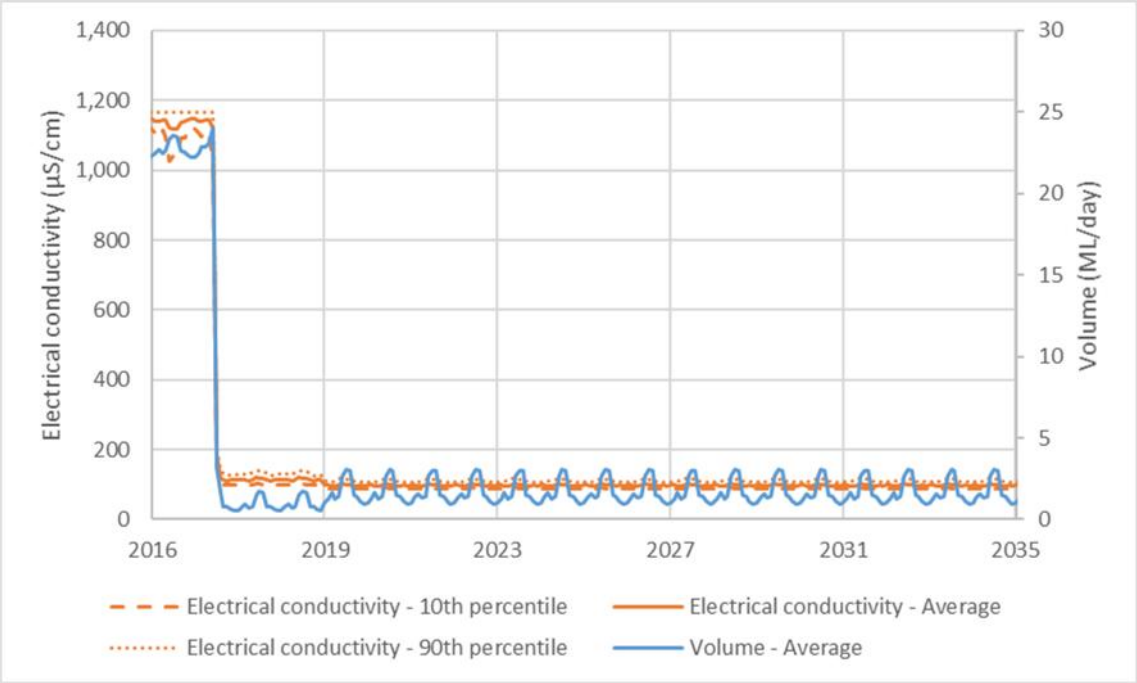


Figure 6-40 Scenario 3 – Predicted EC of Sawyers Swamp Creek at the confluence with the Coxs River

Figure 6-41 presents the modelled EC of inflows to Lake Wallace. The downward trend in the EC of inflows to the lake is attributed to the cessation of discharges at LDP009, which allows the contribution of relatively low EC catchment runoff to have a greater influence on the EC. At the end of the simulation period in 2035, the average EC of inflows to Lake Wallace was found to be approximately 320 µS/cm, ranging between 247 µS/cm (10th percentile) and 395 µS/cm (90th percentile).

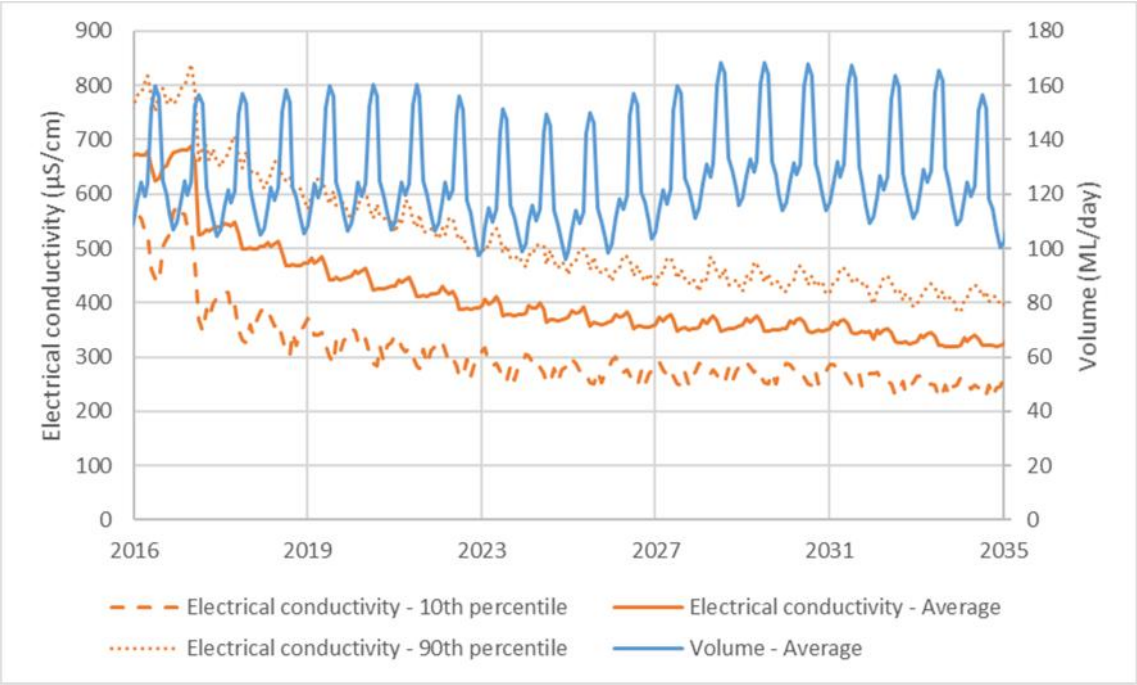


Figure 6-41 Scenario 3 – Predicted EC of flow from the Coxs River to Lake Wallace

The EC of inflows to Lake Lyell presented in Figure 6-42 modelled the same downward trend as the EC of Coxs River flows into Lake Wallace. At the end of the simulation period in 2035, the average EC of inflows to Lake Lyell was found to be approximately 311 µS/cm, ranging between 240 µS/cm (10th percentile) and 377 µS/cm (90th percentile). The EC is slightly decreased compared to the do nothing scenario, due to the absence of LDP009 discharges within the system following the commencement of the Project.

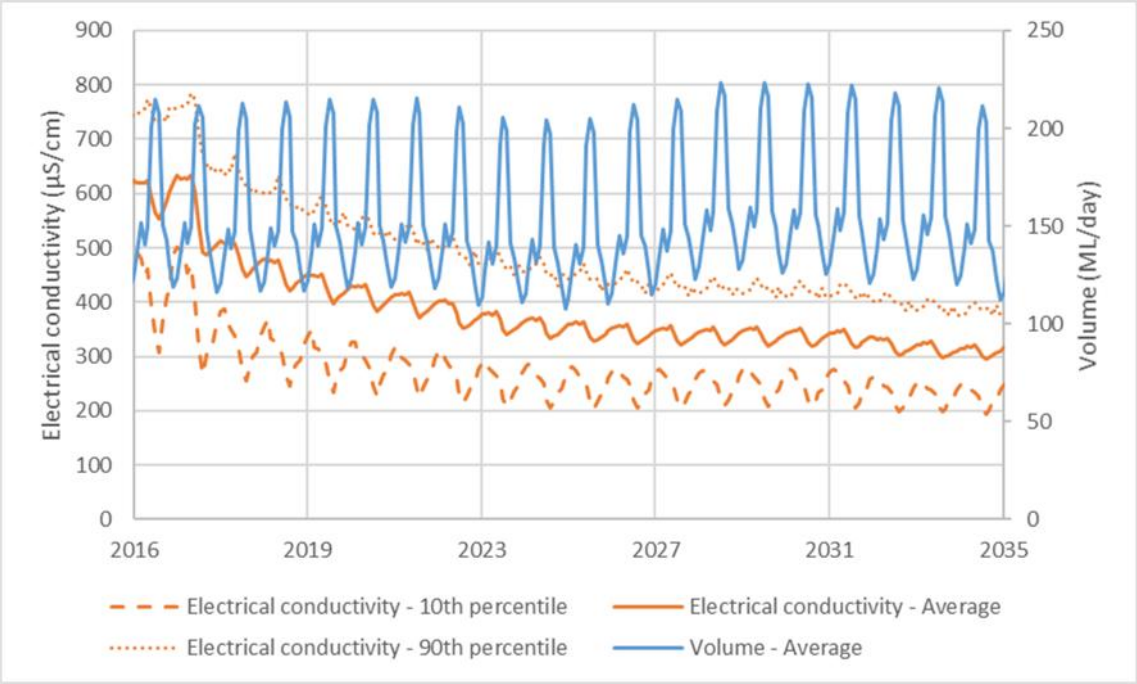


Figure 6-42 Scenario 3 – Predicted EC of flow from the Coxs River to Lake Lyell

Figure 6-43 provides the modelled EC of the inflow from the Coxs River catchment to Lake Burragorang, which was found to be approximately 112 µS/cm at the end of the simulation period in 2035. The modelled EC ranged from approximately 49 µS/cm (10th percentile) and 137 µS/cm (90th percentile) due to the variation in rainfall contributing to catchment runoff. The cessation of LDP009 discharges associated with the Project resulted in a slight decrease in the EC of Coxs River flow into Lake Burragorang.

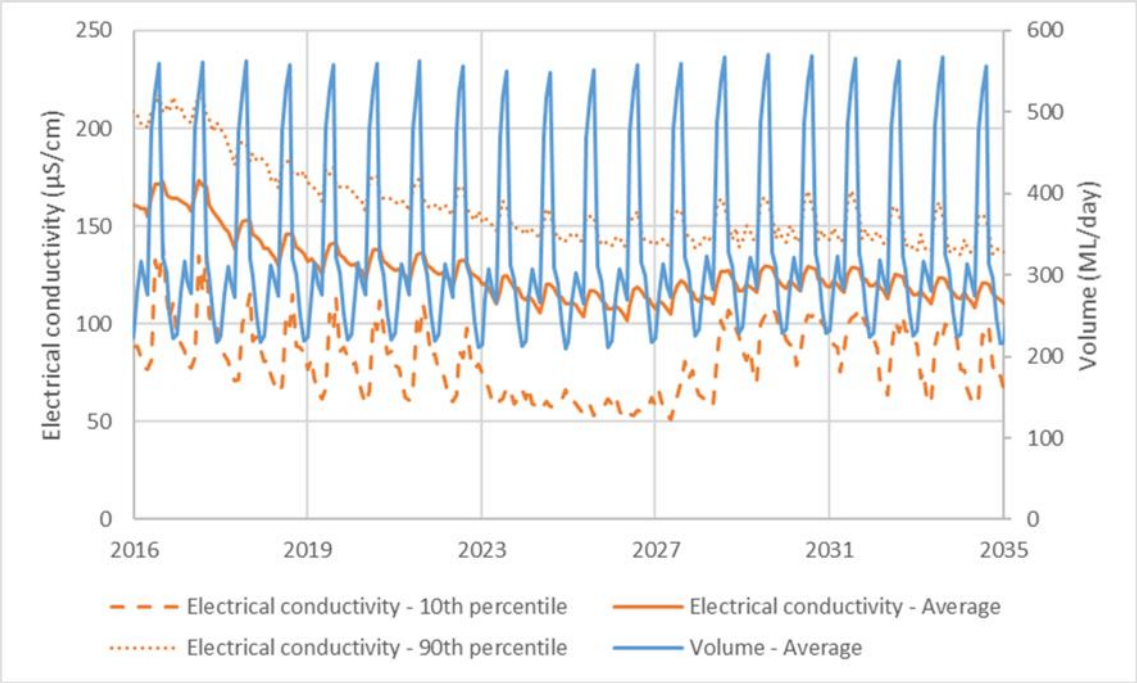


Figure 6-43 Scenario 3 – Predicted EC of flow from the Coxs River to Lake Burragorang

6.2.3 Summary

Summaries of the change in average results between existing conditions in 2016 and proposed conditions in 2030 for the water and salt balance are provided in Table 6-5 and Table 6-6 respectively. For the proposed conditions, results are presented for Scenario 3 and the do nothing scenario. All results are based on a 50% power generation requirement at MPPS. Note that slight differences in modelling results are attributed to an extra day of simulation represented under existing conditions compared to proposed conditions.

As shown in Table 6-5, the Project is proposed to increase the flow in Wangcol Creek at the confluence with the Coxs River by 35% on average compared to both existing conditions and the do nothing scenario. This is as a result of discharges through the proposed LDP as well as an increase in the discharge from LDP006 associated with the transfer of residual material from the Project to the SCSS. The EC in Wangcol Creek was predicted to decrease slightly as a result of the proposed LDP discharge, which was modelled to be relatively low compared to discharges from the SCSS via LDP006.

The cessation of discharges from LDP009 to Sawyers Swamp Creek modelled in Scenario 3 was predicted to decrease flow within the creek by between 93% and 95% and EC by 90%, compared to the results for existing conditions and the do nothing scenario.

For the results for proposed conditions modelled in Scenario 3, inflows to Lake Wallace, Lake Lyell and Lake Burragorang from the Coxs River were predicted in increase slightly, compared to existing conditions, and decrease slightly, compared to the do nothing scenario. This is due to the increase in the mine water make transferred to the SDWTS under proposed conditions (Scenario 3 and do nothing scenario) compared to existing conditions, which is modelled to be used by MPPS in Scenario 3. The EC of the Coxs River at the inflow to the surface water storages is predicted to decrease for Scenario 3 compared to both existing conditions and the do nothing scenario, as shown in Table 6-6. This occurs as a result of the treatment of mine water make using RO processes to decrease EC as part of the Project, compared to the modelled discharge of LDP009 to Sawyers Swamp Creek.

Table 6-5 Summary of change in water volume results under proposed conditions

Location	Existing conditions (ML/year)	Do nothing scenario (ML/year)	Scenario 3 (ML/year)	Change between Scenario 3	
				Existing conditions	Do nothing scenario
Wangcol Creek at confluence with Coxs River	2,900.1	2,893.7	3,912.8	35%	35%
Sawyers Swamp Creek at confluence with Coxs River	8,315.7	13,215.7	617.9	-93%	-95%
Coxs River flow to Lake Wallace	46,586.3	50,917.3	49,467.3	6%	-3%
Coxs River flow to Lake Lyell	57,025.2	61,280.6	59,830.6	5%	-2%
Coxs River flow to Lake Burragorang	123,723.4	127,981.8	126,644.9	2%	-1%

Table 6-6 Summary of change in electrical conductivity results under proposed conditions

Location	Existing conditions (µS/cm)	Do nothing scenario (µS/cm)	Scenario 3 (µS/cm)	Change between Scenario 3	
				Existing conditions	Do nothing scenario
Wangcol Creek at confluence with Coxs River	920	920	850	-8%	-8%
Sawyers Swamp Creek at confluence with Coxs River	1,130	1,120	110	-90%	-90%
Coxs River flow to Lake Wallace	590	650	340	-42%	-48%
Coxs River flow to Lake Lyell	510	570	300	-41%	-47%
Coxs River flow to Lake Burragorang	170	190	140	-18%	-26%

6.3 Catchment hydrology and hydraulics

6.3.1 Hydrology

Wangcol Creek

The hydrology model was modified to consider a discharge of up to 32 ML/day under proposed conditions from the proposed LDP, adjacent to the existing LDP006 discharge from the SCSS. Table 6-7 presents the results from the hydrology model for the 1 year, 10 year and 100 year ARI events as well as the 200 year and 500 year ARI events, to consider the influence of climate change on the hydrology of Wangcol Creek, and an extreme event of three times the 100 year ARI event.

Table 6-7 Results of hydrological model for proposed conditions

Event	Wangcol Creek gauge		Confluence with Lamberts Gully		Outlet of Wangcol Creek	
	Flow rate (m^3/s)	Storm duration (hours)	Flow rate (m^3/s)	Storm duration (hours)	Flow rate (m^3/s)	Storm duration (hours)
1 year ARI	25.0	12	33.6	24	38.5	48
10 year ARI	66.4	2	83.0	2	93.8	6
100 year ARI	119.2	2	144.0	2	155.5	2
200 year ARI	137.0	2	166.6	2	179.4	2
500 year ARI	161.5	2	198.4	2	213.0	2
Extreme event (3 x 100 year ARI)	438.5	2	539.9	2	570.9	2

From Table 6-7 the results indicate a minimal change in peak flow rates and no change in the critical storm duration creating the peak compared to the results for existing conditions presented in Table 5-7. For the 100 year ARI event modelled, an increase in flow rate of approximately 0.4 m^3/s was predicted as a result of the discharge of up to 32 ML/day from the proposed LDP. The effects of the discharge from the proposed LDP of an increase in flow rate of approximately 0.4 m^3/s were maintained for the 200 year and 500 year ARI events and the extreme event modelled.

Figure 6-44 presents the comparison between the existing and proposed hydrographs for the 1 year and 100 year ARI events. The results presented in Figure 6-44 are consistent with the other reporting locations from the model downstream of the proposed LDP, with minor changes to peak flow rate and duration of the hydrograph.

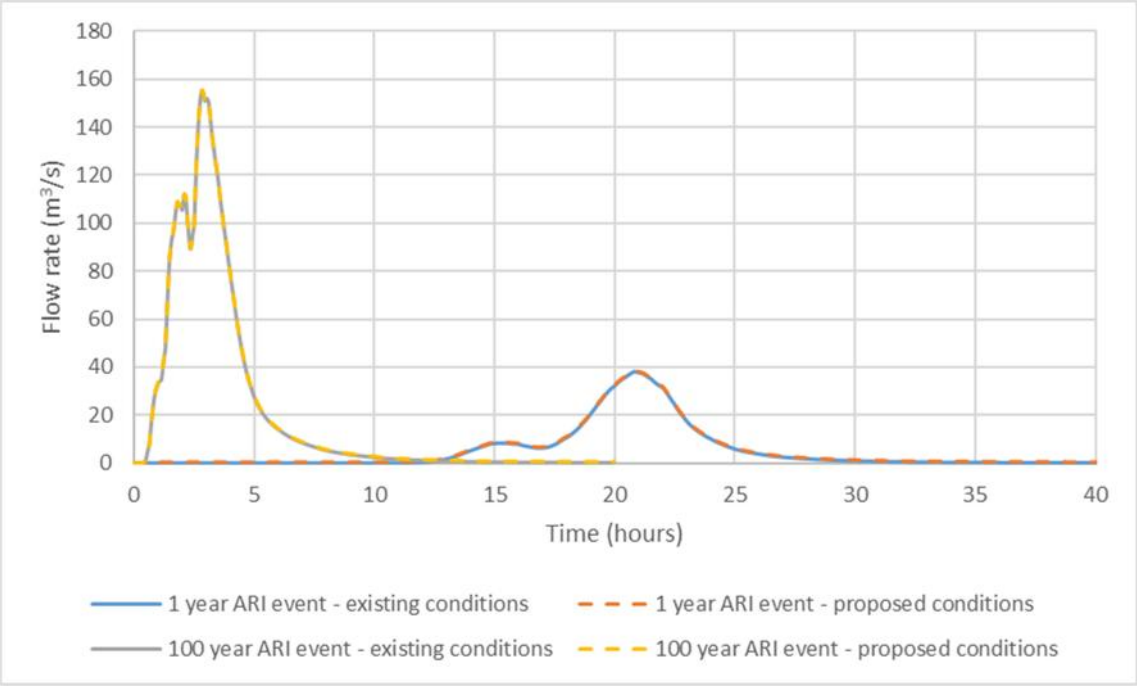


Figure 6-44 Hydrographs for peak 1 year and 100 year ARI events for Wangcol Creek under existing and proposed conditions

Catchment development

At the location of the proposed WTP, it is estimated that the infrastructure will introduce approximately 27 ha of impervious area into the existing water management system of MPPS, assuming 60% development area of the total 45 ha site.

Hydrological modelling of the catchment at the location of the proposed WTP was undertaken to quantify the change to total runoff volumes for a 10 year ARI event. It is estimated that under existing conditions, the development site for the WTP will contribute a peak runoff of 2.1 m^3/s in a six-hour event. The development of the site was predicted to increase peak runoff to the existing water management system to 6.4 m^3/s and increase the critical duration from six hours to a two-hour event. The attributable peak volume of stormwater for management is 967 m^3 in a 10 year ARI event. The additional volume predicted from the development of catchment is likely to be managed downstream of the site within the existing MPPS water management system, which is discussed in Section 5.1.1.

6.3.2 Hydraulics

Hydraulic modelling was undertaken considering the predicted discharge of up to 32 ML/day from the proposed LDP as a result of the Project. The hydraulic results for a baseflow scenario, 1 year, 10 year and 100 year ARI events are provided in Table 6-8. A comparison of the results between the proposed and existing conditions is presented in Table 6-9.

As shown in Table 6-9, the greatest change in results between existing and proposed conditions was found in the baseflow scenario. This is primarily due to this scenario being the most significant flow change with existing conditions estimated at 0.014 m^3/s (1.22 ML/day) and proposed conditions at 0.384 m^3/s (baseflow with the additional 32 ML/day modelled from the proposed LDP).

Table 6-8 Results of hydraulic model of Wangcol Creek for proposed conditions

Event	Wangcol Creek gauge			Access road at the SCSS			Midway down Wangcol Creek			End of Wangcol Creek		
	Flow depth		Average velocity	Flow depth		Average velocity	Flow depth		Average velocity	Flow depth		Average velocity
	m	m AHD	m/s	m	m AHD	m/s	m	m AHD	m/s	m	m AHD	m/s
Baseflow*	0.05	903.05	0.17	0.08	900.08	0.85	0.09	894.09	0.71	0.26	889.26	0.25
1 year ARI	1.25	904.25	1.08	1.25	901.25	1.92	1.37	895.37	1.37	2.09	891.09	0.86
10 year ARI	1.79	904.79	1.42	1.56	901.56	2.30	2.26	896.26	1.01	3.11	892.11	1.12
100 year ARI	2.27	905.27	1.70	1.83	901.83	2.52	2.82	896.82	1.03	3.97	892.97	1.23

Table 6-9 Change in results of hydraulic model for Wangcol Creek as a result of proposed conditions

Event	Wangcol Creek gauge			Access road at the SCSS			Midway down Wangcol Creek			End of Wangcol Creek		
	Flow depth		Average velocity	Flow depth		Average velocity	Flow depth		Average velocity	Flow depth		Average velocity
	m	m AHD	m/s	m	m AHD	m/s	m	m AHD	m/s	m	m AHD	m/s
Baseflow*	0.00	0.00	0.00	+0.07	+0.07	+0.48	+0.08	+0.08	+0.43	+0.21	+0.21	+0.20
1 year ARI	0.00	0.00	0.00	+0.01	+0.01	0.00	+0.01	+0.01	0.00	+0.01	+0.01	0.00
10 year ARI	0.00	0.00	0.00	0.00	0.00	+0.02	+0.01	+0.01	0.00	0.00	0.00	0.00
100 year ARI	0.00	0.00	0.00	0.00	0.00	+0.01	0.00	0.00	0.00	0.00	0.00	+0.01

Figure 6-45 presents the longitudinal profile of Wangcol Creek with the water surface elevation of existing (BF) and proposed baseflow (PBF) scenarios provided. Figure 6-45 also presents the average velocities for both scenarios. Figure 6-45 indicates minimal change in water surface elevation over the length of Wangcol Creek at a rate of 32 ML/day discharged via the proposed LDP. Velocities were determined to vary between the two scenarios from 0.14 m/s to 0.3 m/s across the length of Wangcol Creek.

Other assessed events had minor changes in hydraulic conditions and hence are unlikely to change existing flood extents that were presented in Figure 5-17.

Pipeline off escarpment

The proposed northern alignment of the pipeline will traverse a tributary of Sawyers Swamp Creek which comes from the Newnes Plateau. The estimated catchment of the tributary is 49 ha. The assessment of the flow path for a peak 100 year ARI event was considered using Manning's equation and two typical sections of the gully down the tributary's flow path. The average grade of the tributary is approximately 13% with a regular grade to the base of the plateau where the tributary joins with another arm of Sawyers Swamp Creek.

The water depth down the tributary that the pipeline is proposed to be located on was estimated at 1.2 m to 1.6 m with a flow top width of 12.5 m to 24.4 m. At the time of site inspection of the easement, there was no indication that flow velocities were such that erosion was a risk to be considered. Typically, the roughness of the gully, due to dense vegetation and thick material on the floor, was significant enough to influence the continuity of flow. The pipeline corridor is likely to be cleared to enable the construction along the northern alignment. In this scenario, avoidance of clearing vegetation within the base of the gully would be considered to mitigate potential impacts on the tributary water quality and flow conveyance.

Figure 6-46 presents the typical layout of the northern pipeline alignment as it is proposed down a tributary of Sawyers Swamp Creek.

The consideration of hydraulic performance within the proposed southern pipeline alignment was reviewed. The existing southern route is located along the elevated sections of the Newnes Plateau with the crossing of numerous gullies. One gully is significantly graded at 17%. The hydraulic performance of the pipeline easement was qualitatively and visually assessed with all access tracks located at grade through the drainage gullies. The predicted impacts of the southern route are more likely to be associated with management of *in situ* material stability rather than the conveyance of flow.

Culverts and other crossing structures

The culverts and other crossing structures located along Wangcol Creek were assessed for maximum conveyance capacity as part of the existing conditions. This indicated that the majority of the culverts currently present in the Wangcol Creek catchment, downstream of the proposed LDP, have a conveyance capacity greater than the predicted discharge of up to 32 ML/day. One structure was deemed to have a much lower capacity than the others assessed located approximately 1,695 m downstream from the SCSS entry and proposed discharge location. This culvert structure is located for a light vehicle access road within Pine Dale Coal Mine. As part of the Project, to maintain the existing flow conveyance through Wangcol Creek of between 20 m^3/s to 30 m^3/s, the upgrade or removal of this structure will be proposed.

It must be noted that the estimated capacity of culvert structure's present within Wangcol Creek, downstream of the proposed discharge location, are likely only to service the flow of a 1 year ARI event or less.

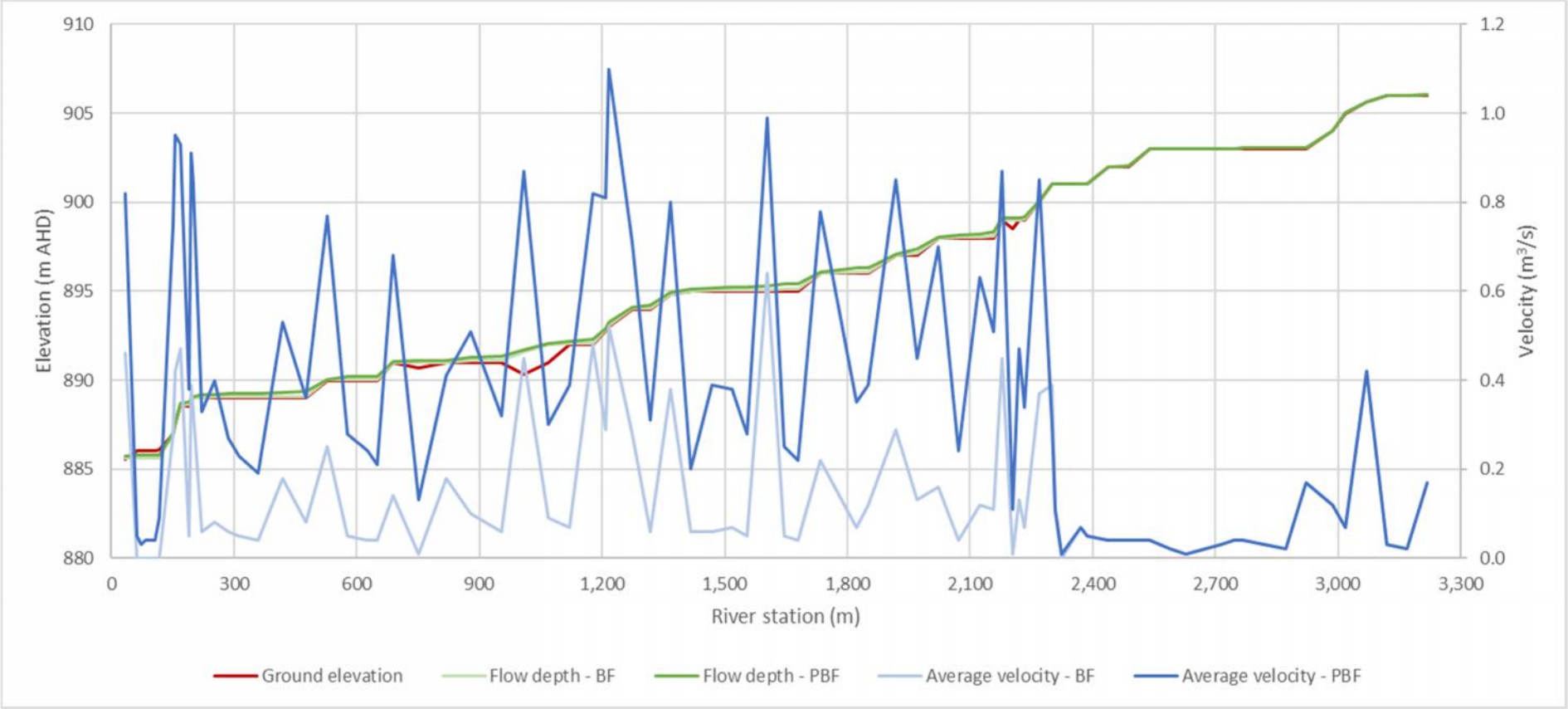
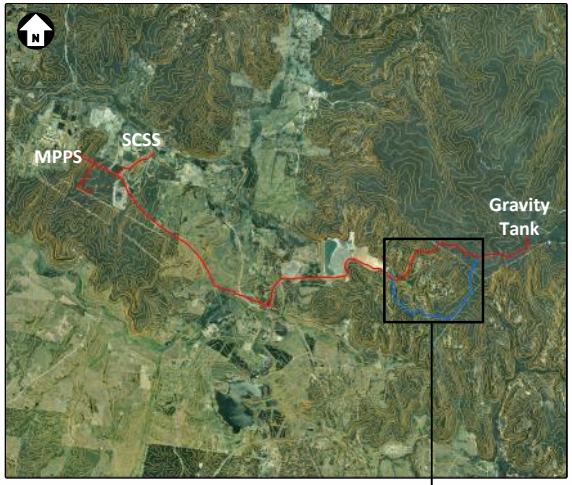
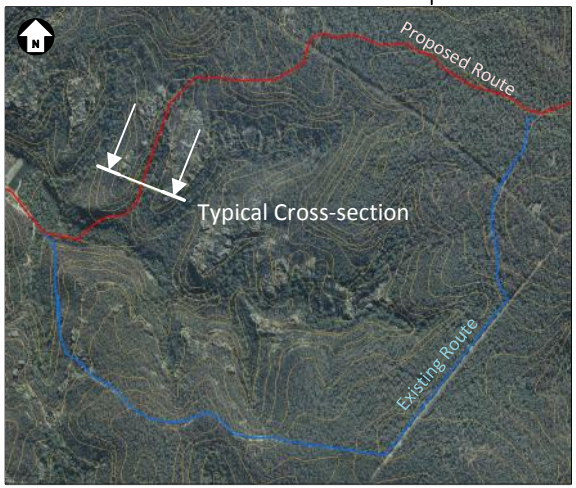


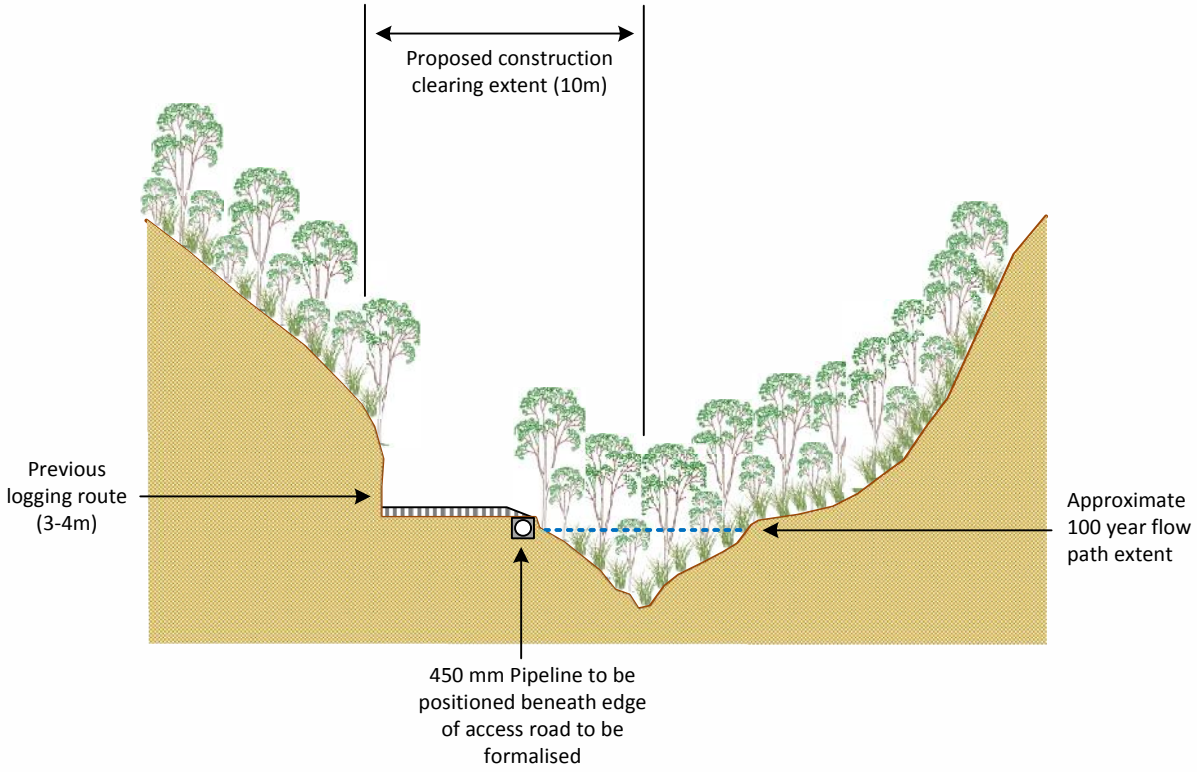
Figure 6-45 Water level and velocity results for Wangcol Creek predicted for baseflow conditions



Proposed Pipeline Alignment Overview



Detail Plan of Pipeline Options



Typical Cross Section of Proposed Pipeline Route

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LOCATION	SCS
SEAM	NA
DRAWN	SM
CHECKED	LH
APPROVED	SG
SCALE	NTS

Centennial Coal
EA/CEY Water Treatment Project
Water Resources Impact Assessment

Proposed pipeline alignment off the Newnes Plateau

Centennial Coal
EnergyAustralia

DATE Aug 2016

Figure 6-46

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6.4 Waterway geomorphology

Identified potential impacts on the geomorphology of waterways as discussed further in the following sections include:

- Channel adjustments along Wangcol Creek downstream of the proposed LDP in response to an increase in the duration of higher magnitude discharges to the creek.
- Direct disturbance to the bed and banks of watercourses as a result of construction of the proposed pipeline.

Works will also be required as a result of the Project around the interface between Lamberts Gully and Wangcol Creek to transition flows in a more controlled manner from LDP006 and the proposed LDP to the channel of Wangcol Creek. These works will address the existing channel incision processes in this area and are therefore considered to have a positive impact on waterway geomorphology and downstream water quality.

6.4.1 Discharge impacts on Wangcol Creek

Based on the hydraulic model results (see Section 6.3.2), flow velocities for the maximum discharge rate of 32 ML/day from the proposed LDP during baseflow conditions in Wangcol Creek generally lie between 0.5 m/s and 1.0 m/s. This is below the velocity threshold of 1.1 m/s for erosion of clay and alluvial silt materials (Fischenich, 2001). However, these modelled values are average values and it is likely there will be localised exceedances of the erosion threshold.

Fischenich (2001) stresses that published erosion thresholds are typically based on studies using short flow durations and do not reflect the erosion potential that can result from discharges maintained at a constant rate over long durations. Further, the increase in the duration and frequency of inundation as a result of proposed LDP discharge may result in changes in the type and extent of fringing vegetation cover. Loss of fringing vegetation due to long periods of inundation, particularly along the toe of banks and across low benches and bars, will expose the underlying sediments to potential erosion during higher magnitude flows.

It is therefore likely that potential channel adjustment risks will arise with a flow rate maintained over long durations at or close to the maximum discharge rate predicted for the proposed LDP. However, discharges to Wangcol Creek as a result of the Project will vary daily to seasonally depending on power generation requirements at MPPS, with discharges on average being much less than the maximum predicted discharge rate. Given this, widespread and systemic channel adjustment along Wangcol Creek downstream of the existing LDP006 and the proposed LDP is not expected to occur as a result of the Project.

Instead, the nature of any channel adjustments is most likely to be limited to localised erosion of the toe of banks. The location, severity and extent of any potential bank erosion will depend on the local channel morphology and existing vegetation associations at any point along the waterway. Steep, unvegetated banks on the outside of bends composed of dispersive and/or unconsolidated materials are most likely to be at risk of any additional erosion in response to the modified discharge regime. However, such banks are already experiencing erosion under the present flow regime. As such, predicting or quantifying the additional bank erosion as a result of the Project is considered impossible with any degree of reasonable certainty.

Therefore, the modified flow regime as a result of the Project presents an unquantifiable risk of localised bank erosion along Wangcol Creek downstream of the proposed LDP. The importance of this erosion risk will be greatest where assets are or could become threatened by additional erosion. These assets include a number of vehicle crossings (bridges and culverts) which have adequate scour protection and are unlikely to be impacted by the modified discharge regime. Additionally, there is a power line easement which crosses Wangcol Creek in reach WC2. At this location, a power pole is located adjacent to top of the channel bank with the bank showing evidence of past ongoing erosion, as shown in Figure 6-47. As a result, the power pole is considered to be at risk under existing conditions and this may be exacerbated as result of the Project.



Figure 6-47 Upstream view of Wangcol Creek displaying power pole located near the top of bank

The potential for erosion along Wangcol Creek downstream of the proposed LDP to impact on the Castlereagh Highway is considered extremely low as the channel is located at least 55 m from the highway at its closest point.

6.4.2 Pipeline

For construction of the proposed pipeline across the Coxs River, horizontal directional drilling (HDD) techniques are proposed. Given the channel of the Coxs River at the proposed crossing point exhibits outcropping sandstone bedrock in the bed and banks, crossing using HDD is not expected to result in any adverse impact to the geomorphology of the river.

Elsewhere, construction of the proposed pipeline will generally involve standard open cut trenching techniques. Impacts associated with trenching pipeline crossings of watercourses may include:

- Disturbance to bed and banks of watercourse channels.
- Stream bed degradation.
- Stream bank erosion.

Typically, the pipeline alignment runs approximately perpendicular to waterways and the potential for ongoing erosion risks at crossing locations can be managed using appropriate stabilisation and rehabilitation techniques. However, the proposed pipeline alignment is set within the narrow valley floor of a steep tributary of Sawyers Swamp Creek for a distance of approximately 650 m. The alignment of the pipeline being parallel to the direction of flow within the valley, in combination with the steep grades of up to 15%, presents a risk of gully erosion being initiated along the disturbance corridor. The potential for this risk to be realised will be most dependent on the actual placement of the pipeline within the valley floor. An alignment that is generally clear of the regular flow path along the length of the valley will present a lower risk of gully erosion to be initiated.

6.5 Erosion and sediment control

The impacts on soil will be mitigated through the application of erosion and sediment controls during construction. Areas of disturbance during construction will be required to be rehabilitated except in those areas where access roads are being established. In the event that access routes are required along sections of pipeline, the establishment of an 8% to 10% gradient threshold will be considered for unsealed access roads.

The soils of highest erosion risk, which were defined in Section 5.5, will require increased efforts in staging and rehabilitation works. Pipeline construction will involve:

- Surface installations (above and trenched).
- Bored using HDD.

As part of pipeline construction, erosion and sediment controls will be employed locally to each section, specifically focused on the nature of installation being undertaken and the length of disturbance.

Specific erosion and sediment control measures to be implemented as part of construction of the Project are discussed further in Section 9.2.5.

6.6 Surface water quality

6.6.1 Treatment water quality

The predicted discharge concentrations from the WTP were discussed as part of the technical specification for a limited number of parameters. This indicated that for metals, the treatment process will achieve a minimum of 90% treatment efficiency. For EC, to achieve 500 µS/cm, a treatment efficiency of at least 61% is required. Based on the treatment efficiency, the evaluation of predicted effluent water quality was considered. This was then considered as an annual load, averaged for different discharge rates, as presented in Table 6-10.

Table 6-10 Proposed treatment water quality

Parameter	Predicted average annual load at 5 ML/day[a]	Predicted average annual load at 30 ML/day	Predicted average annual load at 32 ML/day
Physicochemical parameters			
TDS	522,425 t/year	3,134,547 t/year	3,343,517 t/year
Nutrients			
Ammonia	86 t/year	515 t/year	14,834 t/year

Parameter	Predicted average annual load at 5 ML/day[a]	Predicted average annual load at 30 ML/day	Predicted average annual load at 32 ML/day
Total nitrogen	164 t/year	986 t/year	1,413 t/year
Anions			
Chloride	1,825 t/year	10,950 t/year	11,680 t/year
Cations			
Calcium	1,825 t/year	10,950 t/year	11,680 t/year
Sodium	47,998 t/year	287,985 t/year	307,184 t/year
Potassium	2,008 t/year	12,045 t/year	12,848 t/year
Dissolved metals			
Aluminium	18 t/year	110 t/year	117 t/year
Arsenic	3 t/year	18 t/year	19 t/year
Barium	4 t/year	24 t/year	26 t/year
Boron	91 t/year	548 t/year	584 t/year
Lithium	27 t/year	161 t/year	172 t/year
Manganese	2 t/year	11 t/year	12 t/year
Molybdenum	8 t/year	47 t/year	50 t/year
Nickel	18 t/year	110 t/year	12 t/year
Rubidium	2 t/year	11 t/year	12 t/year
Strontium	3 t/year	19 t/year	20 t/year
Zinc	9 t/year	55 t/year	58 t/year
Total metals			
Arsenic	4 t/year	27 t/year	29 t/year
Manganese	2 t/year	11 t/year	12 t/year
Zinc	9 t/year	55 t/year	58 t/year
Other			
Fluoride	219 t/year	1,314 t/year	15,418 t/year

a Representative of a 40% to 50% power generation requirement at MPPS.

When compared to existing load from mine water discharged via LDP009, the predicted improvement at the proposed LDP is expected to between 17% to 90% for the parameters outlined in Table 6-10. The final resultant water quality to be discharged via the proposed LDP will be confirmed as a part of a commissioning report to be completed following completion of construction of the WTP.

As a result of the RO treatment process, treated water discharged to the environment has a risk of creating a toxic environment due to the low EC and deficiency of major ions that are vital for aquatic life. The proposed configuration of the WTP will blend treated water and higher EC water within a recirculation process. This process optimises the WTP's efficiency and will mitigate water quality risks relating to low EC water. The continuation of discharges via LDP006 at a low rate is likely to also contribute to the amelioration of toxic effects.

Given that the nature of discharges via the proposed LDP cannot be established until the WTP is constructed, the confirmation of the quality of treated water and the result of mixing with LDP006 discharge will be undertaken as part of commissioning works following completion of construction of the WTP. Ecotoxicology testing can be undertaken if required at this time to confirm potential aquatic ecology impacts.

6.6.2 Guideline values

Derivation of site-specific guideline values

SSGVs have been derived for the Project based on a review of the DGVs presented by ANZECC (2000a) and the 80th percentile values for water quality data collected at monitoring location SW1. Table 6-11 presents the recommended SSGV, as well as the DGVs and 80th percentile results for SW1.

The 80th percentile values for water quality data at SW1 have been calculated from the entire dataset available between March 2012 and February 2015. As samples have been collected for over two years, the dataset covers a range of seasonal, climatic and flow conditions.

Table 6-11 Recommended guideline values for the Project

Parameter	Units	DGV (ANZECC, 2000a)	SW1 80th percentile	Recommended SSGV	Comment
Physicochemical parameters					
EC	µS/cm	350	100	500	Based on conditions of SSD-5594 for mine water discharges.
pH	pH units	6.5–9.0	6.4–7.1	6.5–9.0	
TSS	mg/L	25	12	25	
Turbidity	NTU	25	35	35	
Nutrients					
Ammonia	mg/L	0.9	0.03	0.9	

Parameter	Units	DGV (ANZECC, 2000a)	SW1 80th percentile	Recommended SSGV	Comment
Total nitrogen	mg/L	0.25	0.5	0.5	
Total phosphorus	mg/L	0.02	0.08	0.08	
Dissolved metals					
Aluminium	mg/L	0.055	0.24	0.24	
Antimony	mg/L	–	0.001[c]	0.003	ADWG (NHMRC, 2016) value for health used.
Arsenic	mg/L	0.024	0.001[c]	0.024	
Barium	mg/L	–	0.047	0.047	
Boron	mg/L	0.37	0.05	0.37	
Cadmium	mg/L	0.0026[a]	0.0001[c]	0.0026	
Chromium	mg/L	0.001	–	0.001	
Cobalt	mg/L	0.0025	–	0.0025	
Copper	mg/L	0.0014	0.004	0.004	
Iron	mg/L	0.3	0.3	0.3	
Lead	mg/L	0.129[a]	0.001[c]	0.129	
Manganese	mg/L	1.9	0.150	1.9	
Mercury	mg/L	0.0006	0.0001[c]	0.0006	
Molybdenum	mg/L	–	0.001[c]	0.001	
Nickel	mg/L	0.125[a]	0.003	0.003	
Selenium	mg/L	0.011[b]	–	0.011	Applies to total selenium.
Silver	mg/L	0.00005	–	0.00005	
Zinc	mg/L	0.091[a]	0.032	0.091	

[a] DGV modified for hardness.

[b] DGV for total selenium.

[c] LOR.

Derivation of guideline value for electrical conductivity

As part of the response to submissions on the Springvale Extension of Mining Project, the review of EC thresholds was negotiated between Springvale Coal and EPA. This negotiation considered the overall reduction in current salinity contributions to the upper Coxs River catchment from the SDWTS via LDP009. A staged approach was proposed by the EPA to achieve a reduction in the EC of mine water discharges to 700 µS/cm (50th percentile) and 900 µS/cm (90th percentile) leading to 500 µS/cm and ultimately a condition of 350 µS/cm (consistent with the current DGV recommended by ANZECC 2000a). The outcome of the negotiation was the staged approach with the key dates of 30 June 2017 to meet the first criteria and 30 June 2019 to meet the second. The final EC criteria was not agreed to by Springvale Coal and hence a date was not set.

The targets of 500 µS/cm, 700 µS/cm and 900 µS/cm were partially derived from modelling undertaken as part of response to submissions by Jacobs (2015) and a range of water quality and ecotoxicology investigations.

A specific water quality and aquatic ecology investigation was undertaken by OEH in 2011 that was tasked with identifying the influencing factors to the health of the Coxs River. This concluded that, from sampling of 29 waterway sites within the Coxs River catchment, elevated salinity and metal concentrations were present within the Coxs River catchment as a result of mining and power generation land uses with impacts local to those land uses. It was also concluded that nutrients were elevated due to municipal sewage treatment. Generally, a relationship between elevated water quality parameters and the health of aquatic macroinvertebrates was identified. A recommendation was made from the investigation for an interim salinity target level (identified as a key constituent of potential impact) based on published literature and outcomes from the OEH investigation of 500 µS/cm.

It was predicted by Jacobs (2015) that achieving a 900 µS/cm end of pipe limit would match the water quality present within Lake Lyell observed at the time of the assessment. As part of submissions to the Springvale Extension of Mining Project, OEH presented a range of EC criteria derived from species sensitivity distributions from a series of reference projects assessed by Cardno (2010). These criteria are summarised in Table 6-12.

Table 6-12 Reference projects with electrical conductivity criteria

Species protection level	West Cliff Colliery Discharges (Brennans Creek/Georges River)	Tahmoor Colliery (Tea Tree Hollow)	Ravensworth Colliery (Bowmans Creek)
95% protection of species	585 µS/cm	1,000 µS/cm	876 µS/cm
80% protection of species	921 µS/cm	1,146 µS/cm	1,992 µS/cm

The results presented in Table 6-12 indicate some variability to site location and some sensitivities to specific species. As part of the OEH discussion, the identification of toxicity as a function of ionic composition was also made.

An Australian Coal Research Paper (ACARP Project C23010) was prepared in May 2016 which investigated the toxicity of saline solutions with different ionic compositions on freshwater organisms. The outcomes from the investigation were species sensitive distributions for the Georges (Southern Coalfield) and Wollangambe River (Western Coalfield). The calculated concentrations is provided in Table 6-13 for a range of species protection levels.

Table 6-13 Electrical conductivity thresholds from ACARP investigation

Species protection level	Southern Coalfield	Western Coalfield
99% protection of Species	508 µS/cm	549 µS/cm
95% protection of Species	800 µS/cm	901 µS/cm
80% protection of Species	1,229 µS/cm	1,436 µS/cm

From Table 6-13, it is recommended to adopt the 95% protection of species value for the Western Coalfield as an EPL condition for EC. Whilst the consent condition will require the Project to discharge water with a EC less than 500 µS/cm, the environmental harm threshold for EC is recommended to be less than 901 µS/cm.

The DPE Final Assessment report for the Springvale Extension of Mining Project discussed the definition of a beneficial impact. The view was taken that with the concentration limits proposed by the EPA, a 'beneficial' effect is likely to result. This is supported by the predicted outcomes of the water and salt balance, in the event that discharges do occur. The position of the DPE at the time was that a beneficial effect on water quality is best demonstrated through a commitment to reduce salt concentrations rather loads, given that this is what aquatic organisms respond to.

The Project seeks to operate with discharges (when required) of less than 500 µS/cm. Compared to the outcomes of the ACARP paper discussed above this will achieve a species protection of 99% within the Western Coalfield when considering EC in isolation.

6.6.3 WTP hardstand water management

Following the construction of the WTP pad and the stabilisation of the area, surface water runoff will be directed to the existing network of grates and pipes that form the stormwater management system at MPPS. Runoff will ultimately be directed to the Final Holding Pond where it can be reused as make-up water for the cooling water system, pending on the final water quality.

6.6.4 Construction

As part of the construction of the water transfer systems and WTP, temporary risks to surface water quality will exist. Disturbance activities include:

- Clearing vegetation.
- Trenching activities.
- Under-boring and directional drilling.
- Building of infrastructure.
- Construction of surface water storages.

The risks to surface water quality from these disturbance activities will be essentially mitigated through the implementation of erosion and sediment controls which are discussed in Section 9.1.2. There will be no use of drilling fluids as part of under-boring and or directional drilling undertaken for the construction of the pipeline.

6.7 Groundwater

There are unlikely to be any aquifer interference activities as part of the Project. Existing groundwater extraction is undertaken as part of the operations of the SCSS and Springvale Mine and these are managed as part of their respective consents and water management plans.

Trenching and boring activities may intercept shallow groundwater systems such as the alluvial groundwater source of the Coxs River or perched water tables along the pipeline alignment. In the event that groundwater is intercepted, the dewatering of such interceptions will be maintained at a rate less than 3 ML/year, such that a groundwater extraction licence will not be required. In the event that dewatering is required above this rate, then a groundwater extraction licence will be sought; however, this is unlikely to occur.

Groundwater outside of the extents of MPPS and the SCSS is unlikely to be intercepted to any great extent as a result of the Project with pipe trenching to occur within 1 m of the natural surface and typically outside areas of alluvial environments. There is only one exception to this assumption, which is associated with the proposed trenchless crossing of Coxs River.

6.8 Downstream water users

The Project is unlikely to impact downstream water users in both surface and groundwater environments. The Project seeks to improve water quality downstream of the existing mine water discharge via LDP009 and is also unlikely to intercept the groundwater environment through civil works or dewatering.

Based on the search of allotments, two WALs were identified for surface water use that are applicable to allotments that are within the wider water source catchment, however it is unlikely that the Project will impact on these directly as they are located outside of the Wangcol Creek catchment. Specifically, WAL 25659 is allocated to an allotment which is straddled across Wangcol Creek and Pipers Flat Creek and it is unlikely that the Project will impact on this allotment's licensing as its portion within Wangcol Creek catchment is located upstream of the Project.

The operation of the Project is likely to improve water quality and hence the quality of water available by downstream users. In the event that the make-up water demand at MPPS exceed 30 ML/day, it is likely that a net decrease in available water will occur below Lake Lyell.

6.9 Management of waste streams

The Project has two main waste streams as a result of the proposed WTP. These are the continuation of brine emplaced ash which includes the operation of the proposed crystalliser, and the residuals from the WTP.

6.9.1 Pre-treatment residuals

The residuals produced by the pre-treatment process will be a new waste stream from the proposed WTP that will be disposed of in the REA at the SCSS. The co-disposal of the residual stream with reject material within the REA will be compatible with its current design criteria as it is estimated to be a dry solids content of 1.5% (i.e. mostly water). Discharges from residuals pipeline will be spread over multiple points reducing the risk of erosive forces on the material already emplaced. As the transfer will be mostly water, the transferred volume will be decanted from the REA as part of the SCSS operations with some infiltration loss also occurring.

The pre-treatment residuals are likely to be of a typical quality summarised in Table 6-14. Annual flow rates from the treatment plant to the REA are proposed at a maximum rate of 0.43 ML/day.

Table 6-14 Residual stream loads from WTP

Parameter	Median result
Physicochemical parameters	
EC	<2,500 µS/cm
pH	6.5–8.5
TSS	1,386 kg/day
Total metals	
Aluminium	12 kg/day
Arsenic	1.2 kg/day
Boron	2.4 kg/day
Cadmium	0.006 kg/day
Chromium	0.06 kg/day
Copper	0.06 kg/day
Cobalt	0.06 kg/day
Iron	968 kg/day
Lead	0.03 kg/day
Manganese	0.6 kg/day
Mercury	0.003 kg/day
Nickel	0.15 kg/day
Selenium	0.3 kg/day
Zinc	0.6 kg/day

As shown in Table 6-14, the primary loads introduced to the REA, as a result of the residual stream, will be arsenic, boron, nickel and zinc which are consituents from the feed water from the SDWTS and iron which will be elevated due to the use of ferric chloride as a coagulant in the WTP. As the residual stream will contain mostly chemical constiuents in a total proportion, management via a settling process within the REA will entrain the additional loads to the REA within the the existing coal reject material. The risk to the groundwater environment as a result of the transfer of residuals is unlikely to change the existing beneficial use category of the groundwater source due to influencing factors from MPPS and SCSS that have occurred historically.

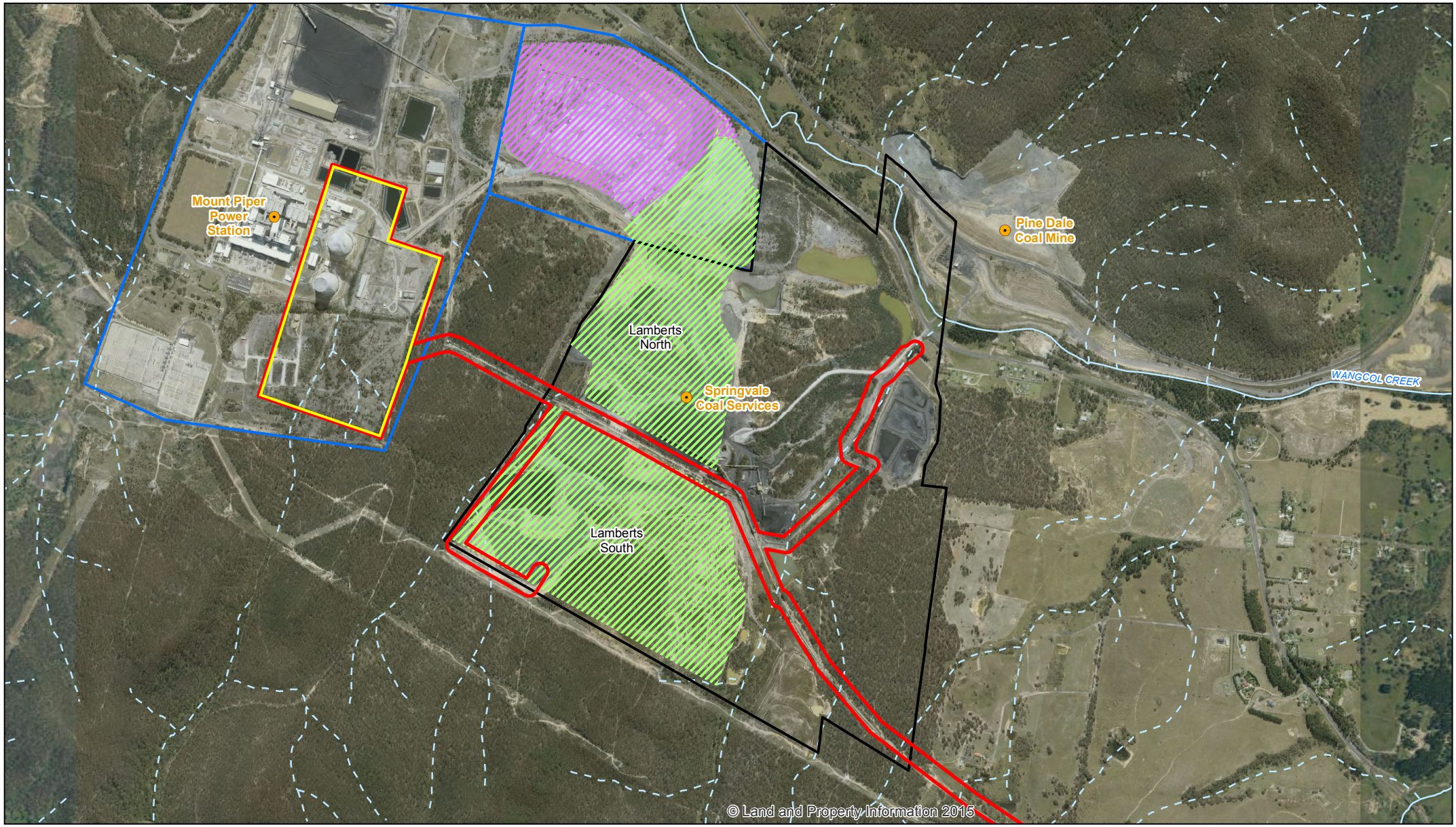
In addition to the above consistuents, the residual will infrequently include chemicals from a RO membrane cleaning process. This will include generic acids and bases (biodegradable and non-toxic) and will be produced at a much lower volume than the overall residual stream. The cleaning solution, once utilised, will be stored and blended with the residual stream as required. The cleaning solution will include trace levels of surfacants and chelating agents dependent upon outcomes to be determined during the commissioning stage.

6.9.2 Water and brine conditioned ash

Ash emplacement has occurred at MPPS since the establishment of the power station. Ash generation from MPPS comprises of both fly ash (approximately 90%) and furnace ash (approximately 10%). The use of water and brine assists in the transport and placement of ash

within the designated ash emplacement area. Project approval was granted for the emplacement of ash in the Lamberts North and South areas as part of Application 09_0186 in February 2012. The two areas of existing and approved ash emplacement are shown in Figure 6-48.

The use of brine for conditioning ash is intermittent and occurs only when the ash is to be directed to an approved co-placement area. The use of brine conditioned ash is undertaken seasonally but is subject to site and operation conditions. Typically, moisture content within emplaced ash is 18% (Connell Wagner, 2007). Co-placement periods will reduce with increased power generation or higher salinity make-up water. During co-placement activities, brine is stored within lined ponds on site (Connell Wagner, 2007).



Paper Size A4

0 0.075 0.15 0.3 0.45 0.6

Kilometers

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

N

LEGEND

- Project application area
- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- Approved ash emplacement area
- Existing ash emplacement area
- Watercourse - Non Perennial
- Watercourse - Perennial

Springvale Coal
Springvale Water Treatment Project
Water Resources Impact Assessment

Job Number 21-25109
Revision 0
Date 10 Aug 2016

Approved ash emplacement areas

Figure 6-48

G:\22\0105001\GIS\Maps\Deliverables\Western\Springvale\2125109\WRIA\10_3\2125109_WRIA025_AshEmplacements_0.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

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Data source: LPI: DTDB/Imagery, 2012, 2015. Created by: tmorton

To characterise potential water quality effects of the ash emplacement, leachate testing of fly ash has been undertaken by CDM Smith (2012) using both freshwater and brine at 1:20 dilution. Two tests were undertaken one a batch test and the other a column leachate test. The results for the batch leachate test are summarised in Table 6-15.

Table 6-15 Batch leachate test results (CDM Smith, 2012)

Parameter*	Result leachate concentrations (mg/L)		
	Rainwater/freshwater (1:20)	Brine (1:20)	Brine result versus rainwater/freshwater
pH	3.7	7.9	+4.2
Aluminium	3.04	0.08	-2.96
Antimony	0.006	<0.005	-0.001
Boron	0.210	1.50	+1.29
Chromium	0.026	0.080	+0.054
Cobalt	0.006	0.060	+0.054
Copper	0.150	<0.005	-0.15
Germanium	0.056	0.050	-0.006
Manganese	0.08	0.220	+0.14
Molybdenum	0.005	0.168	+0.163
Lead	<0.005	<0.005	0.000
Selenium	<0.006	0.007	+0.001
Vanadium	0.016	0.08	+0.064
Uranium	0.0004	0.016	+0.0156
Zinc	0.310	0.1	-0.21

*Assumed that metals are total metal concentrations.

Table 6-15 indicates as a result of batch leachate testing, the following parameters were elevated when brine was used: boron, chromium, cobalt, manganese, molybdenum, vanadium, and uranium.

The results of the column test are presented in Table 6-16.

Table 6-16 Pore volume leachate (CDM Smith, 2012)

Parameter*	Result leachate concentrations (mg/L)		
	Rainwater/freshwater (1:20)	Brine (1:20)	Brine result versus rainwater/freshwater
Initial pore volume			
pH	3.5	7.3	+3.8
Sulfate	0.39	3.2	+2.8
Chloride	<0.1	4,800	+4,799.9
Iron	0.00021	<0.00001	-0.0002

Parameter*	Result leachate concentrations (mg/L)		
	Rainwater/freshwater (1:20)	Brine (1:20)	Brine result versus rainwater/freshwater
Boron	0.008	0.0052	-0.0028
Selenium	0.016	0.052	+0.036
Four pore volumes			
pH	4.7	7.3	+2.6
Sulfate	0.008	0.019	+0.011
Chloride	0.300	0.007	-0.293
Boron	0.00018	0.0002	+0.00002
Iron	0.00004	<0.1	+0.1
Selenium	0.021	0.039	+0.018

*assumed that metals are total metal concentrations

From Table 6-16, concentration of sulfate, chloride and selenium where elevated when brine was applied to the leachate test within the initial pore volume. Following this, four pore volumes were tested which showed that selenium was still elevated along with iron and sulfate, however chloride had reduced substantially due to its non-reactive nature.

As the brine is emplaced with the ash, infiltration of brine occurs into the ash emplacement at a slow rate. Brine will eventually be intercepted by drainage layers at the base of the ash emplacement which will force leachate migration along the base of the coal seam from which the emplacement is largely situated on. Existing groundwater monitoring networks will identify when leachate has reached the groundwater environment and begins influencing groundwater locally.

The emplacement of brine conditioned ash was approved as part of the Lamberts North Ash Placement Project which will continue as part of this Project. The maximum rate of brine produced by the MPPS water cycle following the implementation of the WTP will most likely modify the historical average of between 25 ML/year to 35 ML/year to 11 ML/year to 80.3 ML/year (based on Aurecon 2015 estimates of 0.03 ML/day to 0.22 ML/day for 10% to 100% power generation requirement at MPPS).

The increase in brine generation from the upper power generation percentages is as a result of the utilisation of more saline water from LDP009 compared to that of water sourced solely from the Coxs River via Lake Lyell and Thompsons Creek Reservoir and the Fish River water supply scheme and the duplication of brine generation sources being both the Project and the existing treatment system in place at MPPS. The increase in brine generation will be compensated by a crystalliser plant which will reduce net brine generation to between 4.5 ML/year to 32.1 ML/year (considering a 40% concentration at demands between 10% to 100% power generation requirement at MPPS).

During the period at which brine generation is increased (expected to be less than 18 months during the implementation of a crystalliser system) the deposition rate of brine conditioned ash will increase. The management of the increased rate of ash deposition is to be managed by MPPS as part of their operational variability. Ash emplacement areas are expected to increase over time with the future Lamberts South to commence following completion at Lamberts North. Both these areas provide the maximum approved area for the emplacement of ash. Given the

Lamberts North and South areas are both approved developments, there is no need to modify existing approvals if the management of the area remains unchanged.

The management of existing and proposed brine loads will remain consistent with current management practices. It is predicted that due to the crystalliser, the concentration of brine being generated by the Project could increase. Whether the concentration of salt within the ash being emplaced has increased from the current conditions, the risks associated with the impact to the surface or groundwater environment will remain the same. Salt content within the emplacement should remain within the emplacement only migrating downwards at a slow rate.

Existing mitigation measures for the ash emplacement includes:

- Compaction to 98%–99% of ash material with each 0.5 m lift. Compaction will minimise rainfall infiltration from promoting migration of water through the ash.
- Boundary groundwater monitoring network to identify migration pathways.
- Response plan within existing MPPS water management plans for groundwater migration away from ash emplacement.

Crystalliser

The crystalliser will have two key outputs from its process, a distillate and a concentrate slurry. Typically, these outputs will be a 60/40 split with distillate volume created from 60% of inflow volume and concentrate slurry created from 40% of the inflow volume.

The distillate is to be pumped back into the cooling water system as makeup volume. This water will be low conductivity and hence the water can be reused in the cooling process again. Considering a mass balance approach, given the feed water from the brine concentrator is typically 180,000 mg/L, the concentrate slurry created from the crystalliser is likely to be at a salinity of 500,000 mg/L.

The crystalliser concentrate disposal is proposed to be pumped into an existing ash silo for appropriate placement at a rate required by operational conditions at that time. During periods when concentrate cannot be disposed of in the ash emplacement, concentrate will be stored within lined surface storages constructed as part of the Project. The placement of concentrate will be subject to the same conditions as of the brine conditioned ash currently and hence will present the same environmental risks.

7. Cumulative impacts

7.1 Neutral or beneficial effect

The assessment of NorBE on water quality is undertaken through consultation between WaterNSW and the DPE. As the Minister for Planning is the consent authority for the Project, the assessment of NorBE is at the Minister's discretion. The NorBE guideline (WaterNSW, 2015) provides some guidance to how various projects can be assessed. As the Project is a SSD, it falls under Module 5 of the guideline. Module 5, defined as 'other development', allows for a customised assessment approach that still achieves the overall objectives of the effect-based assessment and provides the framework for the consultation process between WaterNSW and DPE during the evaluation of a project. With respect to water quality effects of the Project, the consideration of consent conditions within SSD-5594 of EC limits are to be considered with respect to the Project's performance outcomes.

To assess the Project's influence over the Coxs River catchment, the evaluation of NorBE on water quality was undertaken using the results of the water and salt balance. These results, provided in Section 6.1 indicate that the Project performance at a number of points of interest requested to by WaterNSW. The results of the water and balance for each point of interest for two key scenarios are summarised in Table 7-1.

Table 7-1 NorBE assessment outcomes for water quality (based on electrical conductivity)

Point of interest	Do nothing conditions for water quality when compared with:
	Proposed conditions in 2030 (results based on Scenario 3 - 50% power generation)
Proposed LDP	Meets consent condition in SSD-5594
Wangcol Creek at LDPs	Current elevated EC as a result of LDP006 contribution to Wangcol Creek is ameliorated by Proposed LDP when discharging – BENEFIT
Wangcol Creek at Coxs River	For scenarios with discharge from the proposed LDP the volume of low EC water will dilute down existing higher EC water within Wangcol Creek – BENEFIT
LDP009	Cessation of discharges allows for the dominance of natural catchment flow volumes and quality – BENEFIT
Sawyers Swamp Creek at Coxs River	Creek returns to natural flow regime and reduced EC – BENEFIT
Inflow to Lake Wallace	Reduced water quality loads Reduction in EC from Proposed LDP discharges and cessation of LDP009 discharges – BENEFIT
Inflow to Lake Lyell	Reduced water quality loads Reduction in EC from Proposed LDP discharges and cessation of LDP009 discharges – BENEFIT

Point of interest	Do nothing conditions for water quality when compared with:
	Proposed conditions in 2030 (results based on Scenario 3 - 50% power generation)
Inflow to Lake Burragorang	Reduced water quality loads Reduction in EC from Proposed LDP discharges and cessation of LDP009 discharges – BENEFIT

Table 7-1 presents the outcomes of two scenarios assessed in the water and salt balance model. The do nothing scenario indicates an influence from maintaining current operations of Springvale Mine on all points of interest downstream of LDP009 (refer to Figure 6-29 to Figure 6-35). Whilst the influence of LDP009 reduces with increasing downstream distance, some minor effects are still predicted at Lake Burragorang.

The proposed scenario in 2030 was also considered in the evaluation of the NorBE test. This scenario considered a 50 % power generation (Scenario 3, approximately 28 to 30 ML/day). Water supply, in this scenario, to the WTP will exceed the 50 % demand and discharges via the proposed LDP will occur. The discharge of treated water into Wangcol Creek was shown to reduce conductivity at the receiving waters of the Proposed LDP (refer to Figure 6-36 and Figure 6-37) and downstream to Lake Wallace (refer to Figure 6-41). At Lake Wallace improvements were also observed as a result of the cessation of discharges from LDP009 which have dominated the EC of water contributing to the Lake during dry weather conditions.

The benefit observed at Lake Wallace was consistent through all proposed scenarios assessed (refer Appendix B). This outcome supports the cessation of discharges from LDP009 as a catchment benefit.

Downstream of Lake Wallace, the benefit outcomes are continued through with minor improvement noted in Lake Burragorang (refer to Figure 6-43). Where power generation (greater than approximately 55%) water demands exceeds 32 ML/day (maximum predicted yield from the proposed WTP) water must be sourced from Lake Lyell. Results in these scenarios are representative of complete removal of treated water from catchment.

Due to the creation of waste streams from the WTP, in events where no discharge from the proposed LDP occurs (that is, complete uptake of WTP water by MPPS), Wangcol Creek may be subject to an increase in EC compared to existing conditions through increased discharge volumes from LDP006. An increase was shown in load of salt predicted at Wangcol Creek at LDPs due to residual material contribution at LDP006 (for all proposed scenarios) and discharges from proposed LDP (for scenarios 1, 2 and 3) compared with the do nothing scenario, which results in a no benefit outcome for salt load into the Wangcol Creek catchment from the Project. However, when considering EC, depending on the scenario considered, the outcome of the Project can vary between no benefit to benefit. The likelihood of elevated EC occurring at Wangcol Creek will be isolated to situations when power generation exceeds 32 ML/day demand (corresponding to 50 to 60 % power generation) where Proposed LDP discharges are minimal. The change in EC is minimal compared with the typical variation present at LDP006.

Despite a potential increase in the salt load and EC within the Wangcol Creek catchment, the Project was predicted by the water and salt balance model to provide an overall benefit for the Coxs River catchment for all proposed scenarios compared to the existing conditions and do nothing scenario.

7.2 Projects within the region

7.2.1 Angus Place Colliery

Angus Place Colliery has an EIS in progress for the extension of mining. This operation is currently in care and maintenance but longwall extraction will recommence following completion of Springvale Mine's extraction in 2024. Development will have commenced before this date.

Angus Place currently discharges surface and mine water into the upper Coxs River catchment through pit top discharge points (LDP001 and LDP002) and via the SDWTS at LDP009. The requirement of the mine to discharge water to the SDWTS is in order to manage underground water volumes. During its current state of care and maintenance underground water volumes are lower than typically what would be required during mining.

As a result of this Project, the predicted impacts associated with the Angus Place EIS for extension of mining are likely to be reduced with the reductions of untreated discharge volumes. The extension of mining Project once approved and works commence will utilise the infrastructure proposed as part of this development, to supply water to MPPS and continue water security of the power station. Dewatering volumes from the Angus Place Colliery are expected to be above that of Springvale Mine's water make as shown in Figure 4-3 reaching a maximum of 36.1 ML/day in 2030.

7.2.2 Lidsdale Siding

Lidsdale siding has been operational for a number of years. A new project approval was granted to the Lidsdale Coal Loader Project PA 08_0223 in 2013 for the upgrade of the train load out facility.

The site discharges water through LDP004 as a result of capturing rainfall and runoff from the site. There are no expected changes or modifications to the site water management expected to occur in the near future.

7.2.3 Pine Dale Coal Mine

Historically Pine Dale Coal Mine has been operating open cut operations. Plans in 2013-2014 were put forward to expand their mining operations northward into the historical Wallerawang underground workings. The project was put on hold in 2014 and the site transitioned into care and maintenance after the existing resource was exhausted.

No date is planned for the restart of the operation or the proposed expansion.

7.2.4 Springvale Coal Services site

With the recent approval of the Western Coal Services Project, there are no current projects underway at SCSS. The site has recently been observing increased groundwater contribution to the site in the form of seepage. This has resulted in an increased requirement to discharge water off site. The operation uses minimal water in comparison to its discharge statistics and seeks to utilise as much recycled water as practicable. In recent times this has had little impact on the water management requirements of the site.

This Project will seek to utilise an additional discharge point in the close proximity to LDP006. The use of an additional discharge point rather than combining the discharge points will allow for segregation of operations, clarity in licensing obligations and maintaining effective performance reporting obligations.

Both Springvale Mine and SCSS are undergoing the separation of licensing instruments following the separation of their combined former development consent (DA/11/92) as part of the Western Coal Services Project (SSD-5579). The segregation of discharge points will further

aid in this separation of operational responsibility. It is proposed that the discharge point licensing be included with the obligations of the WTP operator, likely to be third party to Springvale Coal and EnergyAustralia.

The separation of discharge points will assist in the clarity of licensing obligations. The source and quality of water will differ between the outcomes of this Project and that of the existing SCSS. The separation of this Projects discharge point will ensure a simplified licence which will focus on the specific risks associated with the operation of the pipeline and the water treatment plant. The current licence at LDP006 within SCSS currently has conditions upon it relating to rainfall total, specific quality objectives, air and noise obligations that are applicable to this Project.

The maintenance of effective performance reporting obligations will be achieved through the separation of discharge points. This Project will seek to address conditions of consent placed on the Springvale Mine development approval SSD 5594. This Project will seek to achieve a conforming discharge criteria that meets the conditions of consent relating to salinity and ecotoxicity specifically associated with discharges from the Springvale Mine's LDP009. A second instrument as part of the Springvale Mine conditions of consent relates to the overall improvement to catchment quality through the UCRAMP. Under this instrument, the performance of all Centennial Coal discharge points will be assessed and reviewed for performance. Whilst this Project contributes a large proportion of the overall improvement of water quality within the catchment, each western site contributing to the upper Coxs River catchment will reviewed under the program.

7.2.5 Springvale Mine

Springvale Mine was granted development consent SSD-5594 in 2015 to extend mining to 31 December 2028. Since this approval, a modification has been prepared and submitted to:

- Increase the workforce from 310 to 450 full time equivalent positions.
- Increase the approved ROM coal production rate from 4.5 Mtpa to 5.5 Mtpa.
- Increase the approved ROM coal stockpile from 85,000 tonnes to 200,000 tonnes, with an associated increase in the stockpile footprint area of approximately 0.3 ha.

The Springvale Mine will have LDP009 discharges ceased as a result of this Project. This will result in the sites potential cumulative impact on the Coxs River catchment being reduced.

7.2.6 Wallerawang Power Station and Ash Dam

Wallerawang Power Station commenced decommissioning from May 2014 and is ongoing to 2020. These decommissioning works will include the rehabilitation and capping of the Sawyers Creek Ash Dam and other dry/wet ash emplacements surrounding Sawyers Swamp Creek. These works, once complete are likely to further improve the local water quality contributing to the Coxs River. The works relating to Sawyers Swamp Creek Ash Dam were considered as part of the regional water and salt balance for this Project with the catchment returning to a rehabilitated state following 2020.

8. Licensing requirements

8.1 Water Management Act 2000

All licensing requirement as part of the WM Act 2000 within surface and groundwater sources are met as part of the current operations of Springvale Mine, SCSS and MPPS.

8.2 Protection of the Environment Operations Act 1997

The Project will require a new EPL. The Project will be a scheduled activity under the POEO Act defined as groundwater treatment where treatment will occur of 100 ML/year. The EPL will define the applicant as the owner of the assets however the compliance for environment management will be a third party contractor.

8.2.1 Discharge location and volumetric limit

The new LDP for the Project is proposed to be located on Wangcol Creek. The location of the proposed LDP is presented on Figure 6-4.

The recommended volumetric discharge limit for the proposed LDP is 32 ML/day, which is based on the maximum discharge specification for the WTP. This volume was modelled to comprise of up to 32 ML/day of water RO treated to a required target of 500 µS/cm.

8.2.2 Water quality discharge limits

The Project's EPL will require the consideration of water quality discharge limits for the proposed LDP. The evaluation of guideline water quality limits have been discussed within Section 6.6.2. The Project will seek to operate below the guideline values which are based on the catchment derived percentiles for Neubecks Creek upstream of the site for the proposed LDP. The determined guideline values are proposed to be adopted as 100th percentile limits in the future EPL for the plant. These limits are an improvement on the existing LDP009 Springvale Mine EPL limits.

Guideline values have been based on the concentration of toxicants that provide protection of 95% of species (ANZECC, 2000a) as well as the existing upstream catchment properties. It is unlikely that there would be a significant amount of mixing of discharges after the end of pipe and hence these guideline values have been applied to the end of pipe. The predicted operation of the plant will produce water quality parameter concentrations that are equal to or better than the guideline values providing for an operational buffer to be in place.

With the derivation of thresholds for EC as part of a recently developed ACARP investigation, the recommended 100th percentile value for EC should be 901 μS/cm with 90th percentile value equal to 500 μS/cm as per the consent conditions of SSD-5594.

The guideline values presented in Section 6.6.2 will serve as the basis for the definition of other water quality parameters that will be confirmed through consultation as part of applications for the Project new EPL.

It must be noted that the water quality limits proposed as part of this Project will not be applicable to discharges currently undertaken at LDP006 as part of the EPL 3607. Any pollution reduction programs to be applied at LDP006 shall be addressed as part of the operation of SCSS (as part of the Western Coal Services Project, SSD-5575) and not form part of this Project.

8.2.3 Rationalisation of discharge points

As part of Springvale Mines consent, the cessation of flows from LDP009 and LDP010 will occur from Springvale Mine's existing water management system. The future of these discharge points will be determined as part of the operations of Springvale Mine and the Centennial Coal regional water management strategy. No allowance for an emergency discharge point has been proposed as part of this Project as sufficient redundancy will be provided within the underground workings of the Angus Place 900 Panel Storage Area to hold water temporarily whilst the operational status is restored. In the event of a rare event that the redundancy capacity is not sufficient then discharges may occur from Centennial Coal's network, however the exact location cannot be predicted. This event is likely to be rare and associated with an extreme scenario.

9. Avoidance, mitigation and management measures

9.1 Avoidance and mitigation measures

9.1.1 Catchment hydrology and hydraulics

The key potential impacts, with respect to catchment hydrology and hydraulics, were identified as implementation of discharge infrastructure, discharges to Wangcol Creek and the potential improvement of vegetation within Wangcol Creek for the extent of the creek downstream of the discharge point.

Discharge infrastructure

To improve the conveyance of flow, the proposed implementation of the proposed LDP infrastructure will include the clearing of vegetation currently blocking the Castlereagh Highway culvert, and the localised shaping of the original Lamberts Gully waterway down to Wangcol Creek. This has been provided conceptually, in Figure 6-4, but will require further consultation with Pine Dale Coal Mine and RMS prior to implementation. The implementation of such works will essentially mitigate future progression of existing Wangcol Creek instabilities in this location as well as the improvement the conveyance of flow through the area, in the event that peak discharges from the proposed LDP of 32 ML/day are ever required.

Discharges to Wangcol Creek

There was predicted to be a minor change in the water level elevation as a result of the increased discharge volume in a 0% power demand scenario (32 ML/day). In these events it is likely that the typical capacity of the inset low flow channel (characterised by the baseflow conditions of upper Wangcol Creek) that is present within the bed material of much of Wangcol Creek would be temporarily exceeded resulting in a greater depth of flow and also a greater energy. Whilst this may occur, the flow would be temporary (typically associated with a MPPS shut down period of 1 to 2 days at a time), the significance of this change is minor and the creek would adapt to suit the change in conditions.

A monitoring program associated with trigger action response plan may prove beneficial to visually inspect a major rainfall event and a coinciding discharge of a large volume of water, however in these cases the rainfall volume would exceed that of the discharge input.

The assessment of existing Wangcol Creek culverts and other structures was undertaken as part of the Project. It was determined that at least one structure should be upgraded as an in-direct result of the Project. Structure 5 was identified as having limited conveyance capacity as it currently exists. The consideration of whether the access route provides a current purpose given the care and maintenance status of Pine Dale Coal Mine should be determined. Waterway stability would benefit from the removal or upgrade of this structure and this will be investigated as part of the future stages of the Project.

9.1.2 Water quality

The key potential impacts relating to water quality include construction erosion and sediment control and the commissioning phase and performance of the WTP.

Construction erosion and sediment control

As part of the construction phase of the Project, two key disturbance activities will be required:

- Surface installations (above and below ground), boring (horizontal directional drilling) and decommissioning pipeline extents.
- Clearing, regrading and building infrastructure for the treatment plant.

As part of mitigating erosion and sediment impacts to waterways, prior to construction the Project will prepare a Construction Environmental Management Plan (CEMP). This will include erosion and sediment control plans (ESCP) that will aid the construction works to undertake disturbance activities in a manner that will consider the protection of existing water quality within waterways that surround and intercept the Projects extent.

Generally, the following guidelines will be considered in the development of ESCPs:

- Managing Urban Stormwater: Soils and Construction Volume 1 (The 'Blue Book'; Landcom, 2004) outlines the basic principles for the design, construction and implementation of sediment and erosion control measures to improve stormwater management and mitigate the impacts of land disturbance activities on soils and receiving waters.
- Managing Urban Stormwater: Soils and Construction, Volume 2A - Installation of Services (DECC; 2008a) provides specific guidelines, principles and minimum design standards for good management practice in erosion and sediment control during the installation of services.
- Appendix P: Land-Based Pipeline Construction (IECA 2015) provides a recent guideline on the application of erosion and sediment controls to land based pipelines including the crossings of waterways.

As part of constructing the pipeline route, the ESCPs will include the following control measures:

- Controlled site access locations, with existing access routes to be utilised where possible.
- Sediment fencing and flow breaks in areas of excessive grade (greater than 5%)
- Where disturbed catchments yield a sediment volume greater than 150 m^3/year, a sediment basin will be used.
- Diversion of clean water around disturbance activities using temporary lined channels or appropriate located pipes. Windrows of won material can also be utilised to protect the trenching site.
- Clearance of approximately 10 m of easement in locations where no easement already exists. Clearance will be undertaken as required during construction leaving mulch as groundcover while construction works are being undertaken.
- Excavated spoil material will be placed on the down slope side of the trench.
- Rehabilitation of the trench is to occur within 10 days of the backfilling (IECA 2000). Stabilisation method can take a suitable form that will applicable to the conditions of the disturbance activity with a default condition being the application of jute matting.

With the construction of the WTP, the following control measures will be adopted:

- Clean water diversions for management of the southern catchment. The catchment to the south is expected to be in the order of 32.8 ha.
- Sediment Fencing around the majority of northern perimeter of the site.
- Controlled site access location, with existing access routes to be utilised where possible.

- Isolation fencing to clearly demarcate construction areas from operational areas from within the existing MPPS.
- Surface water storages be constructed early and utilised as sediment basins.
- Rolled erosion control products (RECPs) reduce erosion by completely covering the disturbed area. RECPs are easily applied to disturbed areas in an emergency or where the area requires temporary stabilisation for an extended period of time.
- Dirty water from site shall be directed into the existing water management system present at MPPS.
- Rehabilitation of WTP site will be undertaken using rock mulching material or concrete. Those areas not associated with the plant should be revegetated.

It is expected that the construction period will be in excess of a year.

Water treatment plant commissioning

Following the completion of the WTP construction, a commissioning plan will be developed as part of the contractor's obligations to the Project. With respect to water quality the commissioning plan will include:

- Environmental management
- Management methodologies for dealing with unexpected issues that may arise during the commissioning phase, such as disposing of waste and off-specification production performance.
- Algae growth management
- Confirmation water quality tests to confirm specification has been met from the plant.
- Undertake a corresponding round of surface water monitoring in line with the Project proposed program.
- Prepare the documentation to support the development of a EPL.
- Undertake the report in consultation with EPA.

It is expected that the commissioning period will be at least three months. As a requirement of the commissioning phase, ecotoxicology testing may be required to confirm the toxicity of both proposed discharge and the combination of receiving environment and proposed discharges. This requirement will only be enacted if EPA require it following the commencement of an EPL for the plant.

9.1.3 Geomorphic controls

Pipe outlets

To minimise the impact on the riparian environment and the available waterway areas of discharge location, outlet structures will be proposed in accordance with recommendations by NOW (2010b). An example of an appropriate outlet structure that is sensitive to existing riparian vegetation is shown in Figure 9-1.

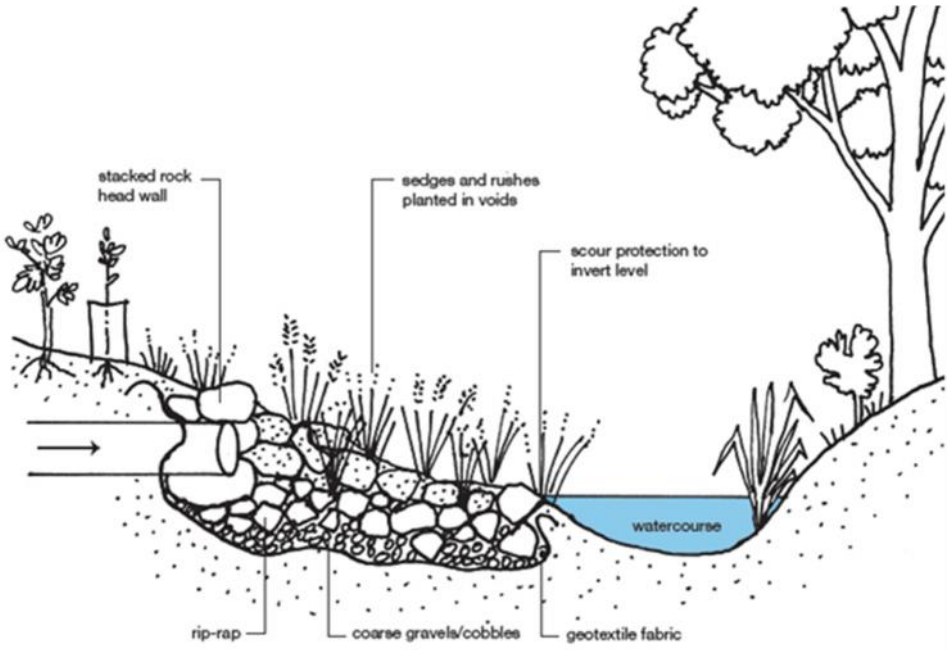


Figure 9-1 Stabilised pipe outlet (NOW, 2010b)

The aim of these works shall be focused in the protection of water flow, water quality, stream ecology and the existing vegetation of Wangcol Creek. The use of scour protection and general rehabilitation methods focused on stabilising disturbed surfaces would be implemented progressively during and after the construction and operational phase of the Project. These works would be implemented downstream of discharge infrastructure proposed as part of the Project and form the interface between the natural and engineered environment.

9.1.4 Waste management

MPPS have existing water management and contingency plans specific to the management of the brine conditioned ash area. The water management plan consists of:

- Groundwater monitoring is undertaken on at least a quarterly basis around the ash disposal area both up and down gradient.
- Chloride is utilised as a tracer for brine leachate in the groundwater.
- Where a significant increase in groundwater elevation is detected by a vibrating piezometer, a bore will be drilled through the ash. Free water in the bore will be analysed for water quality and ash core samples collected and analysed for moisture and salts in leachate tests. Due to the layer of water conditioned ash under the brine conditioned ash, there are limitations in the installation of new bores within some areas of the ash emplacement.
- Surface water runoff is directed to a lined collected basin of a 10 year ARI capacity. Slopes conveying runoff are a maximum of 2%. Batters are graded internally at 1V in 4H.
- Runoff water captured within basins will be utilised for dust suppression.
- Rehabilitated areas of brine emplaced ash are covered with 1 m of water conditioned of ash and 0.25 m of spoil capping.

The MPPS contingency plan includes the following response mechanisms:

- Events exceeding the design criteria of the brine surface water storages would result in an overflow to downstream storages at MPPS. Water captured at MPPS (detention pond) would be manually pumped back to the existing buffer ponds for either RO treatment at the existing MPPS water treatment plant or alternative on-site management.
- In the event that surface water monitoring within Wangcol Creek (WX22/Wangcol Creek gauge) indicates an increase or consistently elevated sampling parameters above guideline values the following will be undertaken:
  - Brine dam will be checked for leaks with any leaks detected repaired.
  - Increased groundwater sampling to a monthly interval until issues are rectified.
  - Placement of brine conditioned ash will be temporarily suspended pending the outcomes of further investigations. Holding capacity of brine is in the order of 40 ML.
  - Where required consultation with DPI-Water, WaterNSW and Lithgow City Council will be undertaken.
  - Review the rate of seepage of leachates from the co-placement area. The vibrating wire piezometer network will be able to detect changes in seepage rates prior to being identified in surface water sources.

Waste streams transferred to SCSS for management will result in a revision to the existing Springvale Coal Services Water Management Plan (RPS 2013). This revision will document the management and response requirements to appropriately accept the proposed volume of residual material from the WTP. A Trigger Action Response Plan (TARP) will be developed which considers triggers and responses to the following potential risks:

- Groundwater contamination.
- Erosion or scour of material within REA.
- Water volume on REA.
- Surface water quality of decant water from REA.

9.2 Monitoring and management requirements

A key component in mitigating the potential impacts of the Project is the monitoring of water quality and waterway condition. A surface water monitoring program will be developed as part of the Project to ensure that water management measures implemented function as designed. The surface water monitoring program will include:

- Monitoring waterway and diversion stability.
- Monitoring of surface water quality.
- Monitoring of groundwater levels and quality
- Management of water quality treatment devices.
- Monitoring erosion and sediment control structures.

9.2.1 Watercourse stability

To manage watercourse stability, an event based monitoring program is proposed. A TARP will be developed to review creek stability following large volume discharge periods for a period of two years following the Projects commencement. A baseline visual survey was established as part of the development of the EIS.

9.2.2 Surface water quality

Monitoring of surface water quality is proposed to continue for the existing Centennial Coal operations and EnergyAustralia monitoring programs as a result the Project. This current program has been summarised below in Table 9-1 and Table 9-2. The programs will remain as part of environment compliance obligations of each organisations operations.

Table 9-1 Centennial Coal surface water quality monitoring program

Location	Frequency	Monitored parameters
Neubeck Coal Project		
SW1 SW2 SW3	Weekly	Physicochemical: pH, EC, turbidity, TSS, O&G.
	Monthly	Anions: alkalinity, chloride, sulfate. Cations: sodium, calcium, potassium, magnesium, total hardness. Nutrients: total nitrogen, TKN, total phosphorus, ammonia as N. Metals (dissolved and total): Al, Sb, As, Ba, B, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se, Au and Zn. Other: cyanide.
Springvale Coal Services		
Wangcol Creek gauge Wangcol D/S Wangcol Far D/S	Weekly	Physicochemical: pH, EC, turbidity, TSS, O&G, TDS, carbonate alkalinity, bicarbonate alkalinity. Anions: alkalinity, sulfate, chloride Cations: sodium, calcium, potassium, magnesium, total hardness. Metals (dissolved and total): Al, B, Cd, Fe, Pb, Mn, Ni, Se and Zn.
LDP006	Monthly during discharge	Physicochemical: pH, EC, turbidity, TSS, oil and grease. Anions: alkalinity, sulfate, chloride. Cations: sodium, calcium, potassium, magnesium, total hardness. Metals (dissolved and total): Al, B, Cd, Fe, Pb, Mn, Ni, Se and Zn.

Location	Frequency	Monitored parameters
Springvale Mine		
LDP009	Weekly (during discharge)	Physicochemical: pH, EC, DO, Temp, TSS, turbidity, O&G, Metals (dissolved and totals): Al, B, Zn, Fe, Cu, Mn, As, Ni Other: fluoride
	Quarterly (during discharge)	Physicochemical: pH, EC, Temp, Turbidity, free chlorine, total chlorine, DO, TSS, TDS, O&G Anions: alkalinity, chloride, sulfate Cations: sodium, calcium, manganese, potassium, total hardness Nutrients: nitrate, nitrite, total N, nitrate + nitrite, TKN, total P, ammonia as N, Metal (dissolved): Cu, Zn, Fe, Mn, As, Ba, B, Cd, Pb, Ni, U, Sb, Li, Mo, Rb, and Sr Inorganics: silica, silicon Semi Volatile Organic: phenolic compounds Other: cyanide, TOC, fluoride
Coxs River D/S	Weekly (during discharge)	Physicochemical: pH, EC Metals (dissolved): Al, B, Zn, Fe, Cu, Mn, As, Ni
	Quarterly	Physicochemical: pH, EC, Temp, Turbidity, free chlorine, total chlorine, DO, TSS, TDS, O&G Other: cyanide, TOC, fluoride Inorganics: silica, silicon Semi Volatile Organic: phenolic compounds Nutrients: nitrate, nitrite, total N, nitrate + nitrite, TKN, total P, ammonia as N. Anions: alkalinity, chloride, sulfate Cations: sodium, calcium, manganese, potassium, total hardness. Metal (dissolved): Cu, Zn, Fe, Mn, As, Ba, B, Cd, Pb, Ni, U, Sb, Li, Mo, Rb, Sr

Table 9-2 EnergyAustralia surface water quality monitoring program

Site location	Frequency	Monitored parameters
Stream Gauge WX22	Weekly	Physicochemical: pH, EC, TSS, Anions: sulfate

Site location	Frequency	Monitored parameters
	Monthly	Physicochemical: pH, EC, TSS, TDS, turbidity, DO Anions: alkalinity, sulfate, chloride Cations: sodium, potassium, calcium, manganese Nutrients: nitrate, nitrite, total nitrogen Metal (totals): Al, Ba, Cu, As, Au, Be, B, Cd, Hg, Mo, Ni, Pb, Se, V, Zn, Cr Metal (dissolved): Al, Cu, Zn, Fe, Mn, V Other: fluoride
Final Holding Pond (FHP)	Weekly	Physicochemical: pH, EC, TSS Anions: sulfate
	Monthly	Physicochemical: pH, EC, TSS, TDS Anions: alkalinity, sulfate, chloride Metals (total): Hg Inorganics: silica
Downstream FHP	Weekly	Physicochemical: pH, EC, TSS Major ions: sulfate
	Monthly	Physicochemical: pH, EC, TSS, TDS, DO, turbidity Nutrients: nitrate, nitrite, total nitrogen Anions: alkalinity, sulfate, chloride Cations: sodium, potassium, calcium, manganese Metal (total): Al, Ba, Cu, As, Au, Be, B, Cd, Hg, Mo, Ni, Pb, Se, V, Zn, Cr, Metal (dissolved): Al, Cu, Zn, Fe, Mn, V Other: fluoride

New monitoring locations proposed for the Project that will be the responsibility of the treatment plant operator are summarised in Table 9-3.

Table 9-3 Proposed additional surface water monitoring locations

Site location	Frequency	Monitoring parameters
Proposed LDP	Daily during discharge	Physicochemical: pH, EC, DO, Temp, TSS, turbidity, O&G Metals (dissolved and totals): Al, B, Zn, Fe, Cu, Mn, As, Ni Other: fluoride
	Monthly during discharge	Physicochemical: pH, EC, Temp, turbidity, free chlorine, total chlorine, DO, TSS, TDS, O&G

Site location	Frequency	Monitoring parameters
		Anions: alkalinity, chloride, sulfate Cations: sodium, calcium, manganese, potassium, total hardness Nutrients: nitrate, nitrite, total N, nitrate + nitrite, TKN, total P, ammonia as N, Metal (dissolved): Cu, Zn, Fe, Mn, As, Ba, B, Cd, Pb, Ni, U, Sb, Li, Mo, Rb, Sr Other: total cyanide, TOC, fluoride Inorganics: silica, silicon Semi Volatile Organic: phenolic compounds
Residual discharge	Monthly during discharge	Physicochemical parameters: pH, EC, turbidity, TSS, O&G. Metals (dissolved and total): Al, B, Cd, Fe, Pb, Mn, Ni, Se and Zn. Anions: alkalinity, sulfate, chloride Cations: sodium, calcium, potassium, magnesium, total hardness.

9.2.3 Surface water discharges / flow monitoring

Discharges are currently monitored daily at Springvale Coal's LDP009 and LDP006. The monitoring of these two locations will continue. The proposed discharge point and residual pipeline will be added to the existing Springvale Coal's discharge flow monitoring program. Monitoring will comprise of an inline electronic metering device recording total volume discharged through each point over a day.

9.2.4 Groundwater monitoring program

The existing groundwater monitoring programs are proposed to remain as they are currently as a result of this Project. Given no direct potential impact has been identified solely as the result of this Project, the existing programs will remain unchanged. The two existing monitoring programs are summarised below in Table 9-4 and Table 9-5.

Table 9-4 Centennial Coal groundwater monitoring program

Site location	Frequency	Monitoring parameters
BH1 to BH15	Weekly	Physicochemical: level, pH, EC, Temp
BH1 to BH15	Fortnightly	Physicochemical: level, pH, EC, Temp, TDS, TSS Anions: alkalinity, sulfate, chloride Cations: sodium, calcium, potassium, magnesium, total hardness

Site location	Frequency	Monitoring parameters
		Nutrients: nitrate Metals (total): Al, Bo, Cd, Fe, Mn, Ni, Se, Zn Metals (dissolved): Ni, Zn, Fe, Mn

Table 9-5 EnergyAustralia Groundwater monitoring locations

Site location	Frequency	Monitoring parameters
MPGM4_D1 MPGM4_D8 MPGM4_D9 MPGM4_D10 MPGM4_D11 MPGM4_D15 to D19 MPGM4_D4 (BG) MPGM4_D5 (BG)	Monthly	Physicochemical: level, pH, EC, TDS Anions: alkalinity, sulfate, chloride Cations: sodium, calcium, potassium, magnesium, total hardness Metals (total): Al, Ba, Cu, As, Ag, B, Cd, Hg, Mo, Ni, Pb, Se, V, Zn, Cr Metals (dissolved): Fe, Mn, V Other: fluoride

9.2.5 Erosion and sediment controls

During the construction phase of the Project site erosion and sediment controls will be management and monitored as per the CEMP to be developed. As a minimum requirement, during construction, the maintenance of erosion and sediment controls will include the following:

- General site inspections of construction works are undertaken weekly and following significant rainfall events. During these inspections, water management and sediment control structures are inspected for capacity, structural integrity, effectiveness and level of sediment within structures, with the results recorded and reported on where appropriate.
- Maintenance of the sediment and erosion control measures when visually defects are observed.
- Maintenance of groundcover in areas of rehabilitation.
- Sediment trapped behind fences is to be cleaned out and appropriately stockpiled.
- The maintenance of all erosion and sediment control measures are required until disturbance activities and site rehabilitation is complete.

9.3 Reporting

The following reporting requirements are to be undertaken as part of the operational phase of the Project.

9.3.1 Environment protection licence

With the commencement of an EPL for the Project, a written report on any discharge or water quality exceedance event should be compiled at the request of the NSW EPA.

Monthly reporting of water quality monitoring results for the operational phase of the Project will be undertaken through the Centennial Coal website. Monitoring reports are currently undertaken for air, noise and water aspects for each of the current operations within the Western Coalfield.

9.3.2 Annual review

The Project will prepare an Annual Review (previously Annual Environmental Management Report) that reviews the performance of operations, provides an overview of environmental management actions taken and summarises the monitoring results over the 12-month reporting period. The Annual Review typically includes the following elements specific to surface water management:

- Any amendments to licensing or statutory approvals.
- A summary of any complaints or incidents relating to the performance of the water management system over the reporting period.
- A summary of the monitoring results collected over the reporting period and assessment against relevant criteria.
- An evaluation of any trends in the monitoring results occurring across the site over the life of the Project.
- Any non-compliance recorded during the reporting period and the actions taken to ensure compliance.
- An evaluation of the site water balance.
- A summary of management actions to be implemented over the next reporting period to improve the environmental performance of the Project.

9.3.3 Management plans

A series of management plans will be developed for water management and surface water and groundwater response planning for the Project and will incorporate the findings and recommendations of this WRIA. These plans will include:

- Operational plant management plan
- Water Management Plan, including:
  - Updated water and salt balance.
  - Erosion and Sediment Control Plan.
  - Surface and Groundwater Response Plan.
  - Surface and Groundwater Monitoring Plan.

A water management plan will be prepared as part of the operational phase of the Project. This water management plan will be prepared concurrently with the commissioning phase of the plant and seek to capture the obligations of all parties to achieve a plant functioning to the specification and achieving its environmental objective. The water management plan will include a response plan and emergency procedures in case of plant shutdown, pipeline failure, or MPPS emergency. These response plans will be consistent with previously prepared plans for the SDWTS.

The management plan will be prepared in consultation with EnergyAustralia, Centennial Coal, WaterNSW, and EPA. The responsibility of implementing the plan will lie with the contractor of the plant.

Following the implementation of the Project, MPPS will update their existing Water Management Plan (discussed in Section 9.1.4) specific to the ash emplacement to cover any specific changes that may need to be considered due to new interfaces with the Project.

9.4 Responsibilities

All personnel carrying out work for the Project must be familiar with the requirements of the Water Management Plan and Discharge Management Plan and comply in full. All personnel will be provided with appropriate instruction and training to possess the necessary skills and knowledge to competently perform their roles and to be aware of the associated hazards and risks. All personnel are required to complete an environmental induction prior to working on site that addresses the hazards and risks associated with the Project.

The key roles and responsibilities with respect to surface water management include:

- WTP/Operations Manager: Manage operations of the plant and reporting in accordance with the EPL and manage resources available to achieve the water management objectives.
- Environment Specilaist (MPPS): Reviews the operations of the plant with respect to the EnergyAustralia property and connections between the plant and the cooling makeup water demands.
- Environment and Community Coordinator (Springvale Mine): Assists in achieving the responsibilities of Springvale Mine in complying with the transfer scheme, investigating opportunities for improvement in water management including reuse, annual performance reviews for water management, annual reporting of water issues, manage the relevant reporting, review and consultation conditions of the Project Approval, and report breaches and discharge events.
- Other site personnel (WTP): Undertake maintenance and associated operations in accordance with the site management plans specific to the plant.
- Site contractors: Ensure that operations are undertaken in accordance with the objectives of the site management plans.

9.5 Review

The Project will be required to review the outcomes predicted within this WRIA and other impact assessments to validate the outcomes of the assessments and further identify issues that may occur as a result of the Project

At a minimum, a review of the Project outcomes must be undertaken every year or specifically as a result of:

- Any statutory or regulatory requirements.
- Any significant change to water management practices.
- Continual exceedances of any relevant criteria.
- Any incident that requires reporting.
- Decommissioning of specific surface water components.

The review process would be undertaken within the development of Annual Reviews (previously referred to as Annual Environmental Management Reports).

10. Conclusions

This WRIA has assessed the potential impacts and benefits of the proposed Project. The current conditions of the Project area included the following:

- The assessment of existing conditions of the catchment. This has included quantification of surface and groundwater environments at key points of interest within the catchment. The outcomes of this indicated a historically modified catchment from mining and agricultural landuse.
- The review of existing water management strategies at Springvale Coal's SCSS and Springvale Mine, and EnergyAustralia's MPPS.
- The evaluation of the existing regional water and salt balance. This indicated that existing conditions and operations influence conductivity of waterways within much of the upper Coxs River.
- The assessment of hydrology and hydraulics within Wangcol Creek. Wangcol Creek was visually assessed to determine the geomorphic processes currently influencing the form of the creek. This indicated that the creek is in a poor to moderate condition but would be resilient to increased flow as result of the Project.

The characterisation of water quality within the local catchment and regionally was undertaken to determine baseline conditions. Catchment specific guideline values were derived from Neubecks Creek. Wangcol Creek quality was more subject to groundwater influences where as Coxs River was dominated by LDP009 discharges.

The summary of ecotoxicology assessments undertaken previously on discharges and within the catchment were provided to support aquatic ecology outcomes.

The existing groundwater environment and its potential interaction with the Project was assessed for level and quality. This indicated a poor water quality source within areas of historical mining due to increased presence of metals and EC due to geochemical processes from exposed coal seams. It was determined that within areas of underground and open cut mining, groundwater to surface water connectivity was more prevalent. Groundwater quality from the existing ash emplacement area indicates some elevated chloride and sulfate ion concentrations within boundary groundwater bores. Some of these bores have historically been high in concentrations of parameters typically trace elements of brine conditioned ash. Groundwater direction is typically from west to east.

The assessment of surface and groundwater users indicated that it was unlikely that the Project would directly influence the viability of existing basic landowner rights. A small amount of surface water users is present within the catchment above Lake Wallace. Groundwater users are dominated by monitoring and stock and domestic users and the Project is unlikely to impact on existing groundwater availability and quality.

Generally, the Project will serve a benefit to the upper Coxs River catchment water quality. This has been supported by the following assessment outcomes below.

The Project considers the construction of infrastructure including pipeline capable of transferring up to 36 ML/day from the existing Springvale Mine's LDP009, to a proposed WTP at MPPS. The WTP will utilise an RO treatment process which will achieve a high percentage reduction of parameters typical within mine water at Angus Place Colliery and Springvale Mine.

The identification and assessment of all works required to implement the Project. This has included the in-direct consequences of the works on other related operations. Where required this has provided conceptual diagrammatic representation of typical layouts for various project components.

The Project will achieve a maximum yield of 32 ML/day (at the peak of mine dewatering activities) for reuse at MPPS or discharge to Wangcol Creek. As there is uncertainty surrounding the future power generation rates at the MPPS the assessment of five proposed scenario covered the likely influence of the Project. Modifications to the water and salt balance developed for the Coxs River catchment indicated that there was an improvement in water quality downstream of the existing LDP009 discharge point. Despite a potential increase in the salt load and EC within the Wangcol Creek catchment, the Project was predicted by the water and salt balance model to provide an overall benefit for the Coxs River catchment for all proposed scenarios compared to the existing conditions and do nothing scenario.

In the event that the discharge of treated water is required to Wangcol Creek, hydrological and hydraulic have been developed to consider the consequences of a peak discharge of up to 32 ML/day. The results of these models indicate a minor increase in velocity and flood depth for events between a 1 year ARI to a 100 year ARI event. When considering a peak discharge in dry weather conditions, the consideration of how baseflow conditions would be modified were considered. The results of this test indicated the greatest change with increase in flow depths of between 0.1 m to 0.2 m and flow velocity increases of 0.2 m/s to 0.4 m/s. This is unlikely to result in wholesale changes to the geomorphology of Wangcol Creek in addition to the low likelihood of discharges of 32 ML/day occurring for a period of time long enough to encourage changes.

Soils across the Project area were categorised with respect to their erosion risk. Erosion risk was typically associated with steeper areas of the Project, located in pockets, off the Newnes Plateau. A number of high erosion risk areas were identified that intercept the pipeline alignment. Soil material within MPPS and SCSS is typically representative of a modified soil landscape.

The geomorphic conditions of Wangcol Creek indicate a low risk to erosion as result of peak discharges as a result of the proposed LDP. Some infrastructure risks were identified within the creek however these can be mitigated with monitoring. Trenchless crossings were assessed as part of options to construct the pipeline across the Coxs River. Underboring the creek is likely to be the least impacting option for Coxs River and is unlikely to modify the rivers geomorphology. The pipeline extent from the Newnes Plateau to Sawyers Swamp Creek was identified as being a potential risk given the steep grades of the valley. The pipeline is likely to follow existing corridors set out by previous logging activities. Erosion of the gully can be mitigated if the pipeline can be located outside of the primary flow path.

Water quality was assessed as a result of the Project considering the likely WTP performance and load reduction that is likely to be achieved, the management of runoff quality from the WTP site, and construction impacts to water quality. The water and salt balance covers the assessment of water quality with respect to salt loads on the catchment.

Groundwater environment was assessed with respect to interception due to the pipeline construction. It is unlikely that the pipeline construction will intercept significant volumes of groundwater however there is likely to be some areas of exception. These are likely to be associated with areas of alluvial material, or shallow groundwater environments such as in the vicinity of the Coxs River and SCSS.

The location of surface and ground water users were considered as part of the Project's impacts. It was determined that the Project would generally benefit surface water users upstream of Lake Wallace through improved water quality. The location of users means that potential changes in water availability would not impact existing licensed users upstream of Lake Wallace. There are no known groundwater users that are likely to be impacted by the Project's operation.

With the development of the WTP, the creation of two waste streams will require management as part of the Project. The key waste stream, that already exists but the Project will contribute to, is the brine management system at MPPS. This consists of a brine concentrator, brine storage ponds, processes in which brine can be conditioned with ash, and a proposed salt crystalliser. Brine conditioned ash placement is only undertaken at levels above 946 m AHD, with ash placed below this level conditioned with water. This approach allows for brine conditioned ash not to be in direct contact within the shallow groundwater environment. The current process of managing ash as it is placed which includes lifts of 0.5 m and compaction to 98% to 99% of its original density will continue which will minimise infiltration of rainfall through the ash.

As a result of using higher EC water in the water supply to MPPS, the brine generation volume is likely to increase, however this increase will be compensated by the crystalliser. The crystalliser will operate by further concentrating the brine into a higher salinity waste, typically reducing waste volumes down by 60%. Annual brine generation will depend upon typical power generation rates and supply rates from Springvale Mine and Angus Place Colliery. The management of residual material from the WTP pre-treatment process will be disposed of within the REA at SCSS. This will increase discharges at LDP006 by 0.2 ML/day on average. This is due to the fact that the residuals are majority water which is taken up within SCSS water management system.

The WRIA considered the water licensing obligations of the Project. As a result of the supply of up to 36 ML/day of water to MPPS (a maximum of 32 ML/day of which can be yielded) from the SDWTS transfers from Springvale Mine and Angus Place Colliery, this would most likely lead to a reduction in the required water volume take from the Coxs River via Lake Lyell and Thompsons Creek Reservoir and the Fish River water supply scheme into the future.

The operation of the WTP would be regulated by a new EPL. Whilst this licence would ultimately be the responsibility of Springvale Coal as the applicant of the Project, a third party contractor would be responsible for the compliant operation of the plant. As part of this assessment, recommendations for EPL conditions have been proposed, based on site-specific guideline values derived by the Project. Following the commissioning of the WTP, the potential revision of concentration limits is recommended to be considered as part of a review one year following commencement. Operation of a new discharge point would be included as part of this EPL with a volumetric limit equal to the peak discharge of the plant (approximately 32 ML/day).

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Appendices

Appendix A – Supporting assessment requirements

Table A-1 WaterNSW requirements

Element	Where addressed
Environmental Impact Statement	
How the project will achieve 'improved environmental incomes for the catchment and meet the water quality performance measures for salinity for mine water discharges required under the Springvale MEP SSD Consent (SSD 5594)'.	Section 6.2, Section 7
The expected water quality within the Coxs River downstream of Lake Lyell and in Lake Burragorang as a result of the project and in comparison with the expected quality at these locations if the permitted discharges under the Springvale MEP SSD Consent (SSD 5594) occurred.	Section 6.2,
Whether the construction of new salt ponds, Water Treatment Plant, installation of a crystalliser and any other infrastructure and disposal of additional brine at the MPPS site and increased impacts on groundwater will trigger a modification to the MPPS existing consent.	Section 6.9
If treated water discharges to Wangcol Creek will be directed to LDP006 or whether a new LDP will need to be approved.	Section 6.1
If a variation to the existing Springvale Mine Environmental Protection Licence (EPL 3607) would be required for the changes to discharges at LDP006 (or new discharge point along Wangcol Creek) and LDP009.	Section 8
Impacts of increased brine and sludge production and disposal at MPPS on groundwater and whether existing infrastructure has capacity to receive and store the additional brine and sludge produced and the proposed management measures.	Section 6.9
The location and description of all water monitoring points (surface and groundwater) including details of proposed monitoring of surface water flows, groundwater and surface water quality, along with information as to how the proposed monitoring will be used to monitor and, if necessary, mitigate impacts on surface water and groundwater resources beyond those predicted.	Section 9.2
Details of measures proposed to be adopted to offset impacts associated with construction activities e.g. earthworks, vegetation clearing, transfer pipeline construction etc.	Further discussed in EIS
Water balance assessment	
Predictions of the frequency, quantity and quality of mine water transfers to the proposed water treatment plant.	Section 6.2
Predictions of the frequency, quantity and quality of treated water being transferred for use by the MPPS and predictions of the frequency and quantity of any water extractions from local waterways to meet additional make-up water demand at the MPPS when the treated water volumes are not enough.	Section 6.2

Element	Where addressed
Predictions of the frequency, quantity and quality of treated water being discharged to Wangcol Creek when the MPPS is operating at reduced capacity and is unable to take some or all of the treated water from the water treatment plant.	Section 6.2
Predictions of the frequency, quantity and quality of mine water if and when it is not feasible to transfer to the water treatment plant including additional 6 ML proposed to be transferred than the existing discharges of 30 ML allowed in EPL for LDP009 and describe the scenarios and likelihood when this may occur.	Section 6.2
Details of the measures to manage site water associated with transferring and treating mine water, general stormwater runoff and any human activities likely to affect water quality at the site and how the neutral or beneficial effect on water quality test will be assessed and applied.	Section 7.1
Surface water assessment	
Comparison of the pre and post development volumes of water extracted from and mine water discharged to the Coxs River catchment (treated and untreated).	Section 6.2
Provide estimates of the volume, quality and pollutant loads of discharges into the Coxs River catchment annually and shall make clear statement as to whether the project would have a neutral or beneficial effect on water quality.	Section 6.5
Specific comparison of the quality and quantity of water currently being discharged from LDP006 with the total quality and quantity of discharges post development including from the water treatment plant.	Section 5.5 and Section 6.2
The potential impacts of any discharges on the water quality of receiving waters and whether there would be any consequences on geomorphology or ecology (flora and fauna) of the receiving watercourses.	Section 6.4 Ecology impact assessments
The potential impacts to receiving waters from LDP009 (or any other discharge location) when mine water is not feasible to transfer to the water treatment plant and whether water quality performance measures required by the Springvale Mine Extension Project will be achieved if this does occur.	The Project does not propose this to occur.
Clarification of the timeframes for the project with respect to meeting the timeframes for pollution reduction contained in the consent for the Springvale Mine Extension Project.	Further discussed in EIS
Concept plans, protocols and/or procedures	
Water management plan including surface water management plan, groundwater management plan and surface and groundwater monitoring programs.	Section 9.3.3

Element	Where addressed
Soil and water management plan which shall consider the principles outlined in the 'Managing Urban Stormwater – Soils and Construction – Installation of Services' manual prepared by the Department of Environment and Climate (2008).	Section 9.1.2
Details of the practices proposed to ensure mine water and waste materials transported to and from the sites do not spill or otherwise cause soil or water pollution.	Further discussed in EIS
Procedures for managing spills and emergency situations.	Further discussed in EIS
Rehabilitation plan.	Further discussed in EIS

Table A-2 DPI-Water requirements

Element	Where addressed
Annual volumes of surface water and groundwater proposed to be taken by the activity (including through inflow and seepage) from each surface and groundwater source as defined by the relevant water sharing plan.	Section 8
Assessment of any volumetric water licensing requirements (including those for ongoing water take following completion of the project).	Section 8
The identification of an adequate and secure water supply for the life of the project. Confirmation that water can be sourced from an appropriately authorised and reliable supply. This is to include an assessment of the current market depth where water entitlement is required to be purchased.	Section 8
A detailed and consolidated site water balance.	Section 6.2
A detailed assessment against the NSW Aquifer Interference Policy (2012) using DPI-Water's assessment framework.	Section 6.7
Assessment of impacts on surface and groundwater sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land and groundwater dependent ecosystems and measures proposed to reduce and mitigate these impacts.	Section 6
Full technical details and data of all surface and groundwater modelling, and an independent peer review.	Not undertaken
Proposed surface and groundwater monitoring activities and methodologies.	Section 9.2
Proposed management and disposal of produced or incidental water.	Section 6.9
Assessment of any potential cumulative impacts on water resources and any proposed options to manage cumulative impacts.	Section 7
Consideration of relevant policies and guidelines.	Section 2

Table A-3 EPA requirements

Element	Where addressed
Development Consent Conditions – SSD_5594	
The EA needs to provide a timetable for works for Package 1 (Transfer System) and Package 2 (Water Treatment System) to ensure compliance with Development Consent Conditions 12 – Water Management Performance Measures.	Further discussed in EIS
Environment Protection Licence 3607 (EPL 3607)	
The abovementioned timetable for works for Package 1 (Transfer System) and Package 2 (Water Treatment System) is also required to ensure compliance with Condition U1 (1.1) – Pollution Studies and Reduction programs of EPL 3607.	Further discussed in EIS
Western Coal Services and Licensed Discharge Point (LDP006)	
The current quality of the discharge from LDP006 and the concentrations of water quality parameters.	Section 5.5
The characteristics of toxicity from the current discharge of LDP006.	Undertaken as part of Upper Coxs River Action and Monitoring Plan
The concentration of water quality parameters and quality of the treated water to be directed to LDP006.	Section 5.5
The toxic characteristics of the treated water.	To be undertaken as part of Commissioning Plan
The concentration of water quality parameters, quality and toxic characteristics of the blend of treated mine water with groundwater seepage and rainfall runoff that will be discharged through LDP006.	To be undertaken as part of Commissioning Plan
Potential impacts on the aquatic ecology of Wangcol Creek and the upper Coxs River of (a) the blend of the water sources and (b) when the discharge is only groundwater seepage and/or (c) with rainfall runoff.	Aquatic Ecology Impact Assessment
An assessment of the groundwater and groundwater seepage that may be occurring within the general area of the Western Coal Services site and the Mount Piper ash emplacement area, that is not captured and discharged through LDP006, and has the potential to disperse off-site within the upper Coxs River catchment and impact on the aquatic ecology of Wangcol Creek and the upper Coxs River.	Not part of Project
Address the need to implement a reliable groundwater monitoring program between the Western Coal Services site and Wangcol Creek.	Section 9.2

Element	Where addressed
For the water quality parameters list below, they should be assessed, and expressed in both total and acid extractable concentrations, for the following: • Total suspended solids, turbidity, pH, salinity (EC), total oil and grease. • Fluoride. • Elements and metals: aluminium, arsenic, barium, beryllium, boron, cadmium, calcium, chromium (III and VI), cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, sodium, sulfur, uranium, zinc. • Anions: chloride, sulfate. • Alkalinity (carbonate, bicarbonate and total). • Nitrogen and phosphorus: total nitrogen, TKN, nitrite, nitrate, total ammonium N, total phosphorus. • Phenolic compounds (total).	Section 5.5
Compare the various proposed combinations of discharges from LDP006 with the ecosystem protection levels of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment and Conservation Council 2000 – ANZECC 2000).	Section 5.5
Volume of mine water	
Provide the reasons why the volume of the pipeline needs to be increased to 36 ML/day and the source of the additional mine water directed to the SDWTS.	Section 6.1
Sludge disposal	
The quantities of sludge to be disposed per annum.	Section 6.2 and 6.9
The chemical composition of the sludge (e.g. metals, elements, salts, pH etc.)	Section 6.2 and 6.9
The classification of the sludge under the Protection of the Environment Operations Act 1997 (Waste Act and Regulations 2014).	Further discussed as part of EIS
The suitability for co-disposal with tailings.	Section 6.2 and 6.9
Brine management and disposal	
The volume of brine concentration/crystals to be directed annually to the MPPS ash emplacement area.	Section 6.9
The potential for the leakage of saline water from the MPPS ash emplacement area to link with the groundwater below this facility and for dispersal via subsurface groundwater plumes towards the Coxs River.	Section 5.7
The need for a reliable groundwater monitoring program around the current ash dam (i.e. multiple piezometers with groundwater quality testing in between the ash dam wall and Coxs River).	Section 9.2

Element	Where addressed
The need to include proper monitoring/estimation of wet weather flows with the potential to transport salt and ash over the dam wall.	Section 9.1
An assessment of the potential for prolonged, heavy rainfall to cause the capacity of the MPPS ash emplacement area to be exceeded, with the potential for brine concentrate and ash to be flushed into the Coxs River.	Section 9.1
The impact of the disposal of this additional brine concentrate on the capacity, and life, of the MPPS ash emplacement area.	Section 6.9
The leakage of salt from the salt ponds into the local groundwater.	Section 6.9
Measures to achieve compaction to prevent leakage of salt to the local groundwater	Section 6.9
Construction of the pipelines	
Provide information on the sediment and erosion control measures that will be implemented during the construction of the pipelines.	Section 9.1
Routine maintenance and contingency operations	
Address the management strategies to be followed when there is either routine maintenance of the pipeline or water treatment system or a failure of either system.	Further discussed in EIS
Address the procedures being proposed to handle untreated mine water in the case of either routine maintenance or an emergency situation, to avoid the discharge of untreated mine water into the upper Coxs River or other local surface waters within the catchment.	Further discussed in EIS

Table A-4 OEH requirements

Element	Where addressed
The EIS must map the following features relevant to water and soils: b. Rivers, streams, wetlands, estuaries. c. Groundwater. d. Groundwater dependent ecosystems. e. Proposed intake and discharge locations.	This document
The EIS must describe background conditions for any water resource likely to be affected by the Springvale Water Treatment Pipeline, including: a. Existing surface and groundwater. b. Hydrology, including volume, frequency and quality of discharges at proposed intake and discharge locations. c. Water Quality Objectives including groundwater as appropriate that represent the community's uses and values for the receiving waters. d. Indicators and trigger values/criteria for the environmental values identified at (c) in accordance with the ANZECC (2000) Guidelines for Fresh and Marine Water Quality and/or local objectives, criteria or targets endorsed by the NSW Government.	Section 5
The EIS must assess the impacts of the Springvale Water Treatment Pipeline on water quality, including: a. The nature and degree of impact on receiving waters for both surface and groundwater, demonstrating how the Springvale Water Treatment Pipeline protects the Water Quality Objectives where they are currently being achieved, and contributes towards achievement of the Water Quality Objectives over time where they are currently not being achieved. This should include an assessment of the mitigating effects of proposed stormwater and wastewater management during and after construction. b. Identification of proposed monitoring of water quality.	Section 6.5
The EIS must assess the impact of the Springvale Water Treatment Pipeline on hydrology, including: a. Water balance including quantity, quality and source. b. Effects to downstream rivers, wetlands, estuaries, marine waters and floodplain areas. c. Effects to downstream water-dependent fauna and flora including groundwater dependent ecosystems. d. Impacts to natural processes and functions within rivers, wetlands, estuaries and floodplains that affect river system and landscape health such as nutrient flows, aquatic connectivity and access to habitat for spawning and refuge (e.g. river benches). e. Changes to environmental water availability, both regulated/licensed and unregulated/rules-based sources of such water. f. Mitigating effects of proposed stormwater and wastewater management during and after construction on hydrological attributes such as volumes, flow rates, management methods and re-use options. g. Identification of proposed monitoring of hydrological attributes.	This document

Table A-5 Significant Impact Test

Element	Triggers an impact	Reasoning
Changes to Hydrology		
Flow regimes (volume, timing, duration, frequency)	No	Based on a 50% power generation scenario discharges would be limited to one-two years of the Project and be of a minimal consequence.
Recharge rates	No	No active groundwater interactions
Aquifer pressure or pressure relationships between aquifers	No	No active groundwater interactions
Groundwater table levels	No	No active groundwater interactions
Groundwater/surface water interactions	No	Connectivity exists between surface and groundwater environments however these are existing with no change proposed in relation to these interactions
River/floodplain connections	Yes	Minimal consequence
Inter-aquifer connectivity	No	No groundwater interactions
Changes to Water Quality		
Create risks to human or animal health or to the condition of the natural environment	No	
Substantially reduce the amount of water available for human consumptive uses or for other uses, including environmental, which are dependent on water of a particular quality	No	Improving water quality
Cause persistent organic chemicals, heavy metals, salts or other potentially harmful substances to accumulate in the environment	No	Improving water quality
ANZECC Water Quality Assessment undertaken	Yes	Applied to end of pipe as very little mixing available
Changes to Ecosystem Function and Integrity		
Areas of the water resource being destroyed or substantially modified in a way that has an adverse effect on a water-dependent ecosystem	No	Improving water quality

Element	Triggers an impact	Reasoning
An adverse change to the benefits or services provided by a water resource	No	Improving water quality
A change in the biological diversity or species composition of a water resource or its ecological connectivity to other water resources	No	Improving water quality
The habitat or lifecycle of native species which are ecologically associated with the water resource or which are important determinants of the water resource's character being seriously affected	No	Improving water quality
An invasive or pest species that is harmful to the ecosystem functioning or integrity of the water resource becoming established (or an existing invasive or pest species being spread) in the water resource.	No	Improving water quality
Cumulative Impacts		
An assessment of the cumulative impacts of all other known projects in the surface or groundwater source area	Yes	Standard cumulative assessment approach down to the boundary of Lake Burragorang
Timing, Scale and Value		
An assessment of the impacts in both the short and long term. The long term will at a minimum be 100 years, unless otherwise defined by a peer reviewed hydrogeological model	Yes	Assessment period determined from length of groundwater supply (2035). No hydrogeology component.
Timing of the activities that are likely to impact water resources	Yes	Up to 2035.
A robust water balance that identifies when in the project timing water impacts are likely to be greater than the existing situation	Yes	Regional water and salt balance that considers both local (operational level) and regional scales
A complete or revises existing local and regional water balance and hydrogeological model	Yes	Development of new modelling considering multiple scales (operations and regional) of modelling. No hydrogeology modelling.
A statement as to the value of the water resource must be included in the significant impact test. This statement must be in the context of the services provided by the resource as well as the connectivity of the resource to other water resources. Services include provisioning to other industries or potable	Yes	The value of Coxs River is high as it contributes to the drinking water supplies of Sydney. The value of Wangcol Creek is low as it only supports aquatic ecology

Element	Triggers an impact	Reasoning
water supplies, cultural services and supporting ecosystem services.		that is somewhat degraded.

Table A-6 Consolidated IESC Checklist

Element	Assessed within WRIA or AEIA
Background Data and Modelling Identification of the water related assets Identification of the geological formation/aquifer to which groundwater dependent ecosystems (GDEs) are connected Location of springs and other groundwater dependent ecosystems A site specific water balance complemented by a regional water balance A description of the water resources of the site A description of the geology and hydrogeology at a local and regional level, including definition of the geological sequence The depth to aquifers and standing water levels, hydro-chemical characteristics A description of the likely recharge sources for each aquifer, details of discharges from each aquifer, direction of groundwater flow and contours of groundwater elevations for all aquifers Surface water assessment and model, including hydrology and water quality parameters Relevant information to describe the existing state of water related ecosystems	Yes
Water and Salt Balance A site specific water balance and a site specific salt balance, complemented by a regional balance of both water and salt covering the larger area of potential impact. An assessment of the changes to any water storage or flow of water in the system as a result of the project, including changes to salt loads.	Yes
Assessment of the likely significant impacts on water resources and water related assets Consideration of the State based policies and guidelines Predicted change to both local and regional water balances Impacts associated with surface water diversions Estimates of the quantity and quality of operational discharges of water, including emergency discharges Indication of the vulnerability to contamination and the likely impacts on the identified water assets	Yes

Element	Assessed within WRIA or AEIA
Consideration of the impacts of water management infrastructure on the biodiversity assets Assessment of the cumulative impact of the project with past, present and known future projects Proposed mitigation measures for each identified impact	
Assessment of cumulative impacts The cumulative impact assessment needs to consider all past, present and known future projects, undertaking with regard to the regional water balance. Catchment and regional scale information Total existing and planning licensed and extracted water for consumptive, industrial and agricultural purposes in the surface catchment and groundwater system Existing water quality guidelines, targets, environmental flow objectives and requirements for the ecosystems of the surface and groundwater systems The proportional increase in water resource use and impacts as a consequence of the proposal The overall level of risk to water related assets that combine probability of occurrence with severity of impact of all past, present and known future projects	Yes
Ongoing management and monitoring Plan of management is to be included that focuses on the avoid, mitigate, manage and offset principles Clearly defined monitoring objectives Maps/figures demonstrating location of bores, their purpose and distribution such that impacts to groundwater gradients, flow directions, recharge processes, quality and water levels in each aquifer Variables such as water levels, EC, pH and other quality parameters to be measured and the interval for measurement An ANZECC water quality assessment and the development of guideline trigger values	Yes

Appendix B – Water and salt balance additional information

B.1 Operations timeline

A summary of the assumed operational phases for each site is provided in Figure B-1.

Operations Timeline

	Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Angus Place	**Status**	Active Mining			Active Mining															Rehab							SDWTS only
	Description	Current Approved Mining			Proposed Extension Project															Mine water to DWTS continues. Mine water to LDPs ceases. Taper runoff							
Lidsdale Siding	**Status**	Regular Operations	Construction		Regular Operations																						
	Description		Extra dewatering																								
Mount Piper	**Status**	Regular Operations																									
	Description																										
Neubeck	**Status**																										
	Description																										
Pinedale	**Status**	Active Mining	CM																								
	Description	Last yr of Stage 1																									
Springvale	**Status**	Active Mining			Active Mining										Rehab							SDWTS only					
	Description	Current Approved Operations			Proposed Extension Project										DWTS continues, Mine water to LDPs cease, LDPs taper down												
Wallerawang	**Status**	CM																									
	Description																										
Western Coal Services	**Status**	Regular Operations																									
	Description																										

Active Mining | Care & Maintenance | Rehabilitation | Other | No Discharges or Extractions

B.2 Water and salt balance model data

B.2.1 Catchment modelling data

The areas of each sub-catchment of the Coxs River catchment modelled are provided in Table B-1. The development footprints of each of the operations considered in the model are presented in Table B-2. Figure B-2 presents each of the sub-catchments and development footprints for the Coxs River catchment.

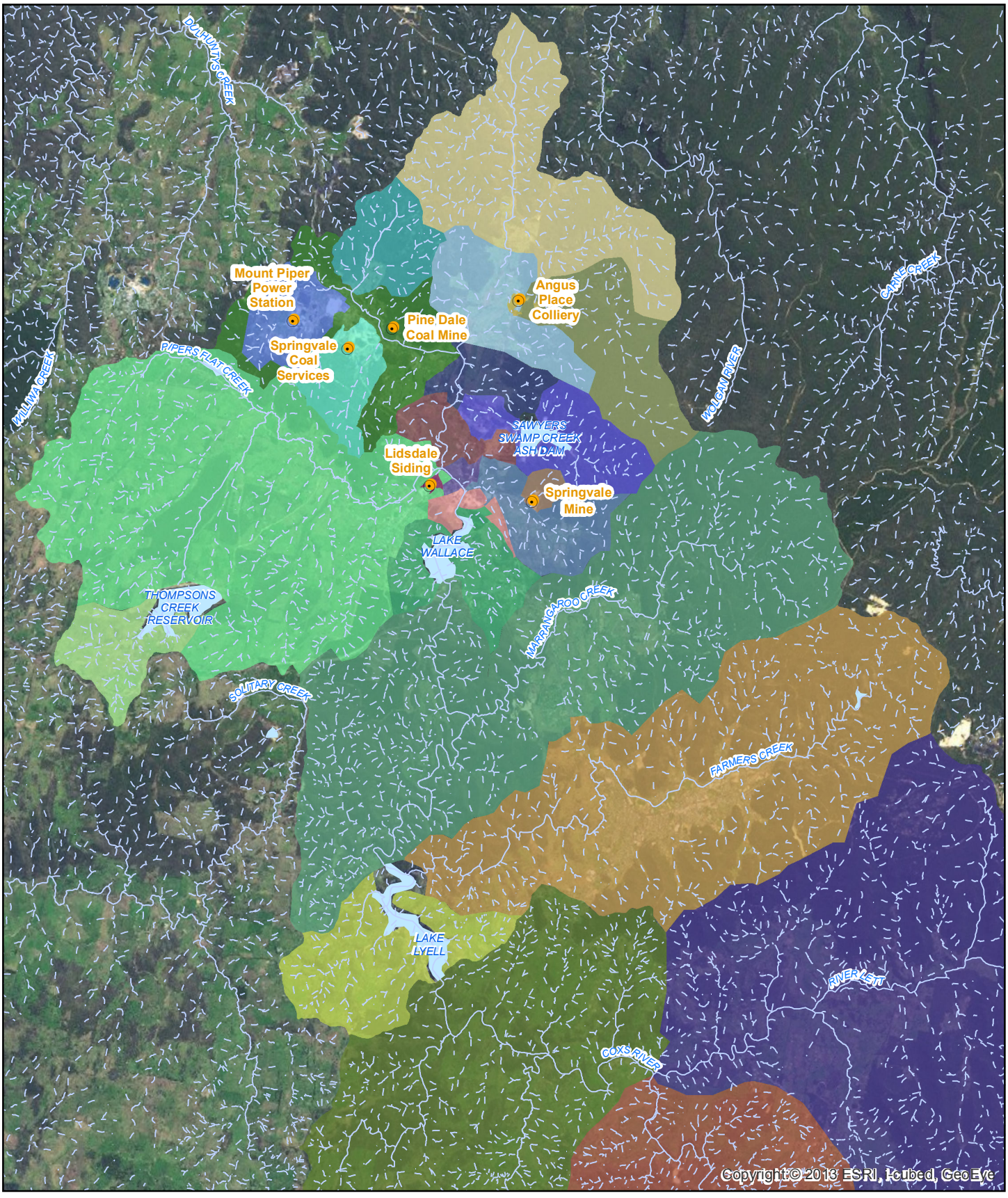
Table B-1 Sub-catchment areas

Sub-catchment	Area (ha)
Blackheath Creek	6,776
Breakfast Creek	7,193
Coxs River upstream	2,775
Coxs River upstream Blackheath Creek	7,036
Coxs River upstream Ganbenang Creek	9,504
Coxs River upstream Lake Burragorang	5,348
Coxs River upstream Lake Lyell	9,256
Coxs River upstream Lake Wallace	160
Coxs River upstream Pipers Flat Creek	383
Coxs River upstream Pulpithill Creek	7,528
Coxs River upstream Sawyers Swamp Creek	433
Coxs River upstream Springvale Creek	73
Coxs River upstream Wangcol Creek	1,015
Farmers Creek	7,240
Galong Creek	5,249
Ganbenang Creek	4,960
Jenolan River	12,340
Kanangra Creek	7,103
Kangaroo Creek	1,294
Lake Lyell	1,512
Lake Wallace	792
Little River	5,540
Long Swamp Creek	3,229
Megalong Creek	4,592
Mumbedah creek	4,060
Neubecks Creek	697
Pipers Flat Creek	7,162
Pulpithill Creek	1,987

Sub-catchment	Area (ha)
River Lett	10,226
Sawyers Swamp Creek	1,288
Springvale Creek	740
Thompsons Creek	718
Wangcol Creek	1,681
Whalania Creek	4,550

Table B-2 Development footprint areas

Development	Area (ha)
Angus Place Colliery	31
Lidsdale Siding	17
Mount Piper Power Station	596
Springvale Mine	110
Springvale Coal Services site	629



LEGEND

- Angus Place Colliery
- Coxs River upstream
- Coxs River upstream Blackheath Creek
- Coxs River upstream Ganbenang Creek
- Coxs River upstream Lake Lyell
- Coxs River upstream Lake Wallace
- Coxs River upstream Pipers Flat Creek
- Coxs River upstream Sawyers Swamp Creek
- Coxs River upstream Springvale Creek
- Coxs River upstream Wangcol Creek
- Farmers Creek
- Kangaroo Creek
- Lake Lyell
- Lake Wallace
- Lidsdale Siding
- Mount Piper Power Station
- Neubecks Creek
- Pipers Flat Creek
- River Lett
- Sawyers Swamp Creek
- Springvale Coal Services
- Springvale Creek
- Springvale Mine
- Thompsons Creek
- Wangcol Creek
- Waterbody

Paper Size A4

0 650 1,300 2,600 3,900 5,200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

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Centennial Coal
EA/CEY Water Treatment Project
Water Resources Impact Assessment

Modelled Coxs River sub-catchments

Job Number 21-25109
Revision A
Date 30 Jun 2016

Figure B-2

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

G:\22\0105001\GIS\Maps\Deliverables\Western\Springvale\2125109\WRIA\Superseded\2125109_WRIA026_WaterBalanceCtch_A.mxd

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Data source: © NSW Office of Water: Groundwater Data, 2013; ESRI: Aerial Imagery, 2009. Centennial: Imagery, 2016. Created by: tmorton

B.2.2 Data sources

The sources of data for the water and salt balance are shown in Table B-3.

Table B-3 Data sources

Source	Data
Provided by EnergyAustralia	MPPS power generation capacity
	MPPS cooling water demand
	Pump rate from Lake Lyell to MPPS and Thompsons Creek Reservoir
Technical specifications of WTP (GHD, 2016f; 2016g)	Maximum capacity of WTP
	Rate of residual material transferred to SCSS
	Brine proportion
	Salinity of treated water and residual material
Provided by Centennial Coal	Water quality monitoring data
Provided by CSIRO (2015)	Groundwater inflows into underground workings of Angus Place Colliery and Springvale Mine
Queensland Department of Science, Information Technology and Innovation	Daily rainfall data
BOM	Average monthly evaporation data
Queensland Department of Natural Resources and Water (DNRW, 2007)	Salinity of rainfall

B.2.3 General operational data

Site-specific operational data that was used to develop the water and salt balance model is presented in Table B-4.

Table B-4 Operational data

Parameter	Value
Maximum MPPS power generation capacity	33,600 MWhr/day
MPPS cooling water demand	1.62 ML/MWhr
Maximum capacity of WTP	36 ML/day
Maximum rate of transfer of residual material to SCSS	0.43 ML/day
Brine proportion (for inflows less than 30 ML/day)	14.3%
Brine proportion (for inflows greater than 30 ML/day)	11%
Pump rate from Lake Lyell to MPPS and Thompsons Creek Reservoir	95 ML/day

B.2.4 Salinity data

The salinity data incorporated into the water and salt balance model is provided in Table B-5.

Table B-5 Salinity data

Parameter	Source	Statistic	Value (µS/cm)
Rainfall	Department of Natural Resources and Water, Queensland Government (DNRW, 2007)	Typical value	30
Catchment runoff (bushland/vegetation areas)	Calibrated by water and salt balance model		75
Catchment runoff (impervious areas)	Calibrated by water and salt balance model		373
Catchment runoff (disturbed areas)	Calibrated by water and salt balance model	Typical value	151
Dewatered mine water-make from Angus Place Colliery and Springvale Mine	Water quality monitoring of LDP009 discharges	50th percentile	1,170
RO treated water (for inflows less than 30 ML/day)	Technical specifications of WTP (GHD, 2016f; 2016g)	50th percentile	300
RO treated water (for inflows greater than 30 ML/day)	Technical specifications of WTP (GHD, 2016f; 2016g)	90th percentile	500
Residual material transferred to SCSS	Technical specifications of WTP (GHD, 2016f; 2016g)	Maximum	2,500

B.3 Model validation

Validation of the water and salt balance model was undertaken to ensure that the results of the model were not significantly affected by uncertainty in the adopted model parameters and the range of accuracy of the model was consistent with the application of the model. This accuracy was assessed by a comparison of the modelled and observed time series and cumulative distribution plots for daily total flow and daily average EC. Monitoring data was sourced from DPI-Water at the following two locations:

- Coxs River upstream of confluence with Springvale Creek.
- Coxs River upstream of Lake Burragorang.

Monitoring data was available for a maximum period of 11 years, from 1 January 1995 to 1 January 2016. The daily time step of the monitored data was consistent with the time step used in the water and salt balance model.

B.3.1 Coxs River upstream of Springvale Creek

Figure B-3 and Figure B-4 present the time series of modelled and observed daily total flow and daily average EC respectively for the monitoring point on the Coxs River upstream of the confluence with Springvale Creek. The observed flow and EC data was sourced from DPI-Water for gauge 212054 (referred to as 'Coxs @ Wallerawang'). This location corresponds with WaterNSW monitoring point E0321 shown in Figure 4-6.

The results presented in Figure B-3 and Figure B-4 show that the model replicated the general trends observed from year to year over the validation period. For daily total flow it showed a similar range to observed and matched some of the peak flow events. For daily average EC, the modelled time series had a greater range. Notably, the observed dataset had large gaps after 2009, indicated by horizontal lines in the time series. These periods were excluded from the cumulative probability distribution.

Figure B-5 and Figure B-6 show the cumulative probability distribution of daily total flow and daily average EC respectively for the monitoring point on the Coxs River upstream of the confluence with Springvale Creek. The daily total flow shows a very close match to observed, however overestimated low flows. This can be attributed to the difficulty in reconstructing the operational behaviour of the transfers between reservoirs on the Coxs River and Thompsons Creek Reservoir. The model predicts the median EC to within 11% of the median observed, however has a larger variability than the observed dataset. This again can be attributed to the difficulty in reconstructing the operational behaviour of the transfers between reservoirs on the Coxs River and Thompsons Creek Reservoir. The closeness of the median values and the overall match in the shape of the distribution indicate a reasonable match between the modelled and observed data.

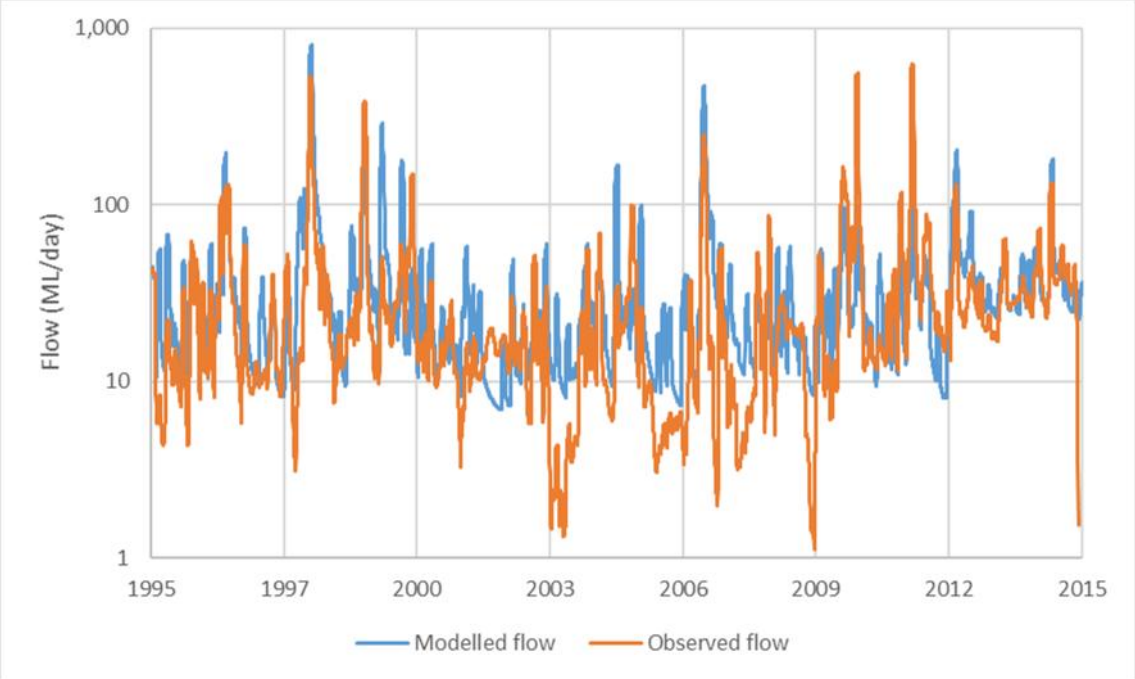


Figure B-3 Modelled and observed daily flow at Coxs River upstream of Springvale Creek

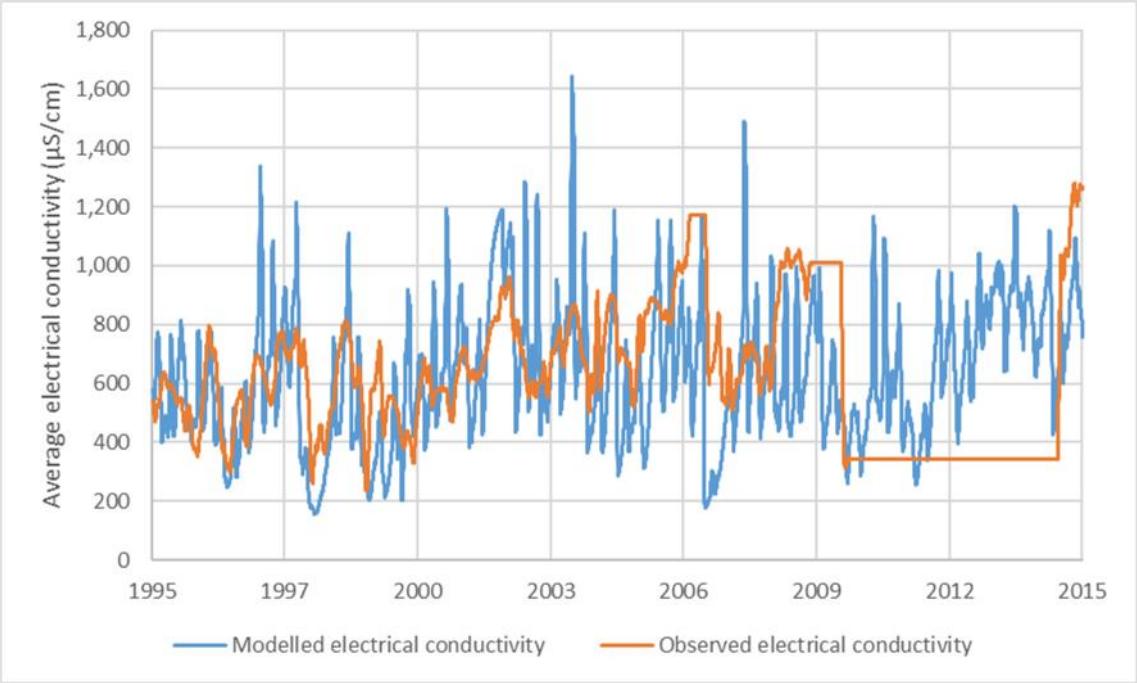


Figure B-4 Modelled and observed daily average EC at Coxs River upstream of Springvale Creek

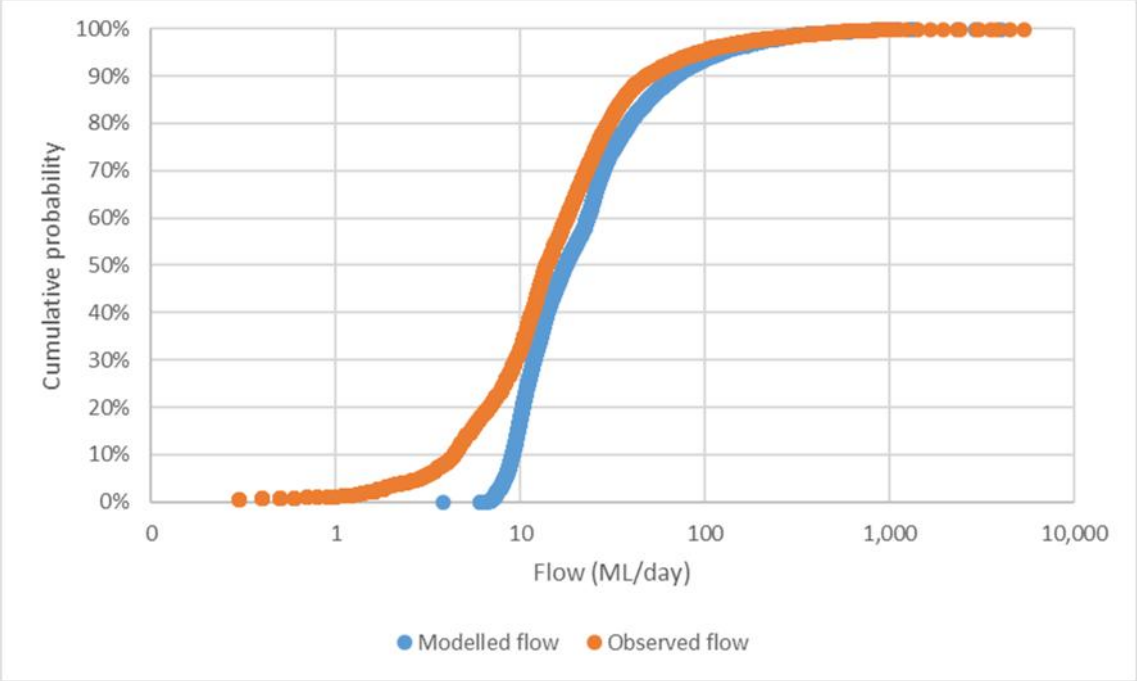


Figure B-5 Modelled and observed cumulative probability distribution of daily flow at Coxs River upstream of Springvale Creek

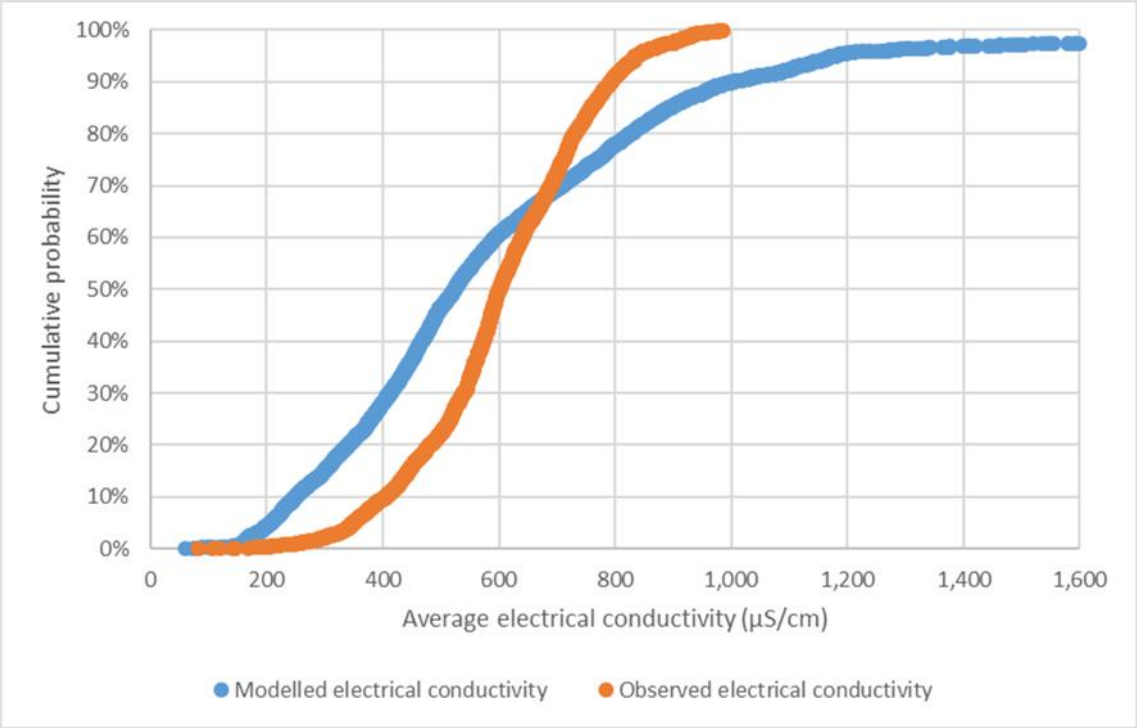


Figure B-6 Modelled and observed cumulative probability distribution of daily average EC at Coxs River upstream of Springvale Creek

B.3.1 Coxs River upstream of Lake Burragorang

Figure B-7 and Figure B-8 present the time series of modelled and observed daily total flow and daily average EC respectively for the monitoring point on the Coxs River upstream of Lake Burragorang. The observed flow and EC data was sourced from WaterNSW for point E083 (referred to as 'Cox's River at Kelpie Point'), as shown in Figure 4-6. This location corresponds with DPI-Water gauge 212250.

The observed EC data had irregular time intervals between observations. To compare the modelled data, the observed EC data was interpolated linearly between observations with the average taken each day. The period before 2005 was excluded from the cumulative probability distribution, which is presented in Figure B-9 and Figure B-10 for daily total flow and daily average EC respectively. The results indicate that the model underestimated median flows by up to 30%, however high and low flows showed minimal variability between modelled and observed results. The closeness of the median values and the overall match in the shape of the distribution indicate a reasonable match between the modelled and observed data.

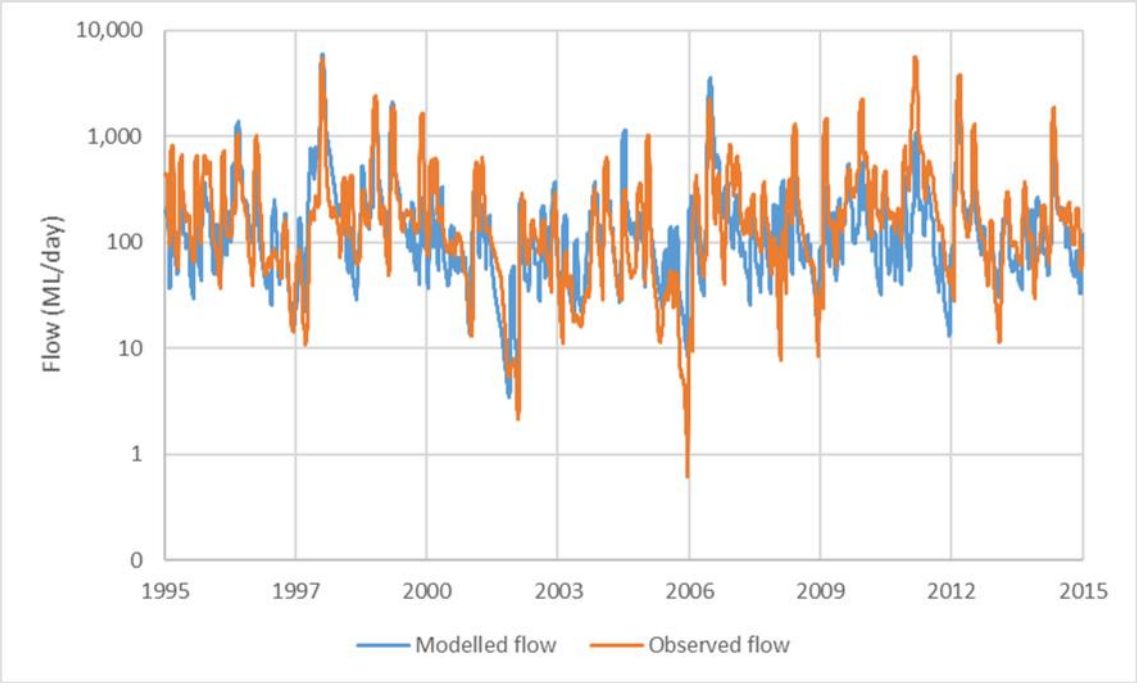


Figure B-7 Modelled and observed daily flow at Coxs River upstream of Lake Burragorang

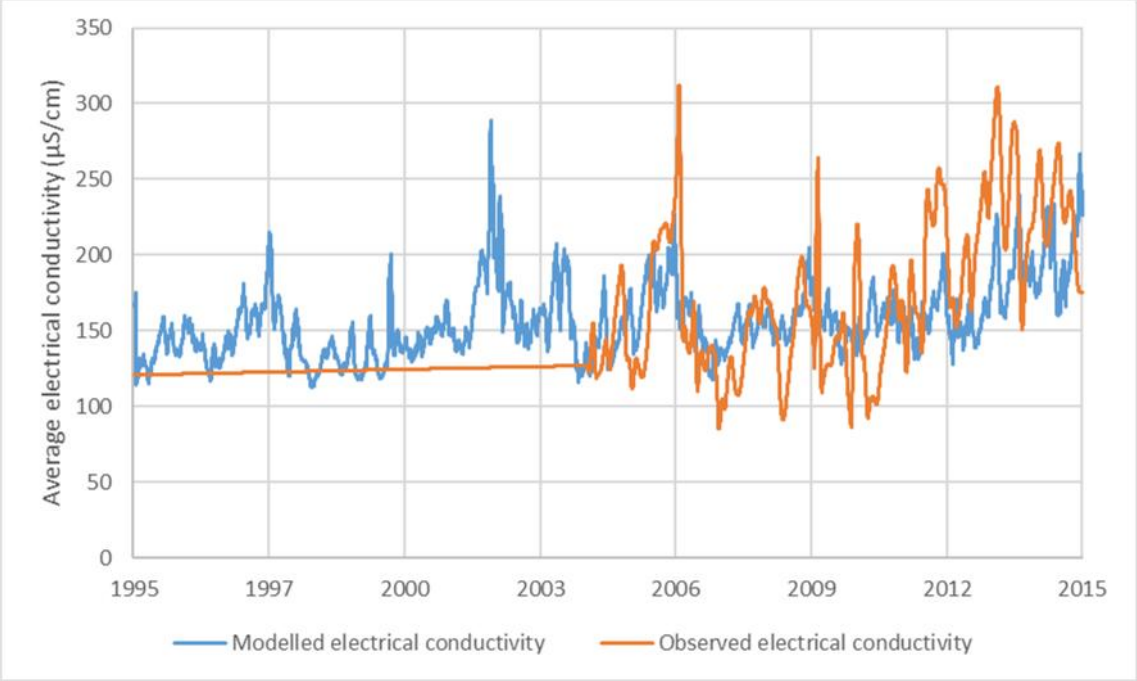


Figure B-8 Modelled and observed daily average EC at Coxs River upstream of Lake Burragorang

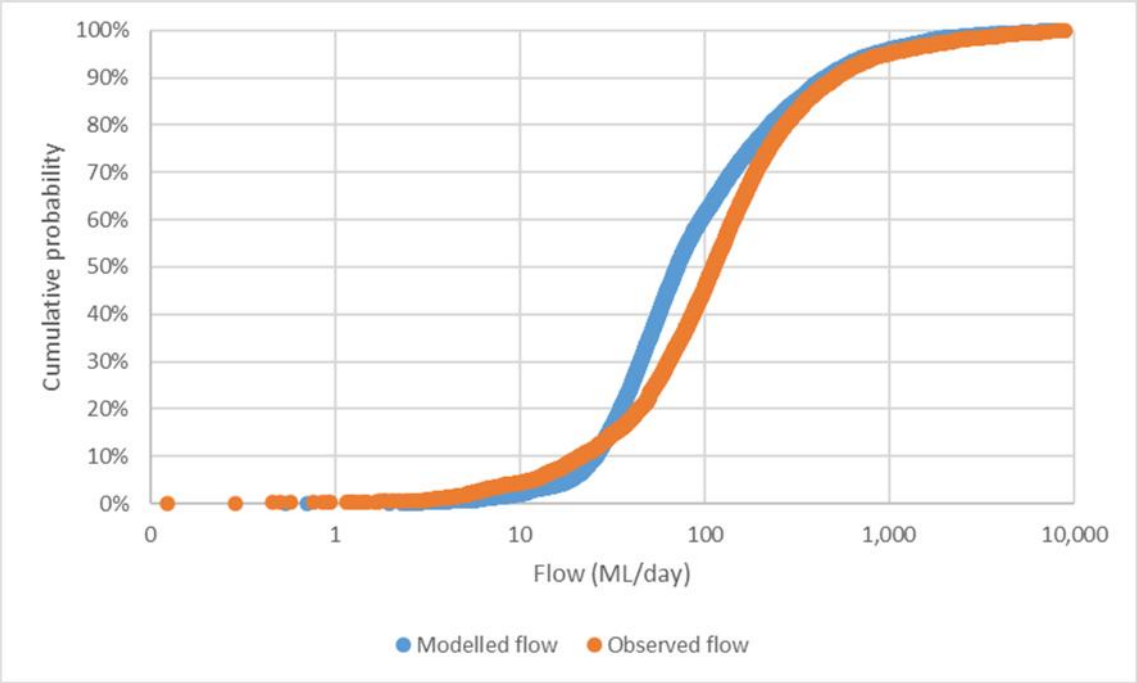


Figure B-9 Modelled and observed cumulative probability distribution of daily flow at Coxs River upstream of Lake Burragorang

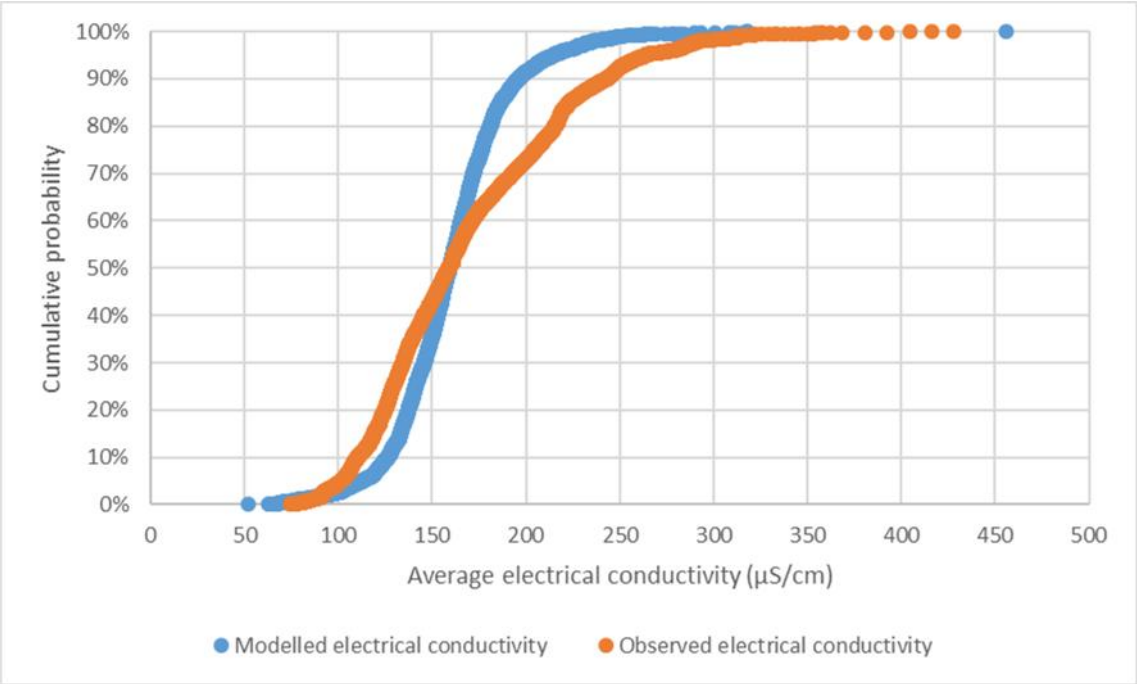


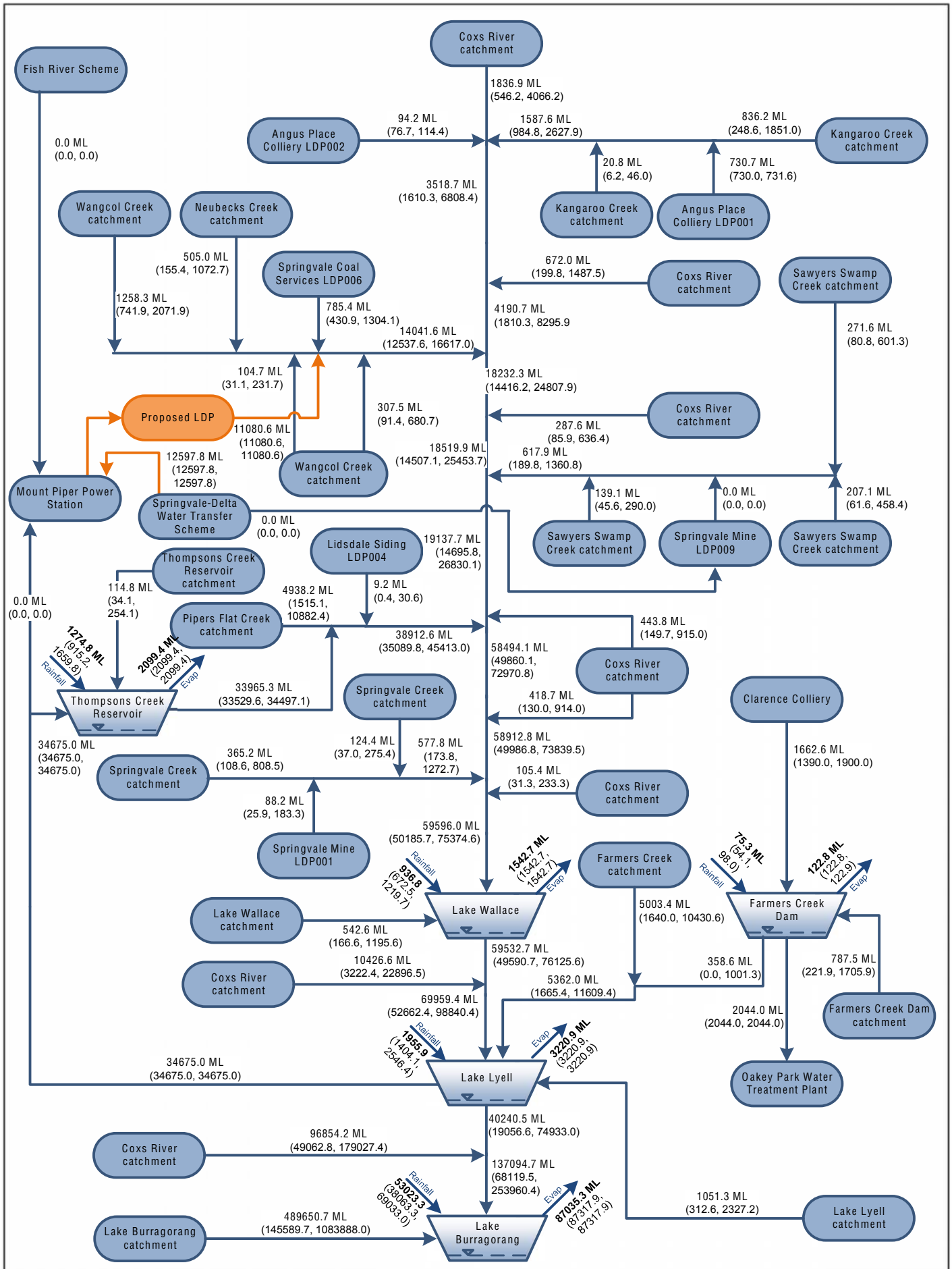
Figure B-10 Modelled and observed cumulative probability distribution of daily average EC at Coxs River upstream of Lake Burragorang

B.4 Additional water and salt balance results

B.4.1 Water balance results

Annual results

The predicted values for each of the water transfers within the Coxs River catchment for proposed conditions in 2030 are provided in Figure B-11, Figure B-12, Figure B-13 and Figure B-14 for scenarios 1, 2, 4 and 5 respectively.



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LOCATION	Coxs River
SEAM	NA
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

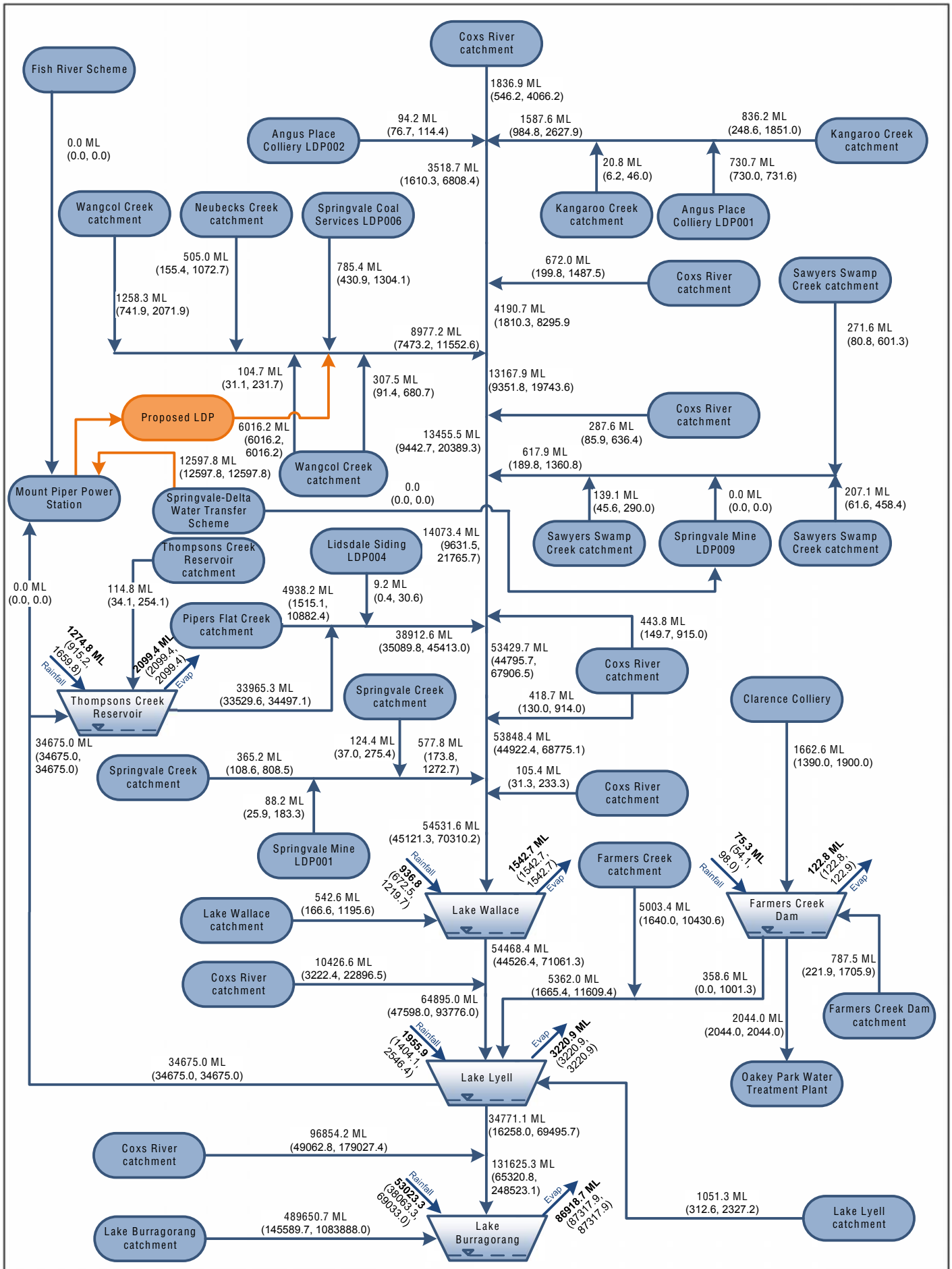
Springvale Water Treatment Project
Water Resources Impact Assessment

Annual water transfers
Proposed conditions (2030)
Scenario 1

Centennial Coal
EnergyAustralia

DATE Jul 2016

Figure B-11



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LOCATION	Coxs River
SEAM	NA
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

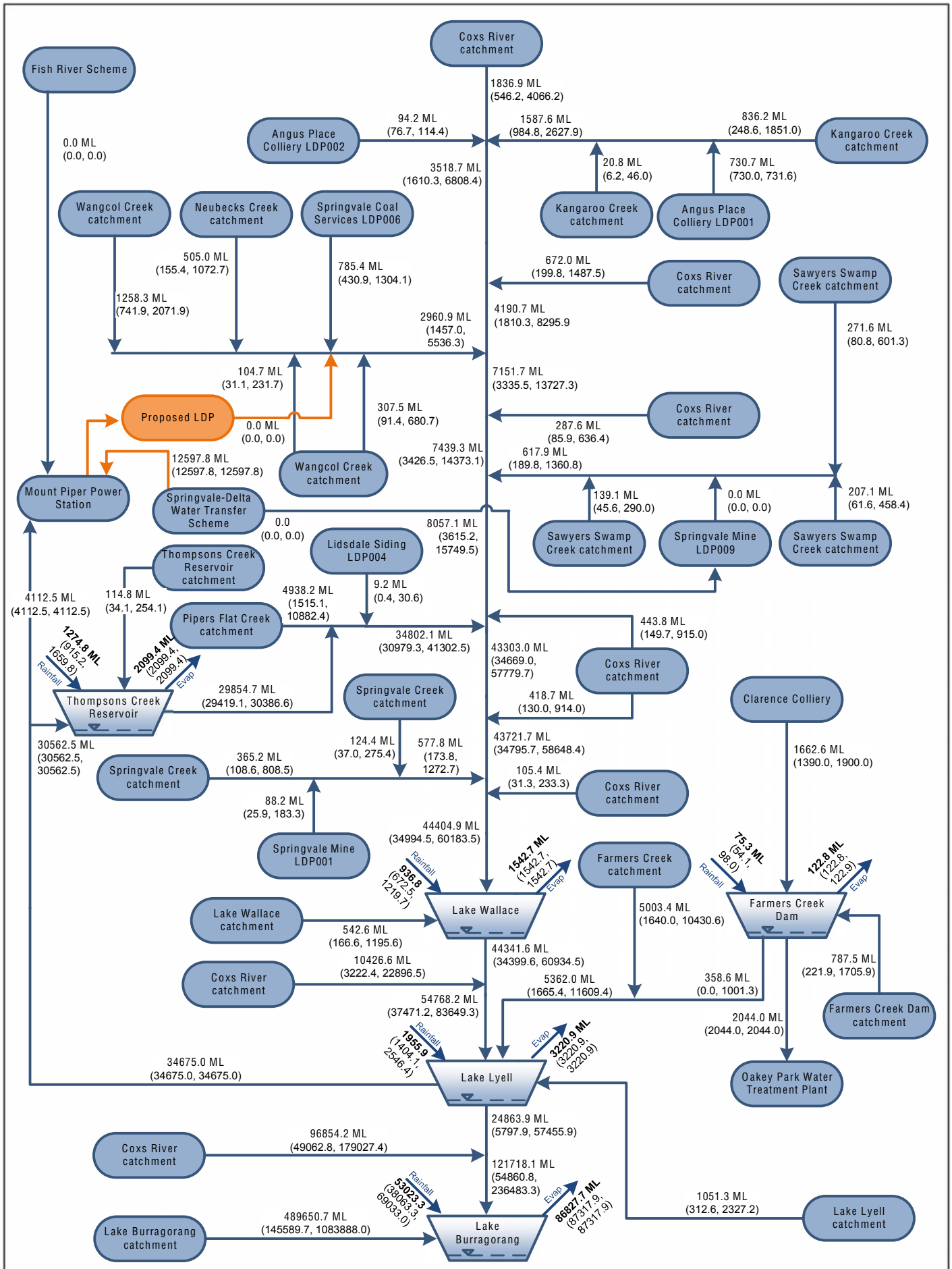
Springvale Water Treatment Project
Water Resources Impact Assessment

Annual water transfers
Proposed conditions (2030)
Scenario 2

Centennial Coal
EnergyAustralia

DATE Jul 2016

Figure B-12



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LOCATION	Coxs River
SEAM	NA
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

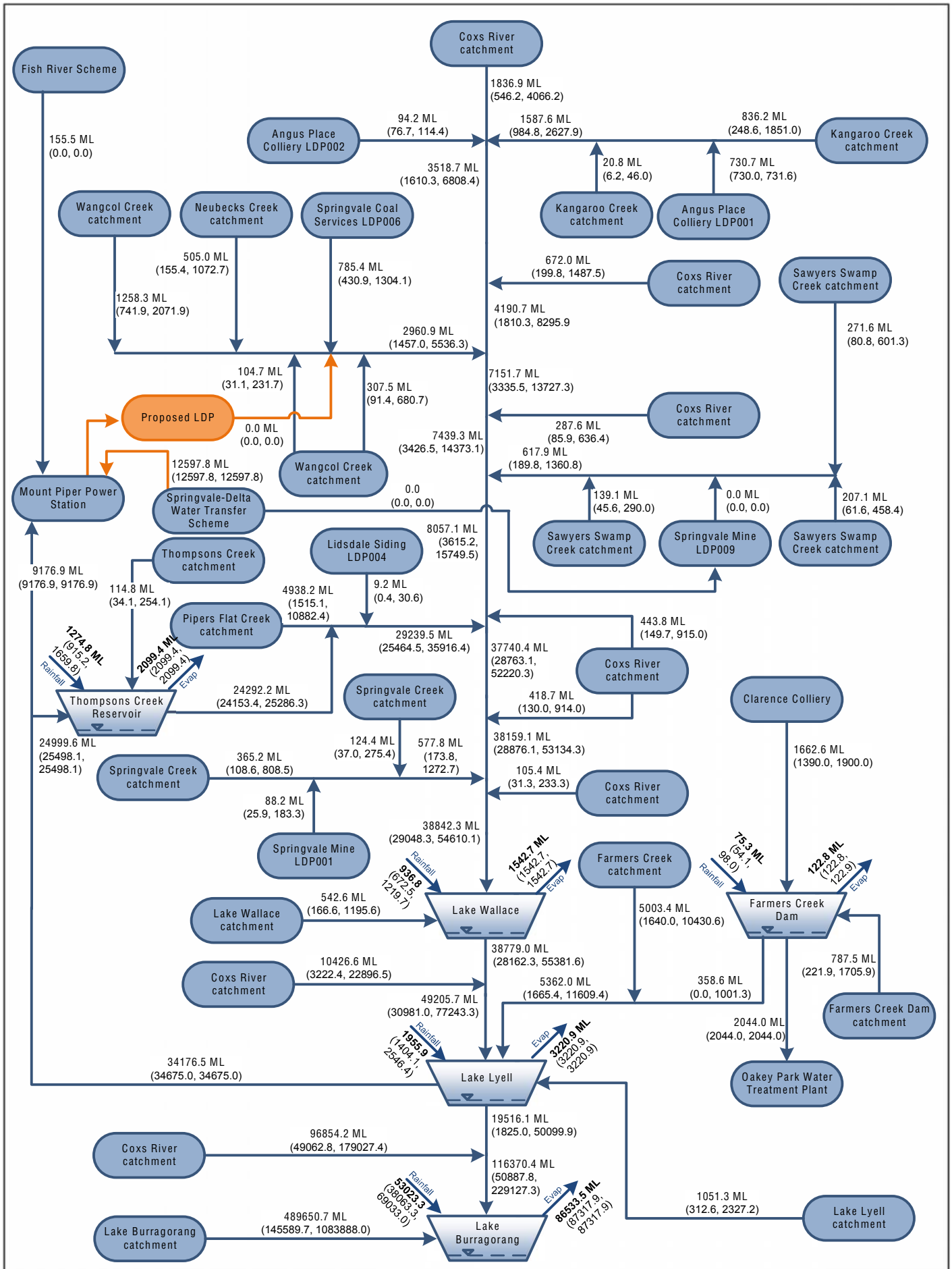
Springvale Water Treatment Project
Water Resources Impact Assessment

Annual water transfers
Proposed conditions (2030)
Scenario 4

Centennial Coal
EnergyAustralia

DATE Jul 2016

Figure B-13



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LOCATION	Coxs River
SEAM	NA
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

Springvale Water Treatment Project
Water Resources Impact Assessment

Annual water transfers
Proposed conditions (2030)
Scenario 5

Centennial Coal
EnergyAustralia

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Figure B-14

Time series results

Monthly average time series results are presented for scenarios 1, 2, 4 and 5 are presented in Figure B-15 to B-46.

Scenario 1

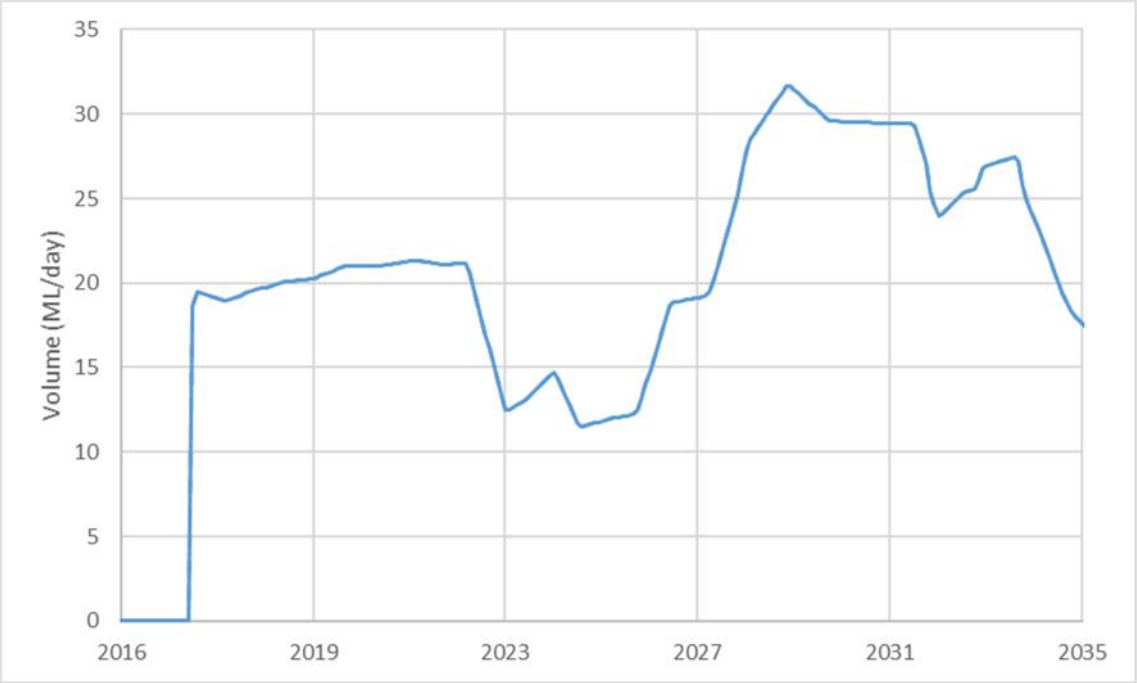


Figure B-15 Scenario 1 – Predicted proposed LDP discharge

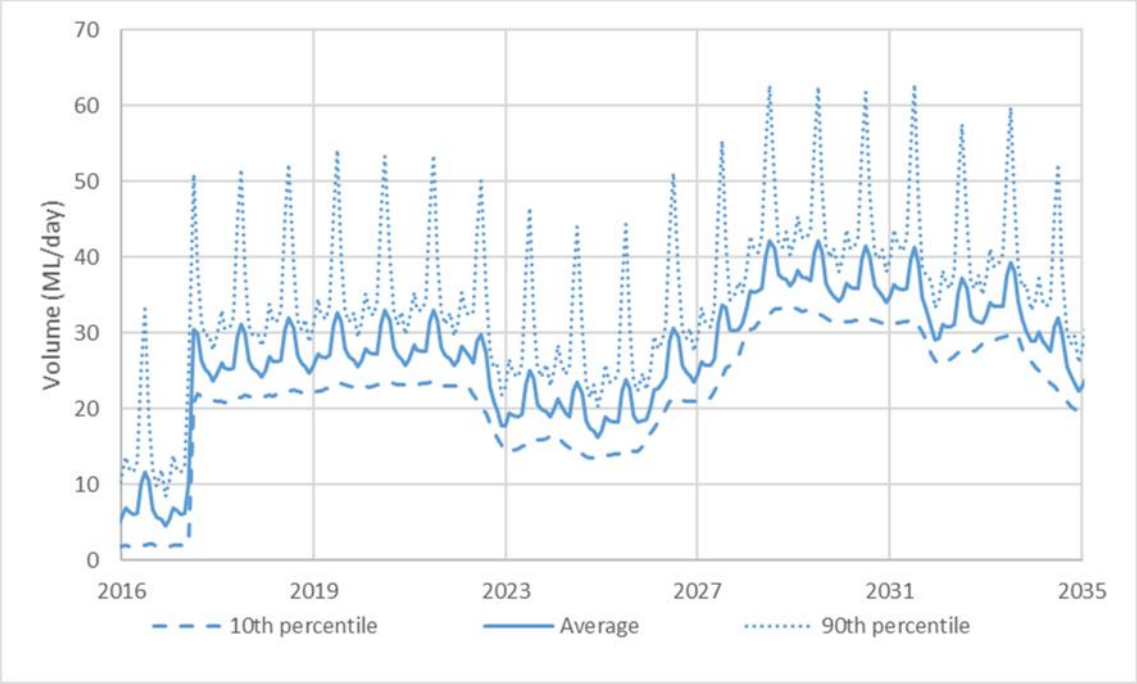


Figure B-16 Scenario 1 – Predicted flow of Wangcol Creek at LDPs

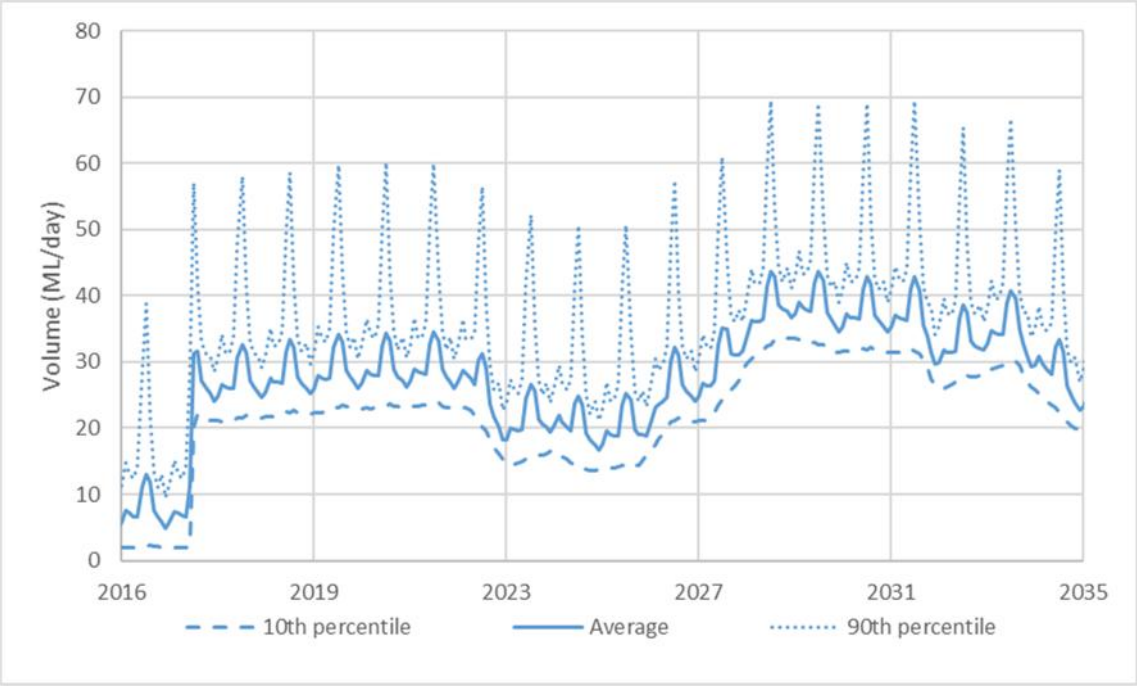


Figure B-17 Scenario 1 – Predicted flow of Wangcol Creek at the confluence with the Coxs River

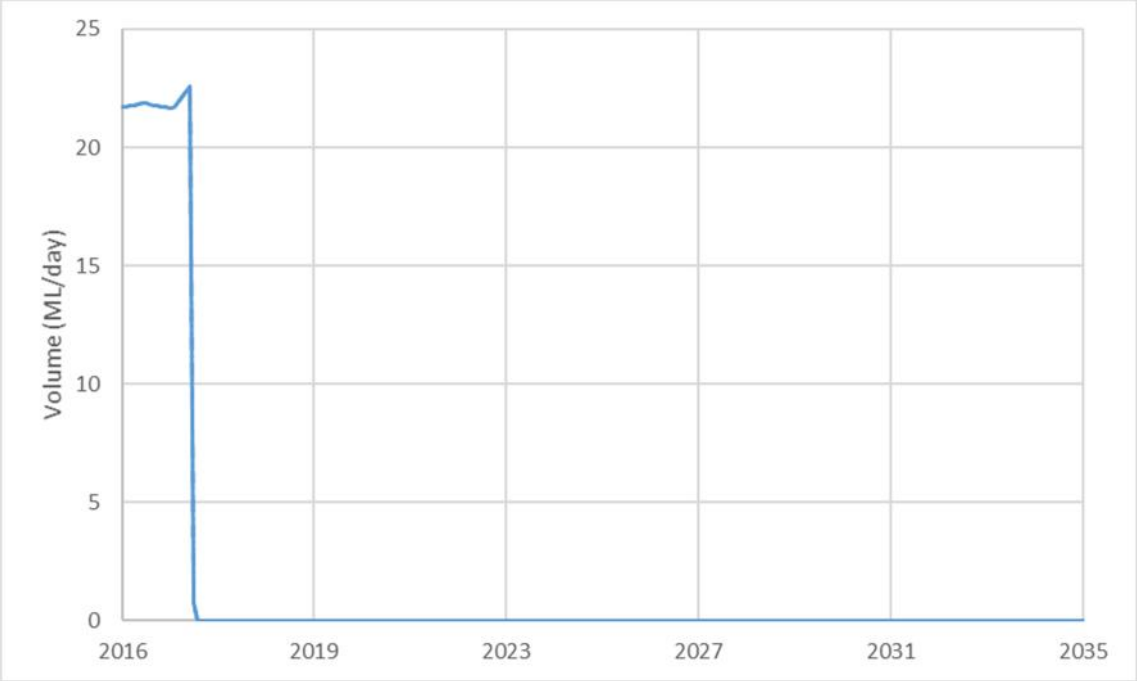


Figure B-18 Scenario 1 – Predicted LDP009 discharge to Sawyers Swamp Creek

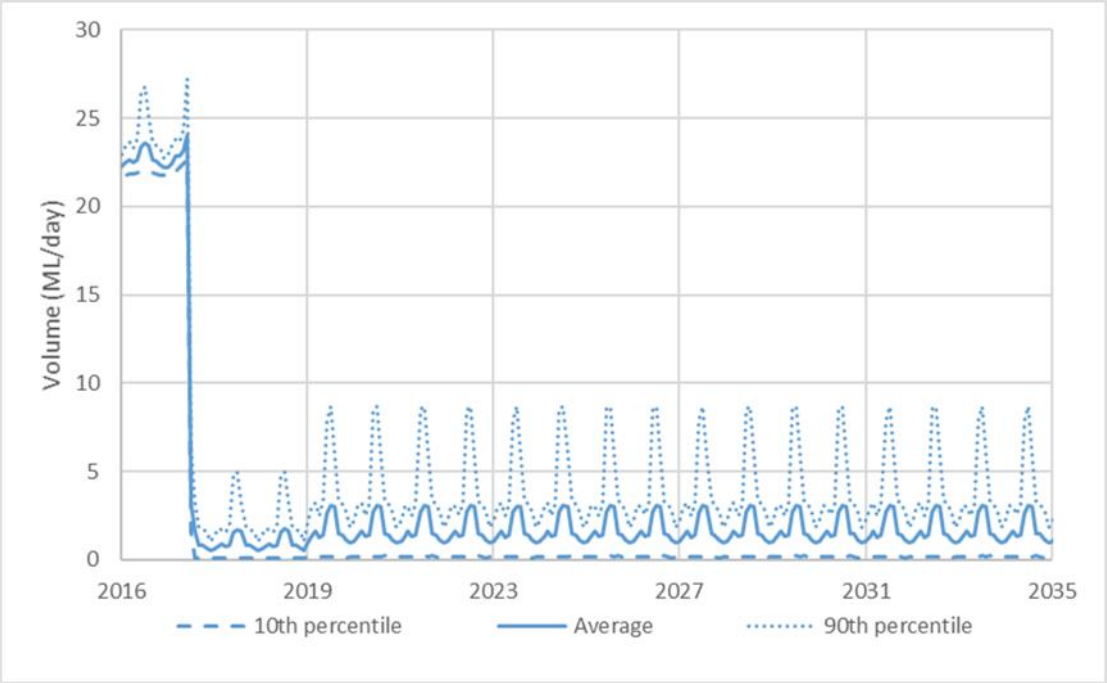


Figure B-19 Scenario 1 – Predicted flow of Sawyers Swamp Creek at the confluence with the Coxs River

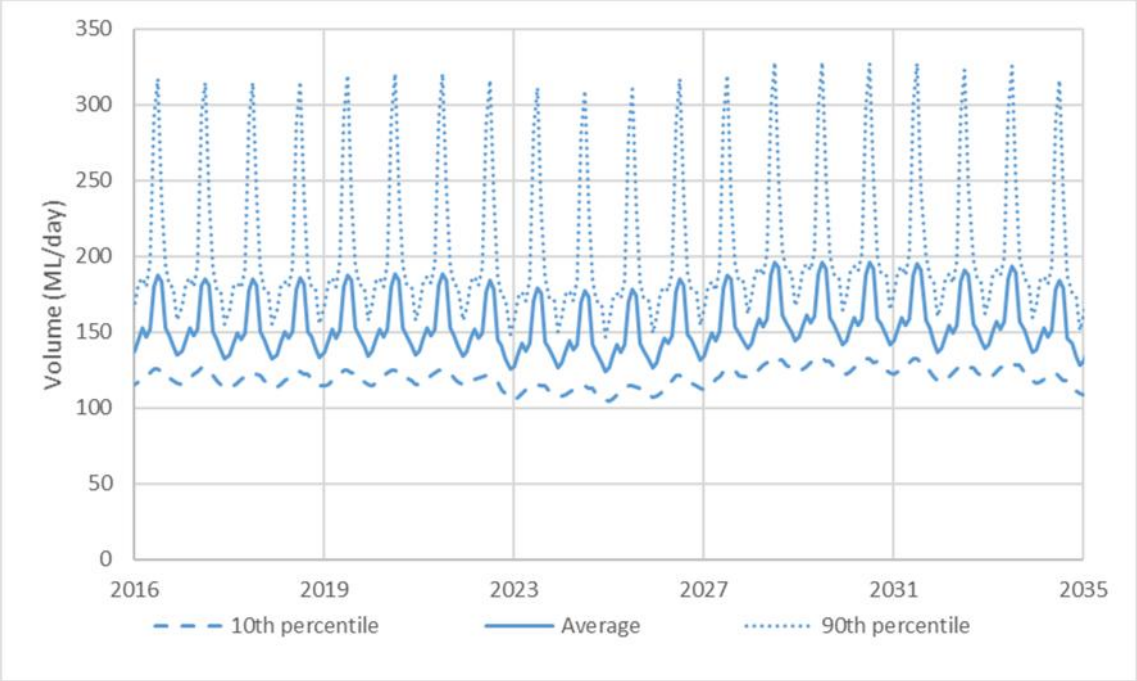


Figure B-20 Scenario 1 – Predicted flow from Coxs River to Lake Wallace

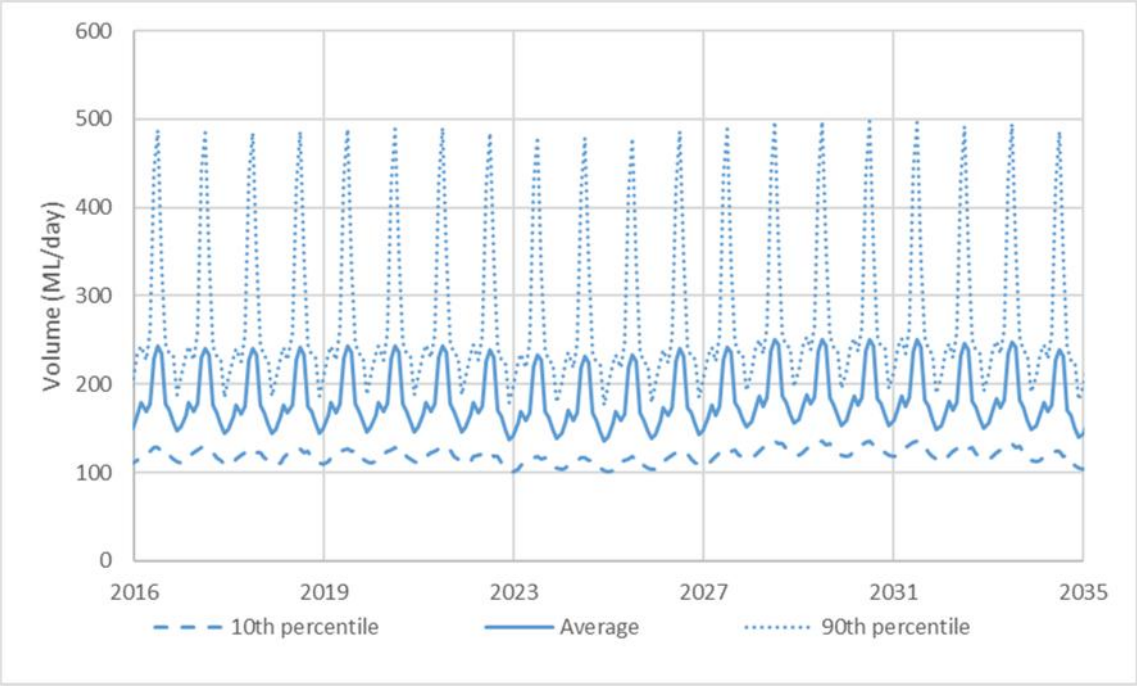


Figure B-21 Scenario 1 – Predicted flow from Coxs River to Lake Lyell

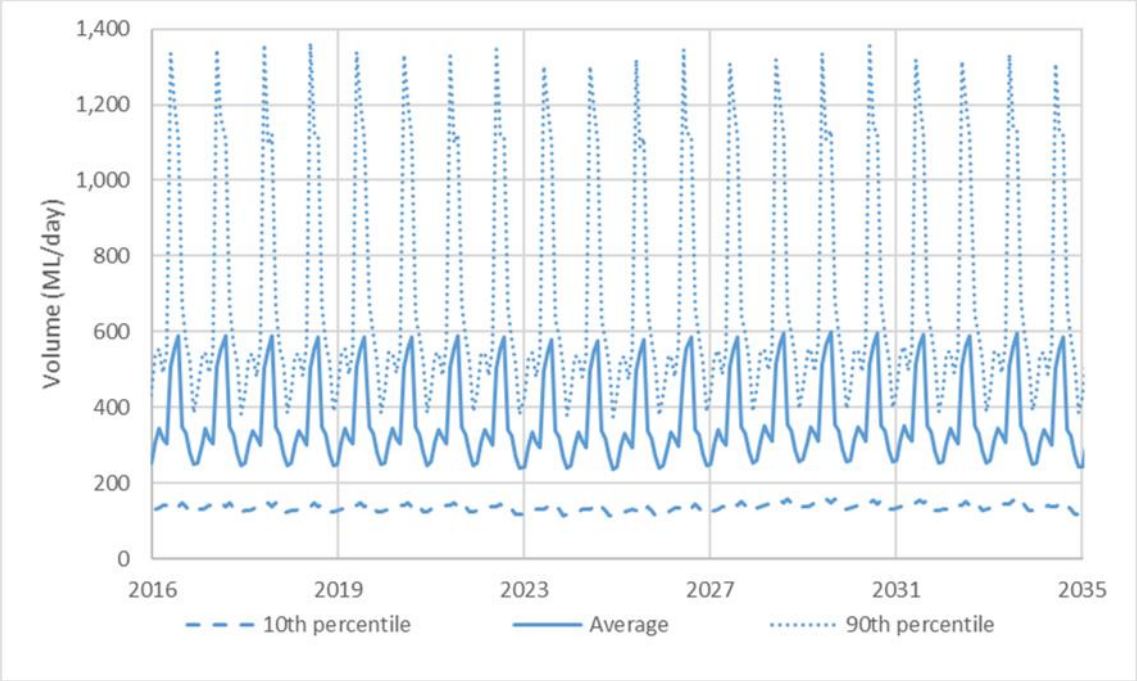


Figure B-22 Scenario 1 – Predicted discharge from Coxs River to Lake Burragorang

Scenario 2

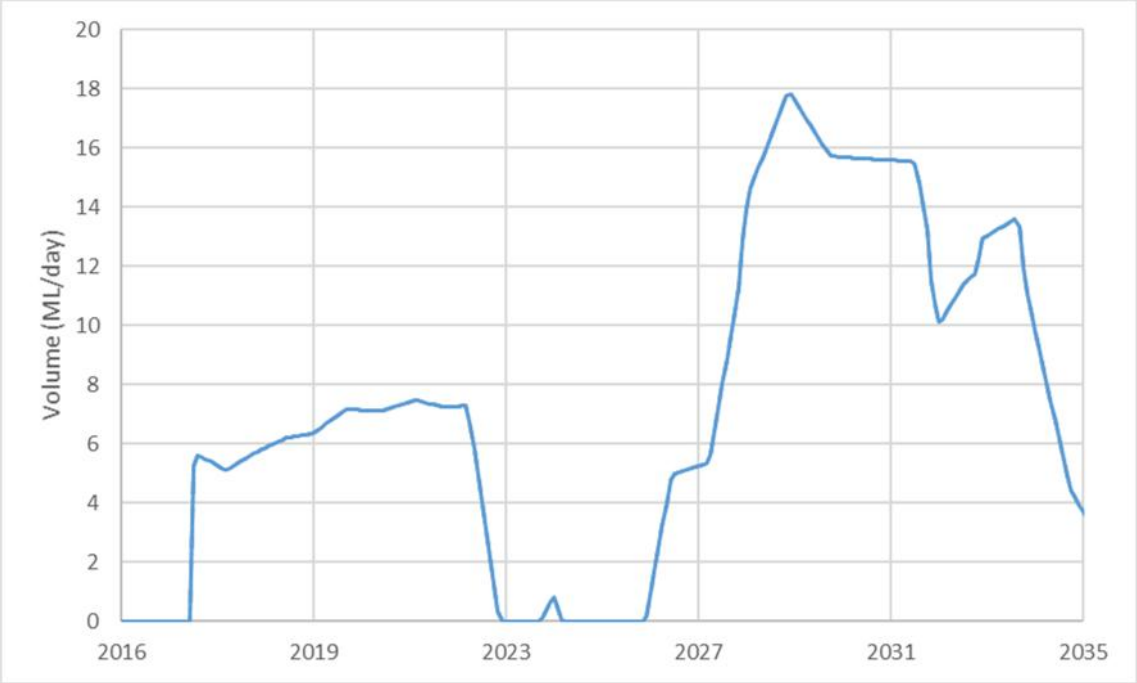


Figure B-23 Scenario 2 – Predicted proposed LDP discharge

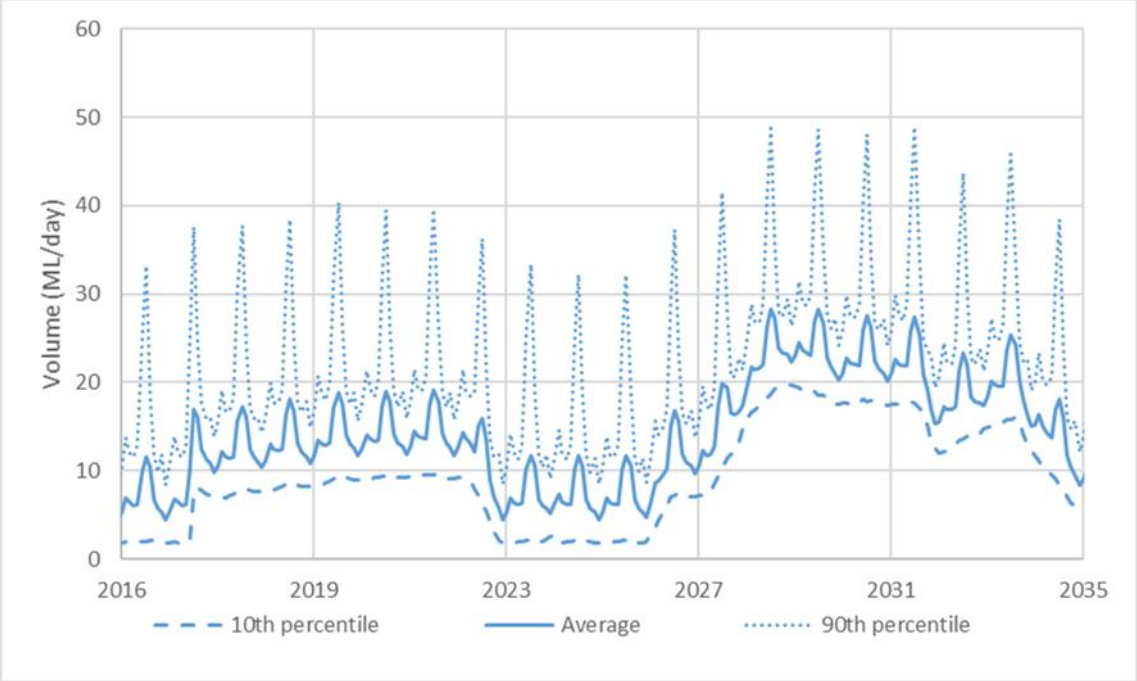


Figure B-24 Scenario 2 – Predicted flow of Wangcol Creek at LDPs

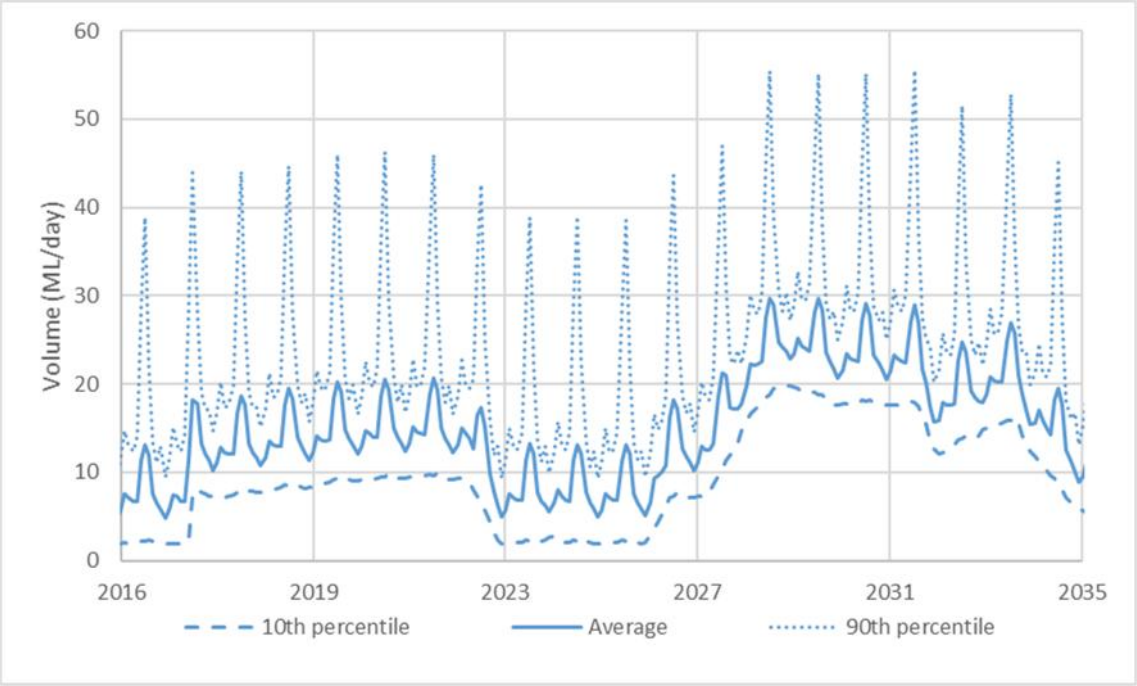


Figure B-25 Scenario 2 – Predicted flow of Wangcol Creek at the confluence with the Coxs River

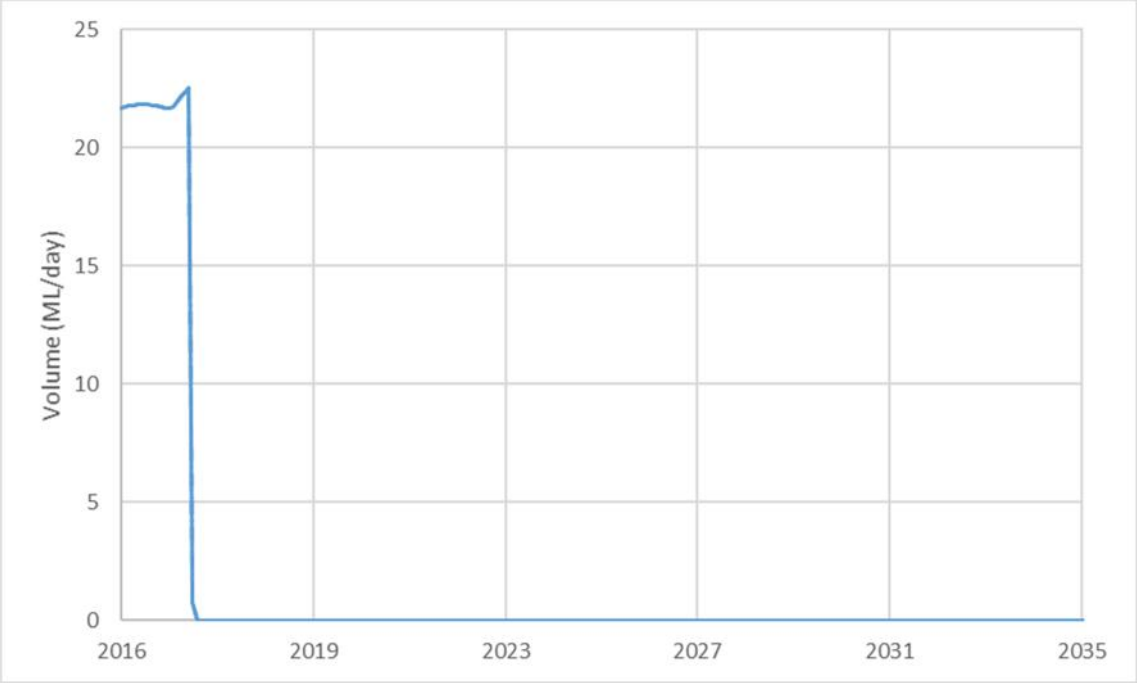


Figure B-26 Scenario 2 – Predicted LDP009 discharge to Sawyers Swamp Creek

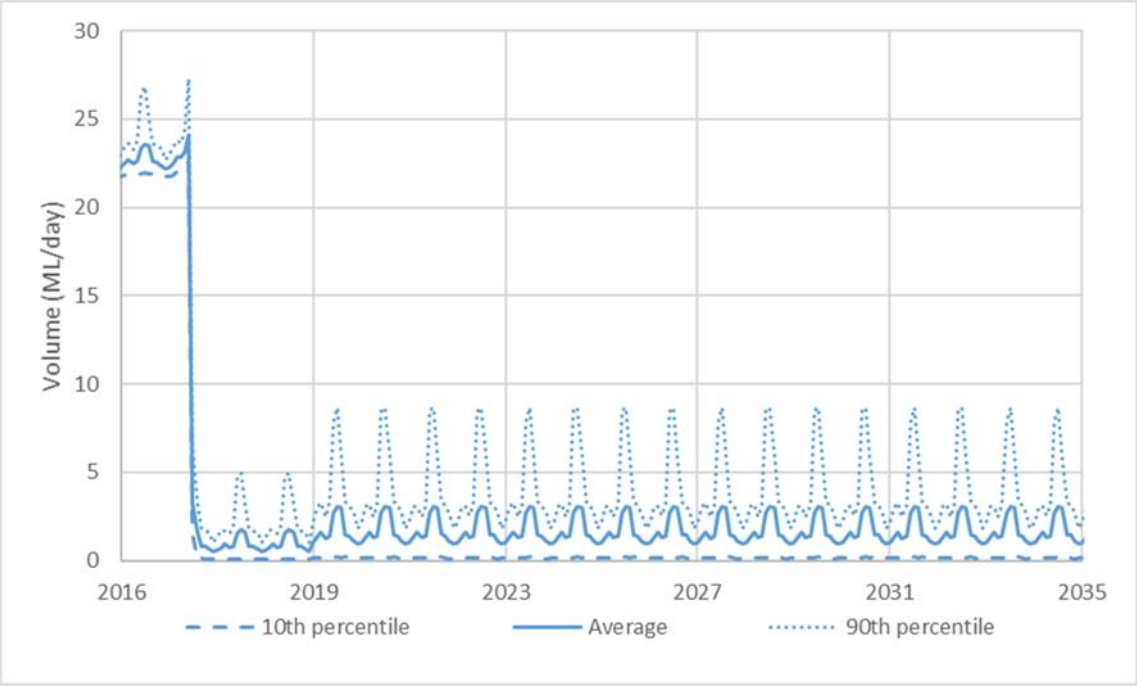


Figure B-27 Scenario 2 – Predicted flow of Sawyers Swamp Creek at the confluence with the Coxs River

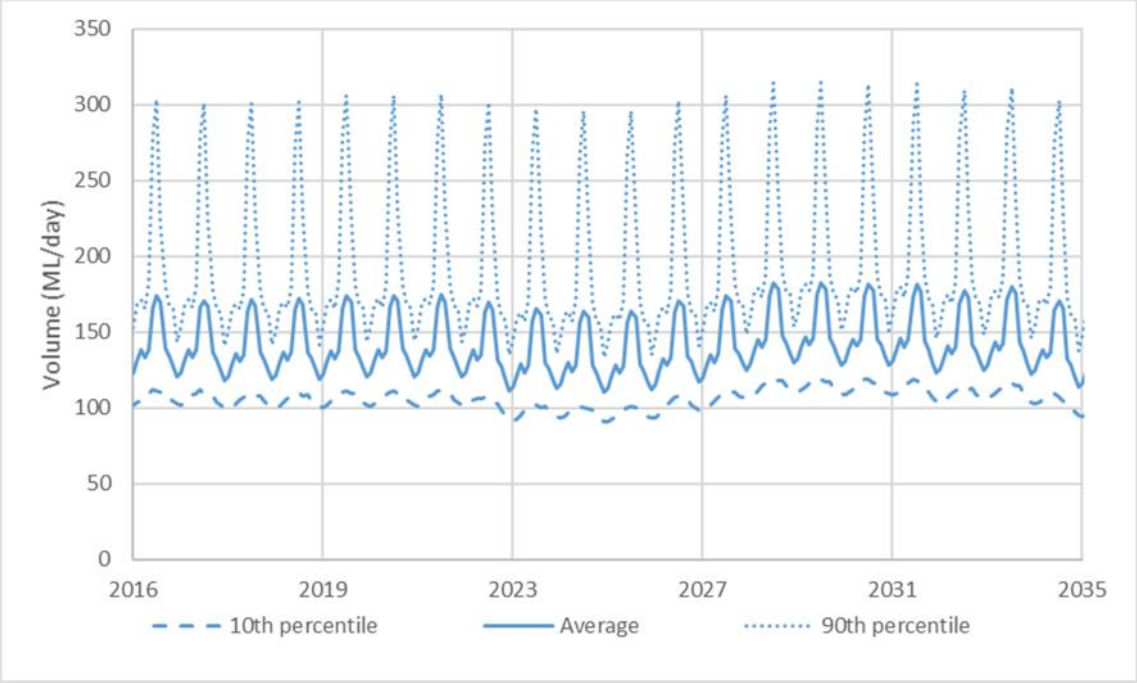


Figure B-28 Scenario 2 – Predicted flow from Coxs River to Lake Wallace

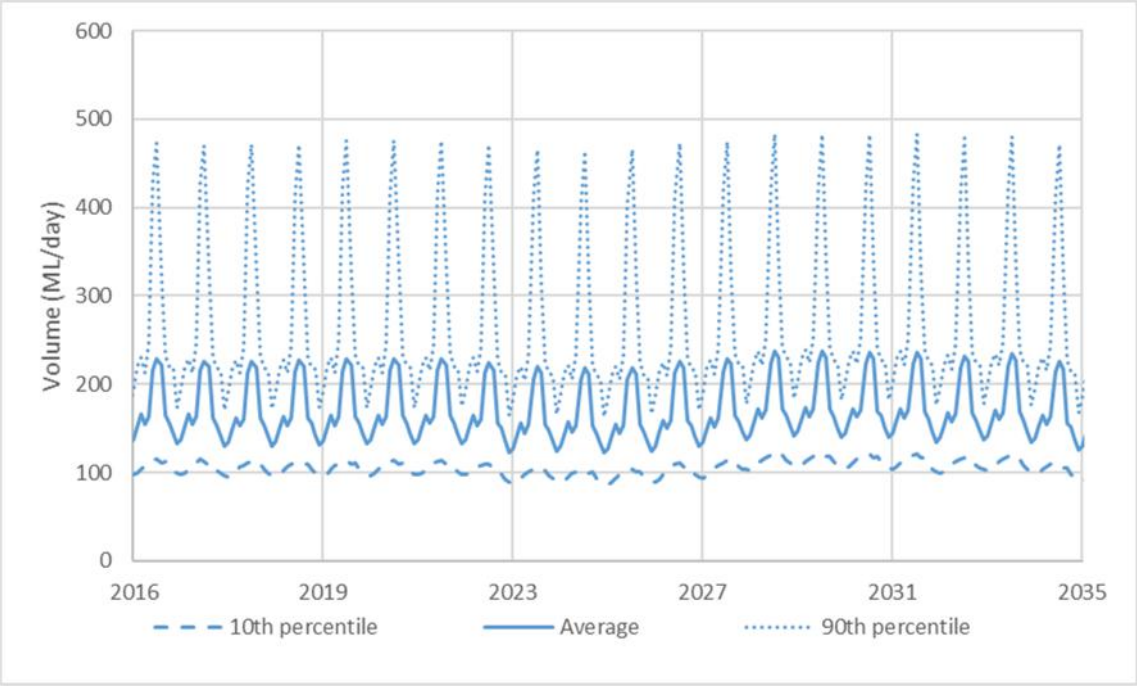


Figure B-29 Scenario 2 – Predicted flow from Coxs River to Lake Lyell

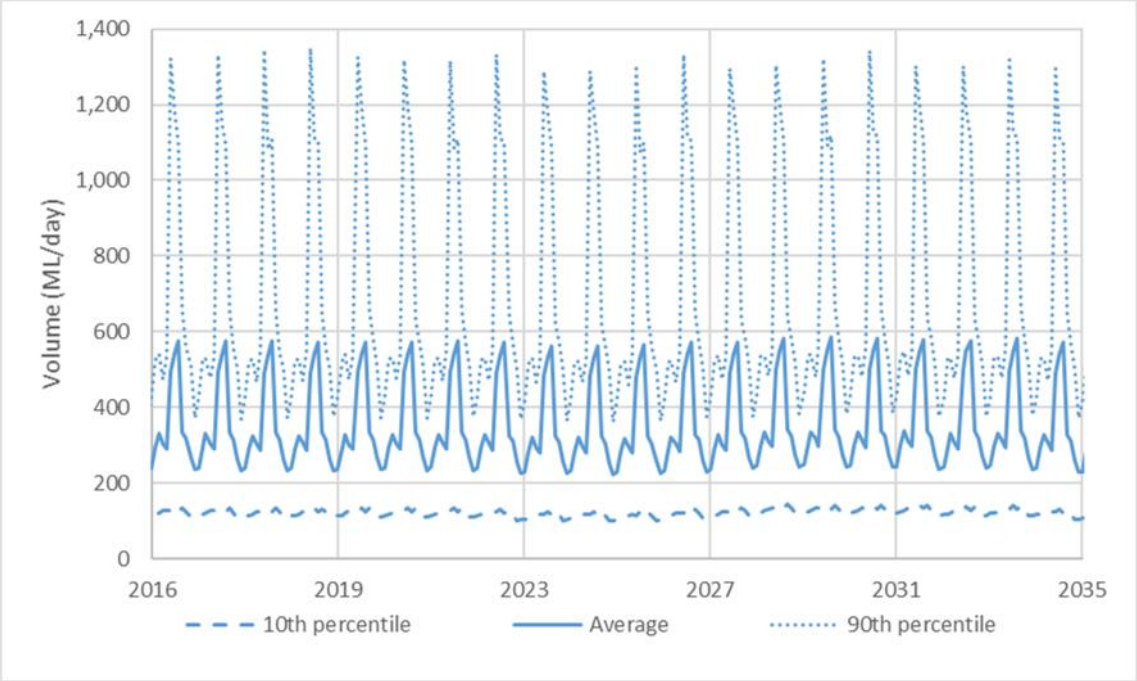


Figure B-30 Scenario 2 – Predicted discharge from Coxs River to Lake Burragorang

Scenario 4

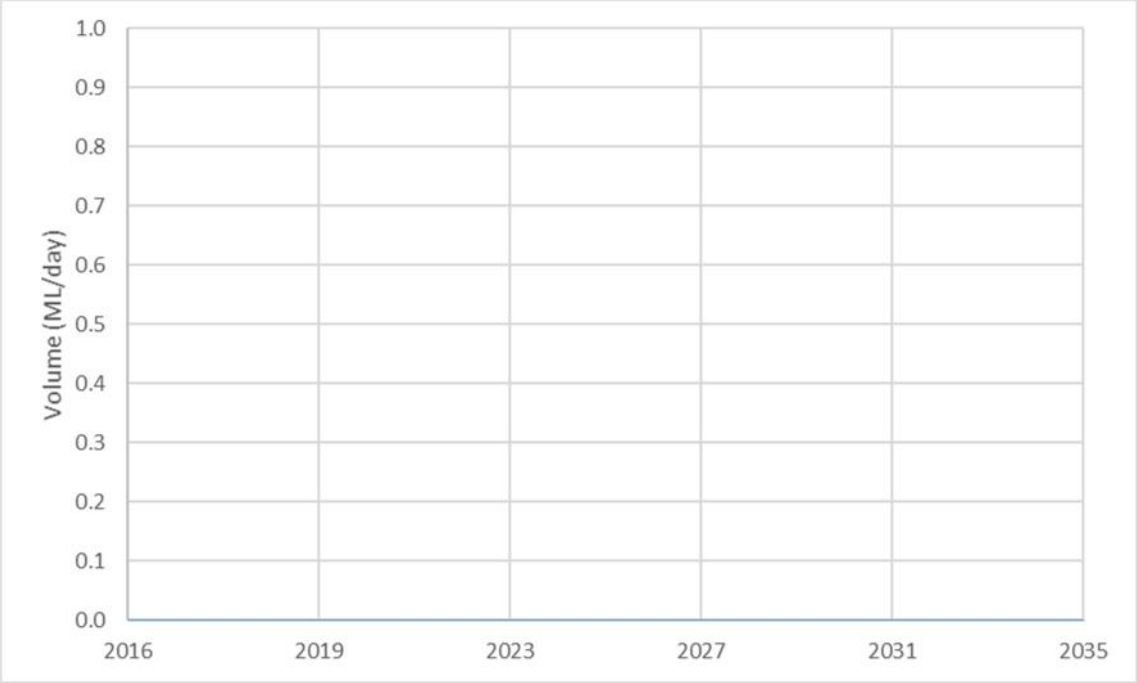


Figure B-31 Scenario 4 – Predicted proposed LDP discharge

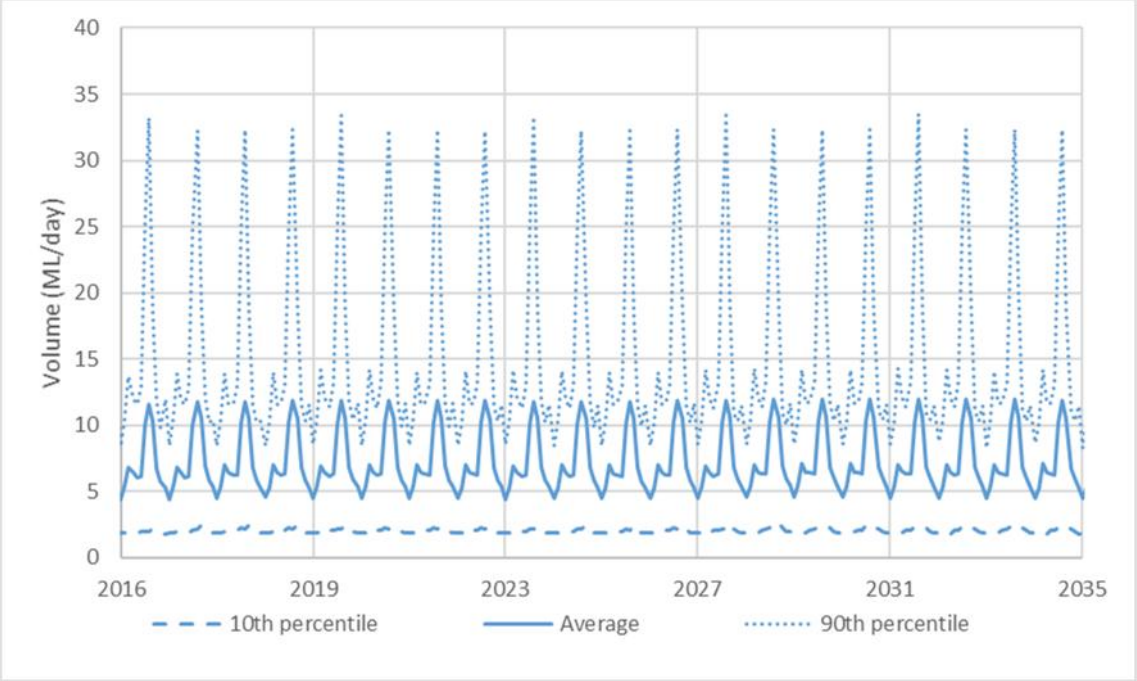


Figure B-32 Scenario 4 – Predicted flow of Wangcol Creek at LDPs

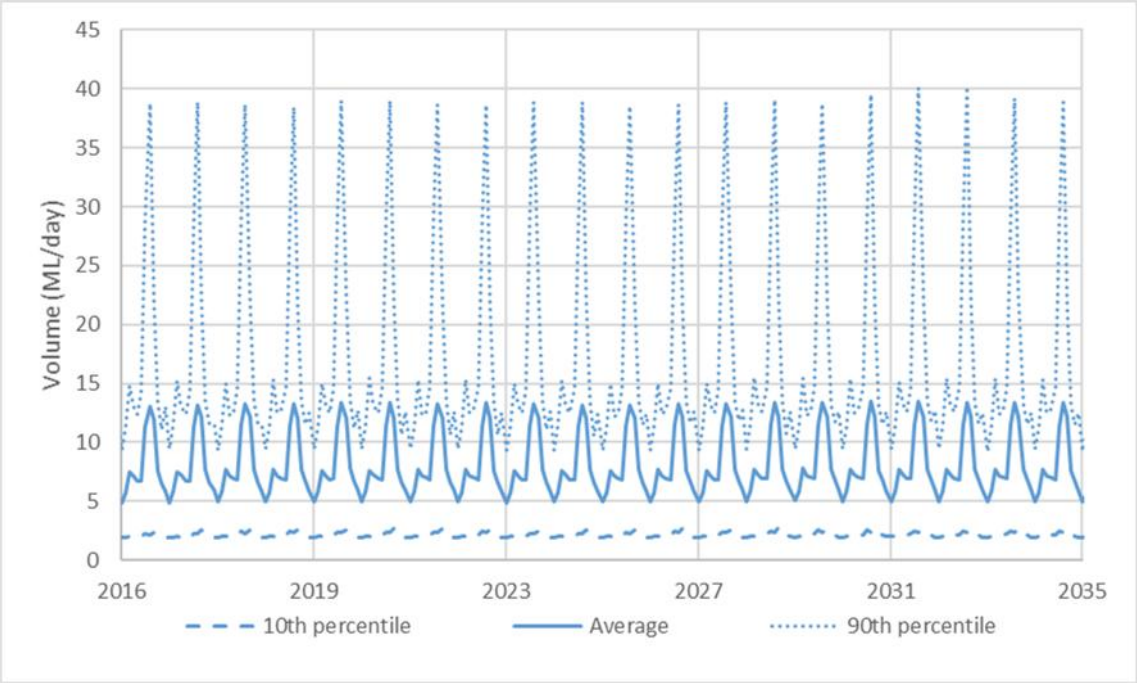


Figure B-33 Scenario 4 – Predicted flow of Wangcol Creek at the confluence with the Coxs River

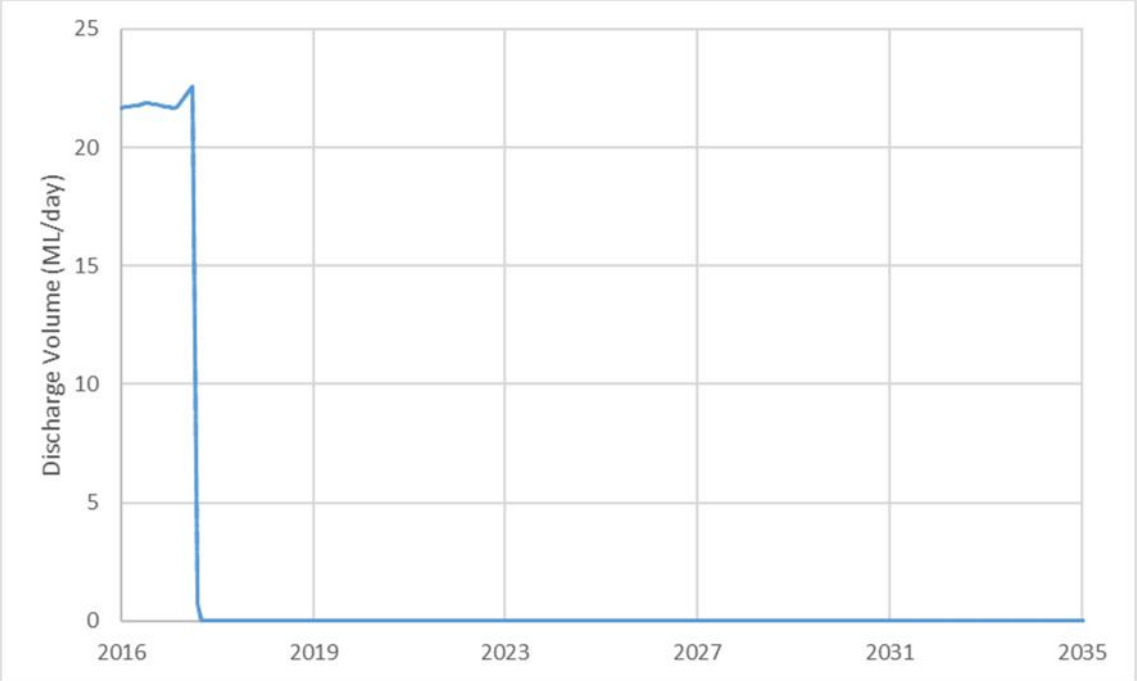


Figure B-34 Scenario 4 – Predicted LDP009 discharge to Sawyers Swamp Creek

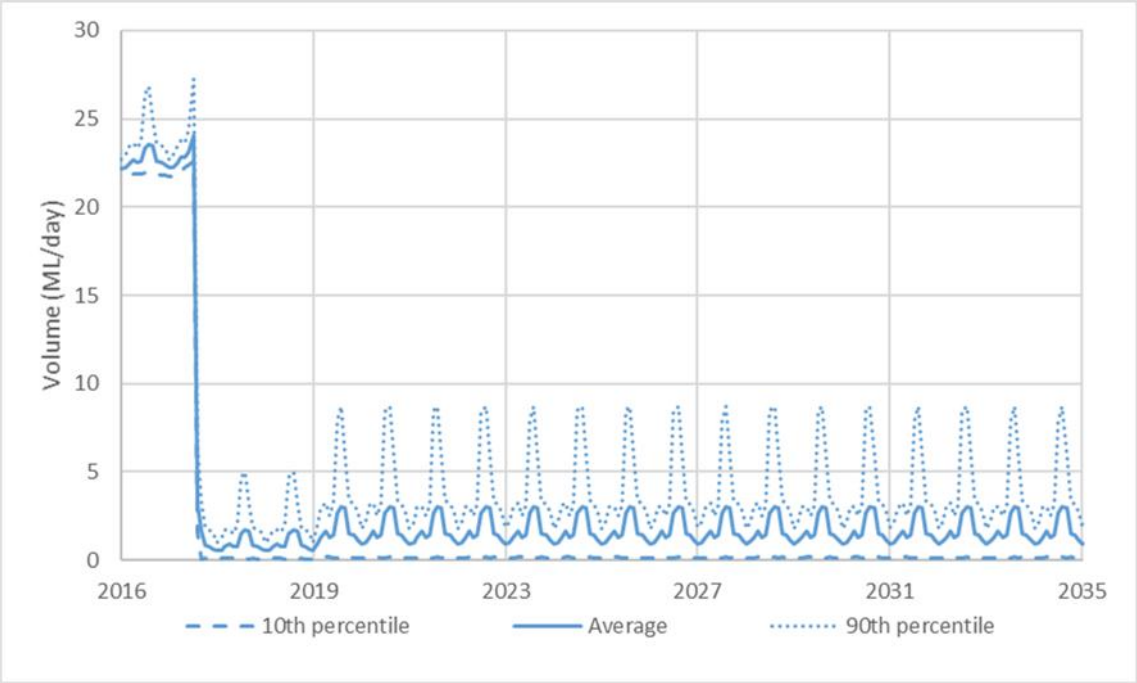


Figure B-35 Scenario 4 – Predicted flow of Sawyers Swamp Creek at the confluence with the Coxs River

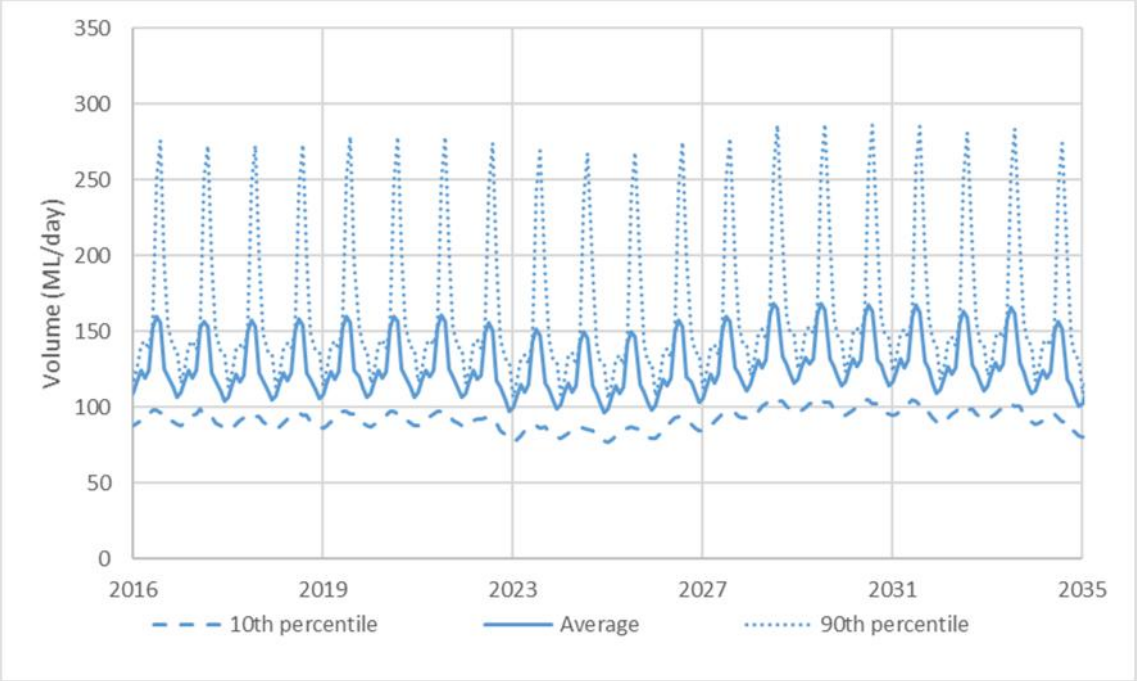


Figure B-36 Scenario 4 – Predicted flow from Coxs River to Lake Wallace

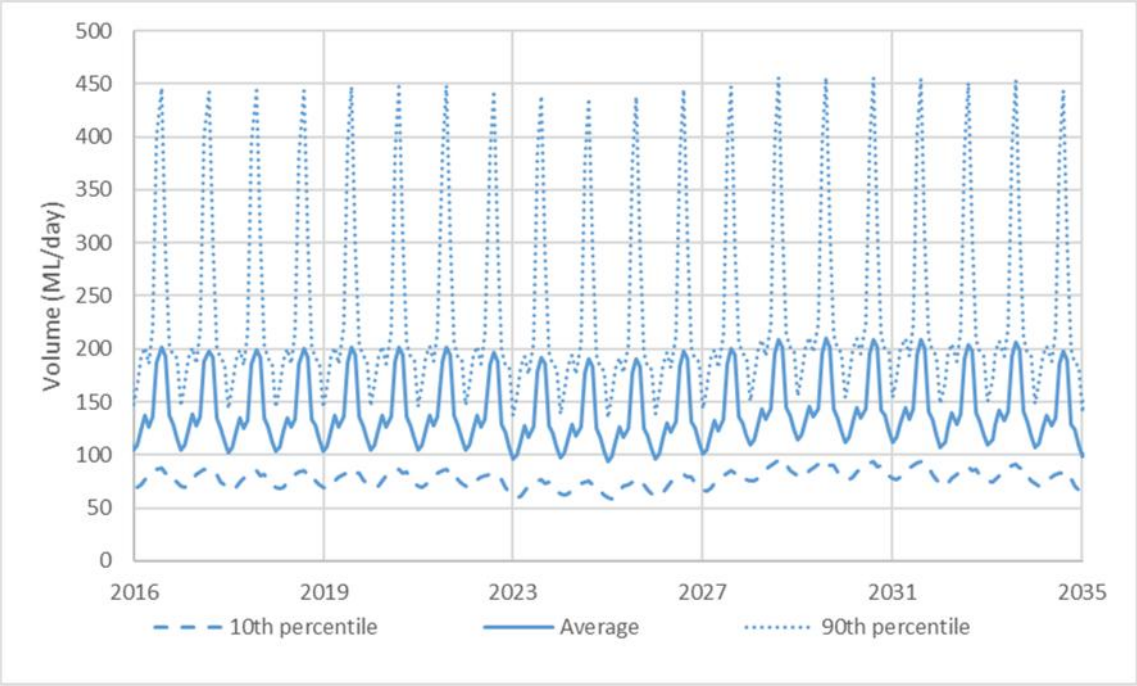


Figure B-37 Scenario 4 – Predicted flow from Coxs River to Lake Lyell

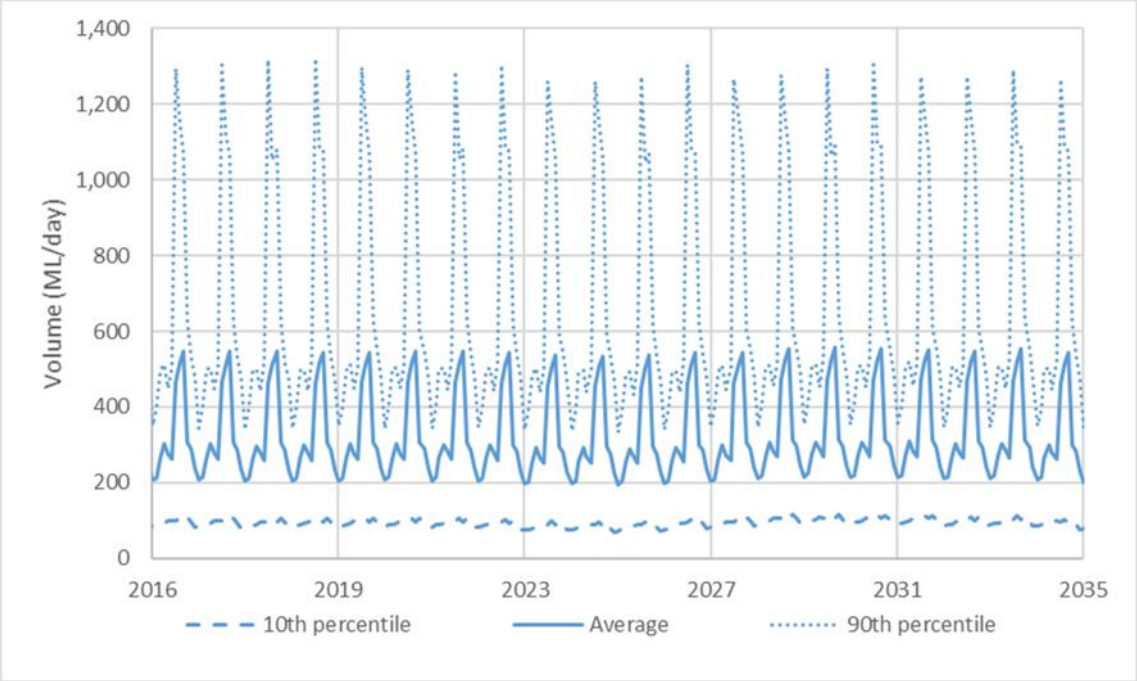


Figure B-38 Scenario 4 – Predicted discharge from Coxs River to Lake Burragorang

Scenario 5

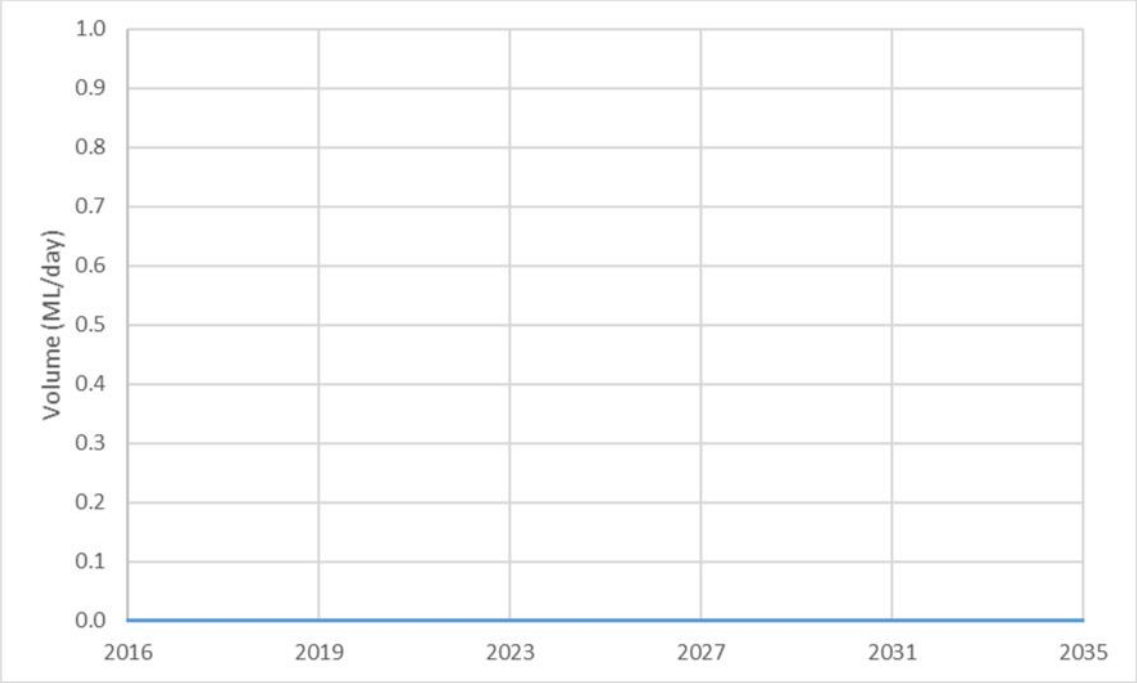


Figure B-39 Scenario 5 – Predicted proposed LDP discharge

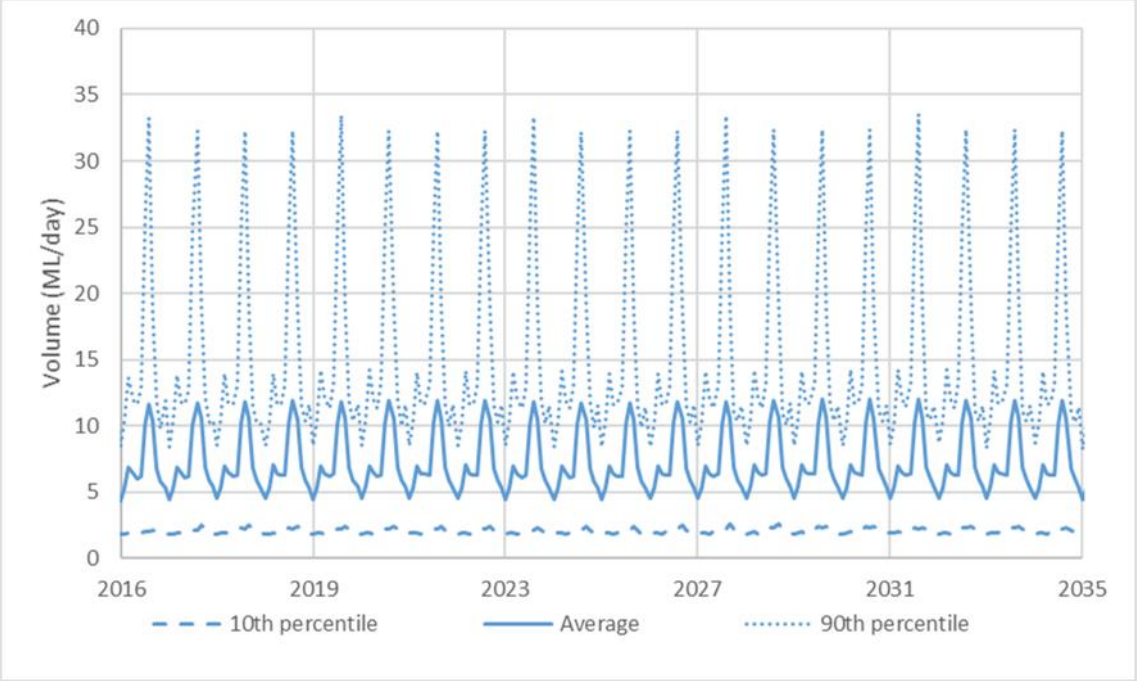


Figure B-40 Scenario 5 – Predicted flow of Wangcol Creek at LDPs

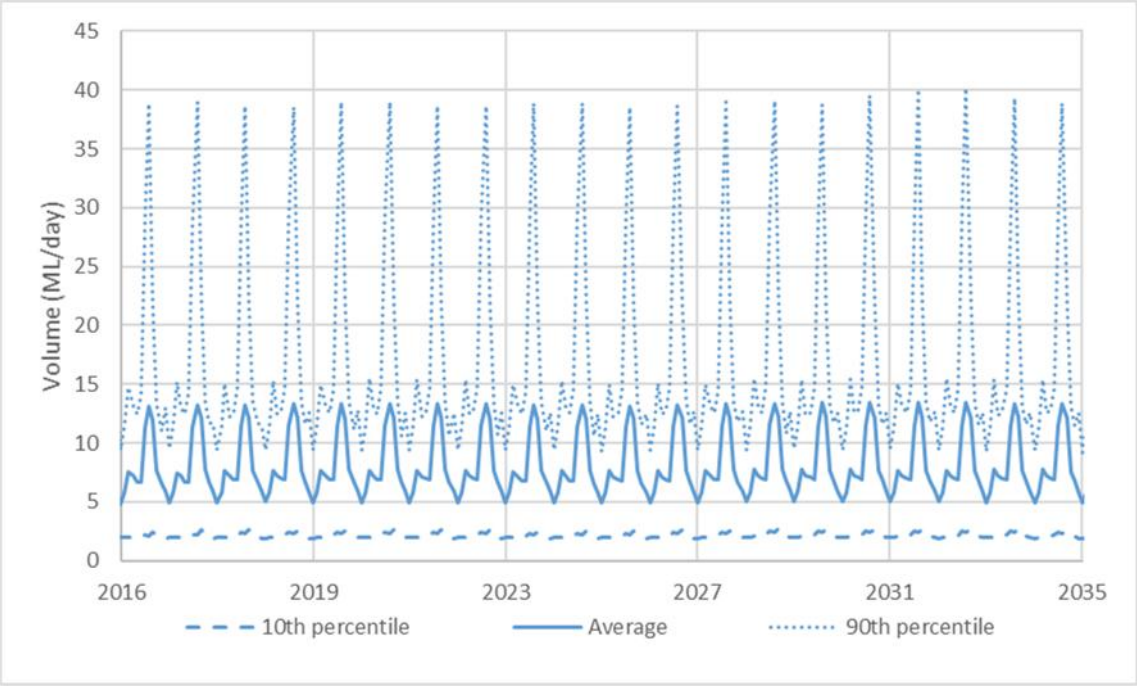


Figure B-41 Scenario 5 – Predicted flow of Wangcol Creek at the confluence with the Coxs River

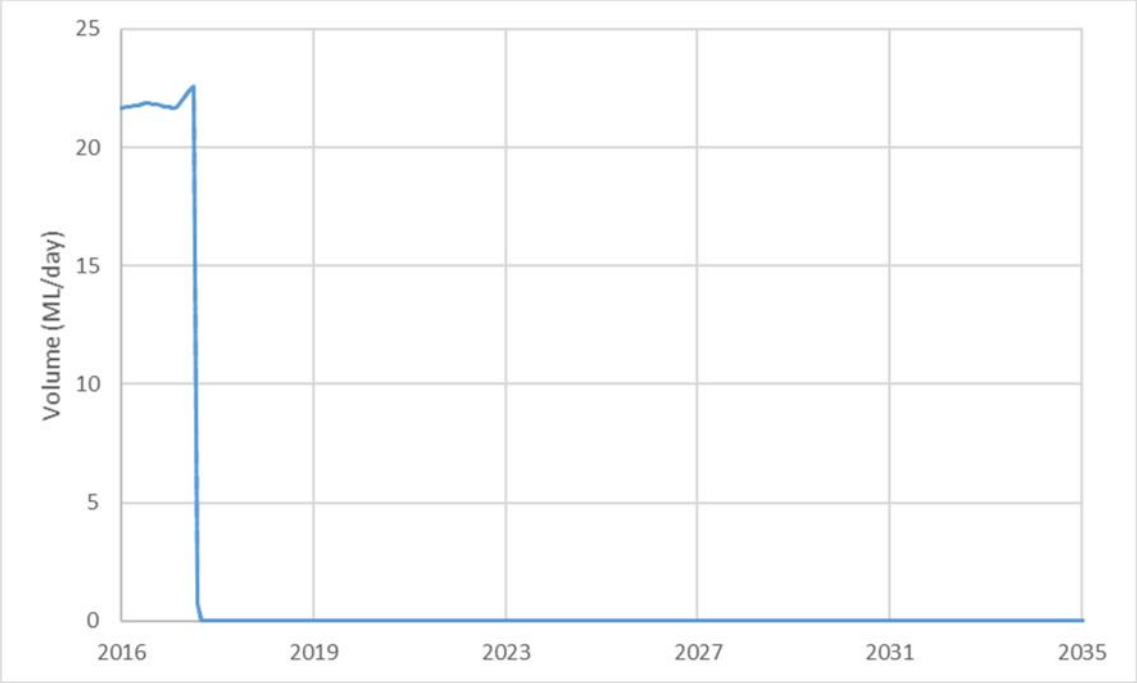


Figure B-42 Scenario 5 – Predicted LDP009 discharge to Sawyers Swamp Creek

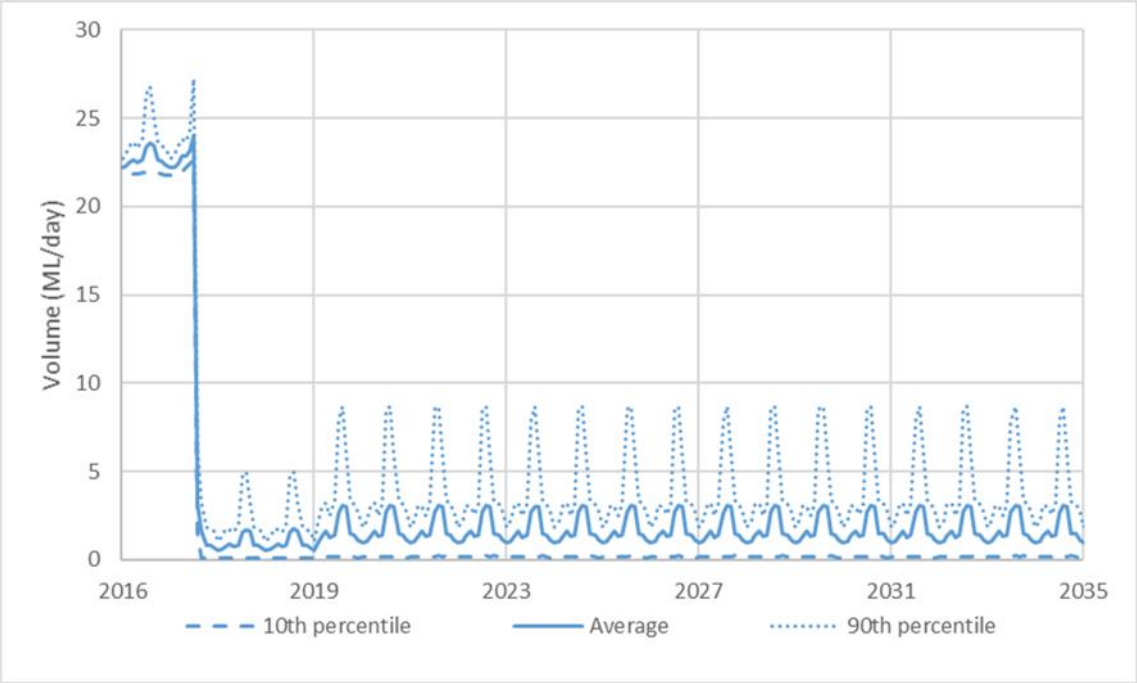


Figure B-43 Scenario 5 – Predicted flow of Sawyers Swamp Creek at the confluence with the Coxs River

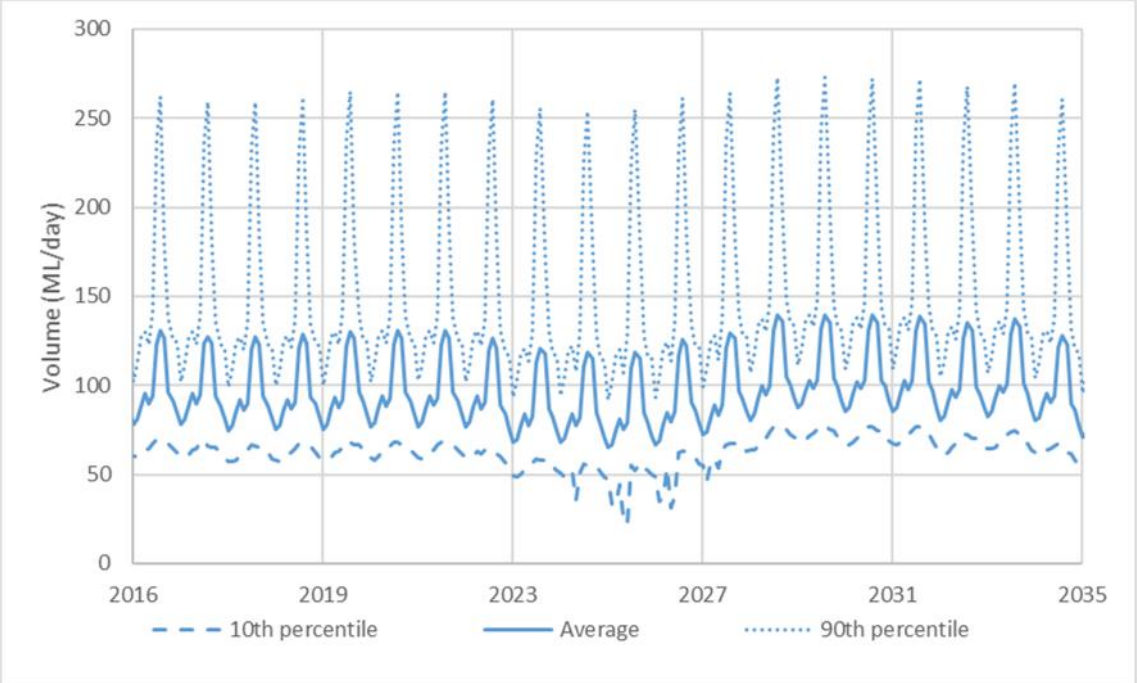


Figure B-44 Scenario 5 – Predicted flow from Coxs River to Lake Wallace

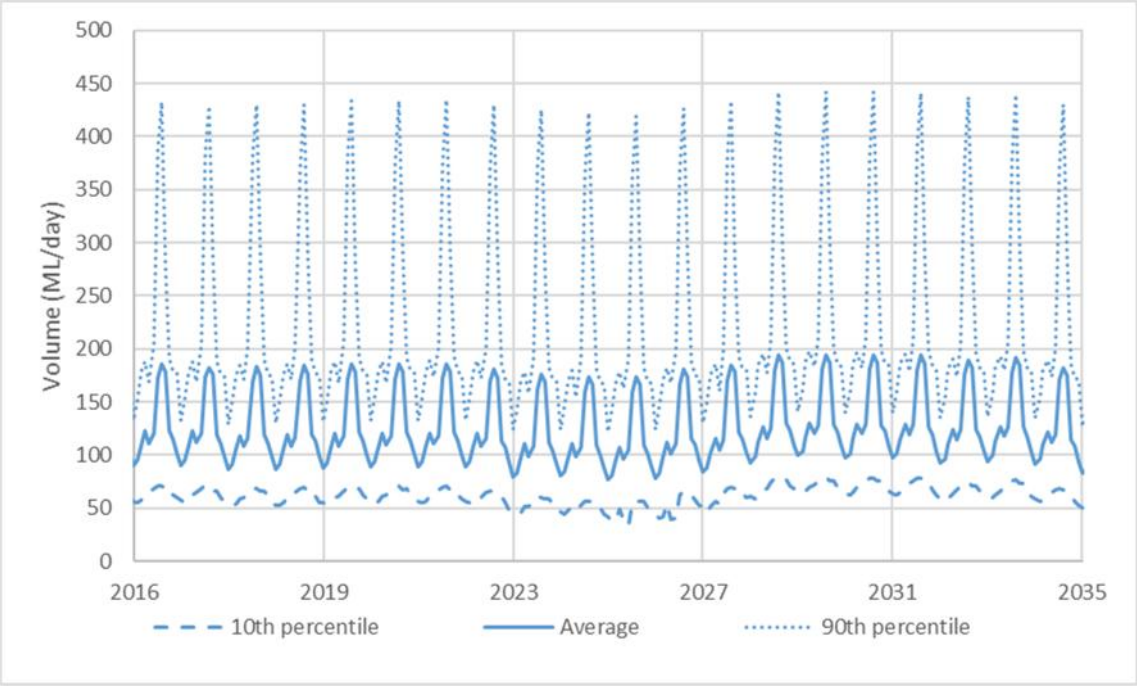


Figure B-45 Scenario 5 – Predicted flow from Coxs River to Lake Lyell

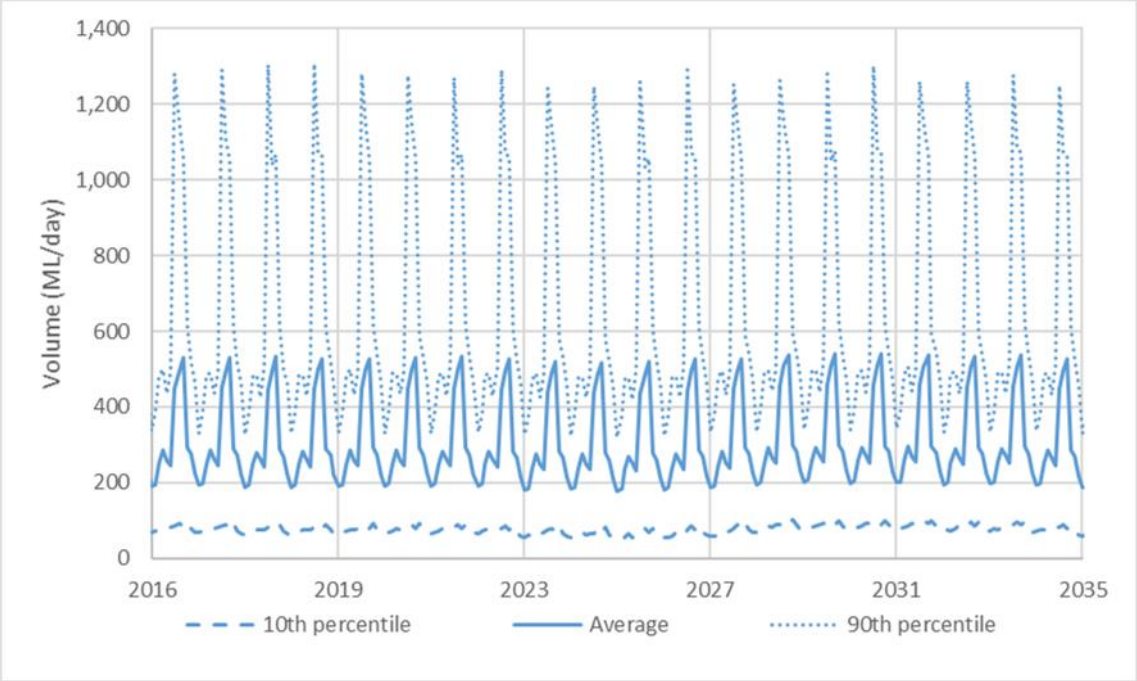
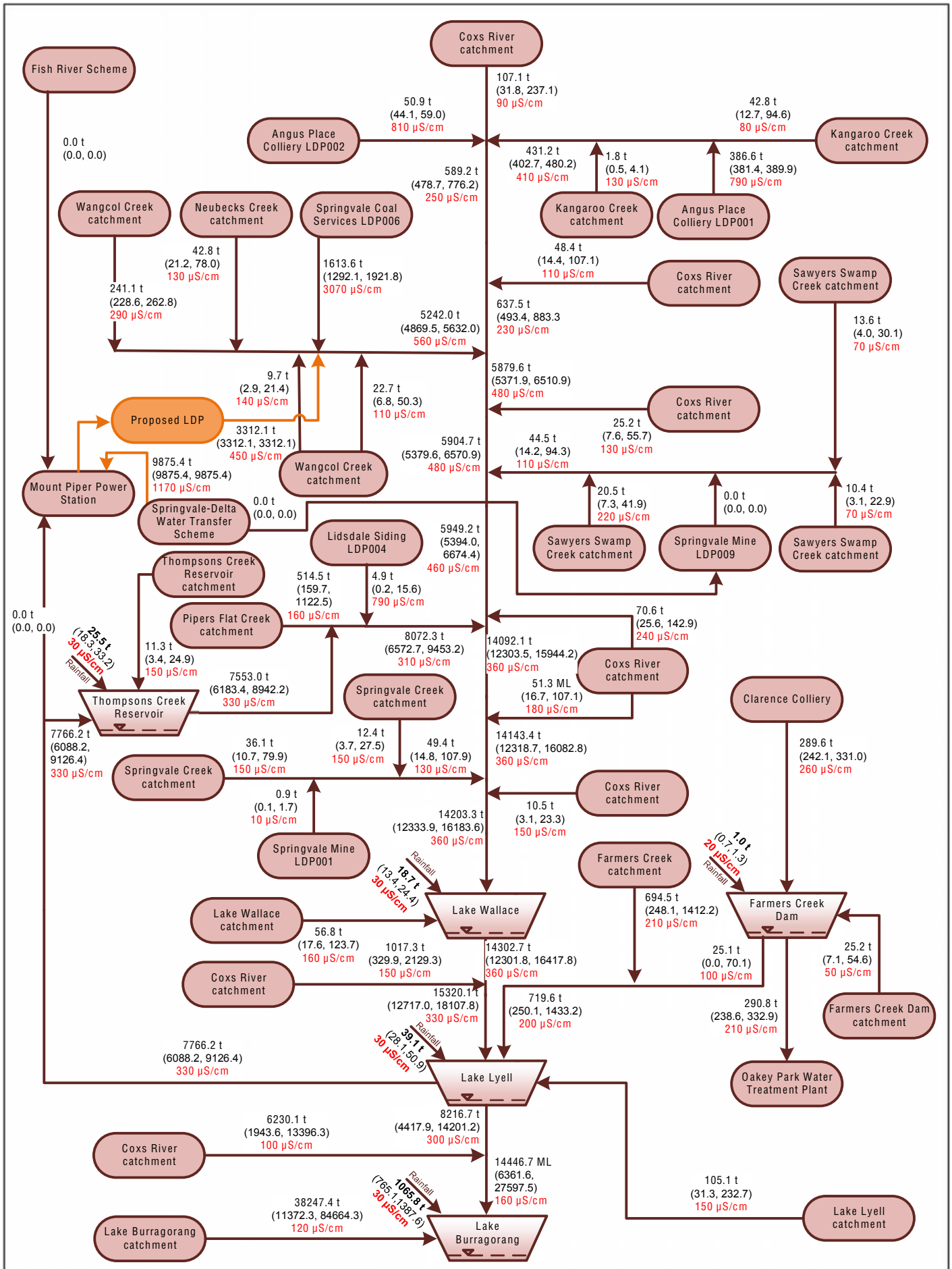


Figure B-46 Scenario 5 – Predicted discharge from Coxs River to Lake Burragorang

B.4.2 Salt balance results

Annual results

The predicted values for each of the salt transfers within the Coxs River catchment for proposed conditions in 2030 are provided in Figure B-47, Figure B-48, Figure B-49 and Figure B-50 for scenarios 1, 2, 4 and 5 respectively.



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LOCATION	Coxs River
SEAM	NA
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

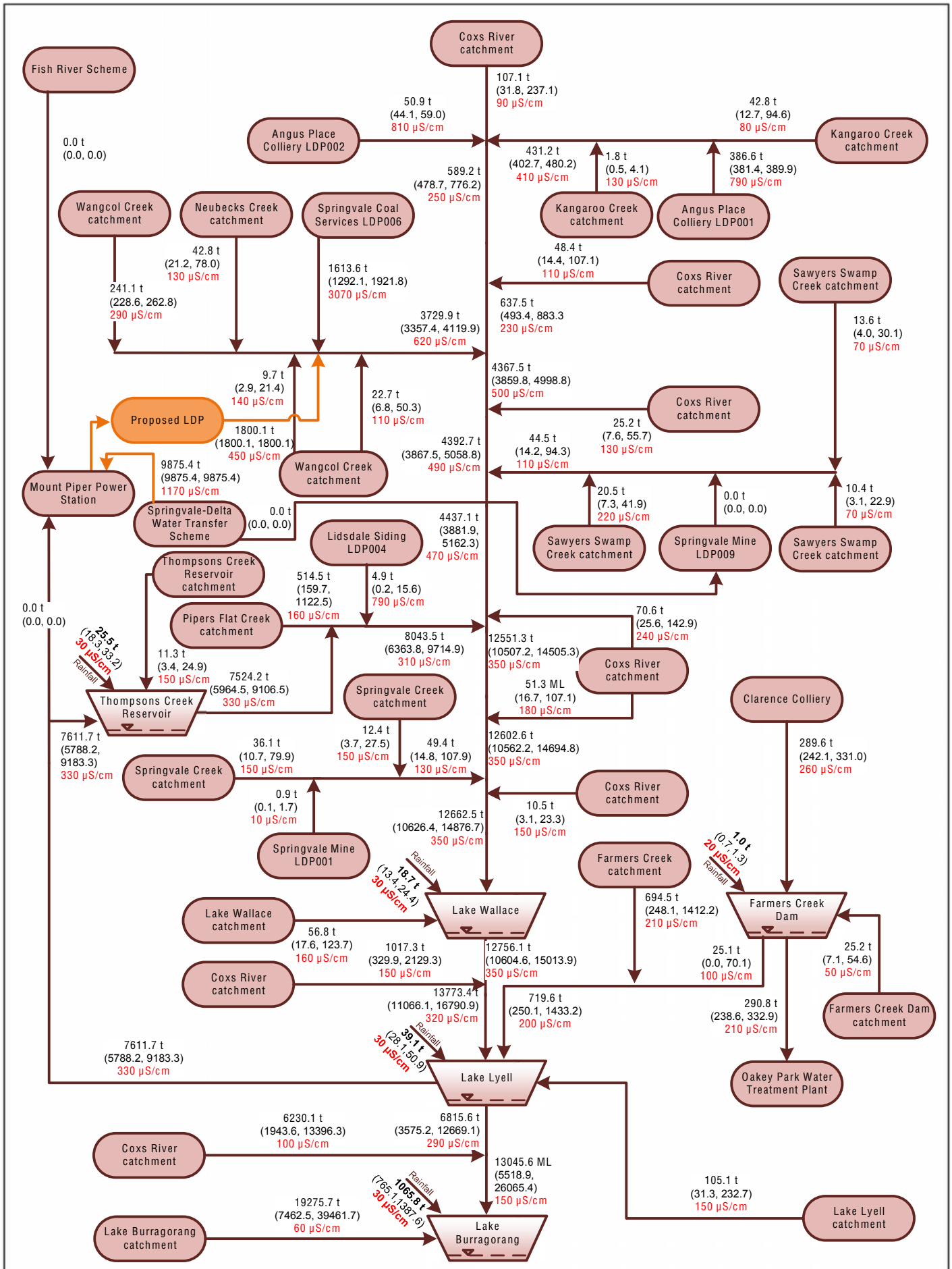
Springvale Water Treatment Project
Water Resources Impact Assessment

Annual salt transfers
Proposed conditions (2030)
Scenario 1

Centennial Coal
EnergyAustralia

DATE Jul 2016

Figure B-47



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LOCATION	Coxs River
SEAM	NA
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

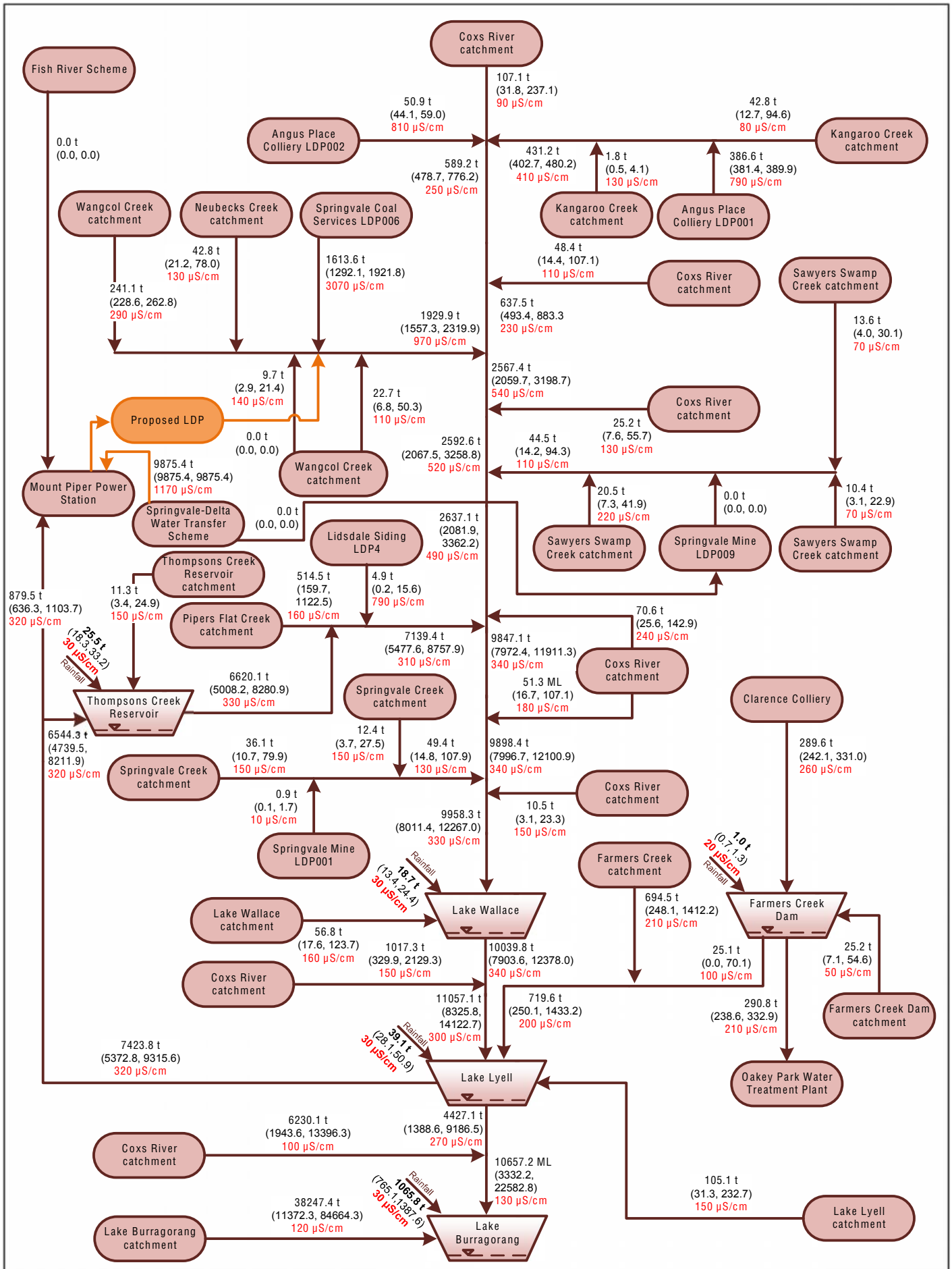
Springvale Water Treatment Project
Water Resources Impact Assessment

Annual salt transfers
Proposed conditions (2030)
Scenario 2

Centennial Coal
EnergyAustralia

DATE Jul 2016

Figure B-47



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LOCATION	Coxs River
SEAM	NA
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

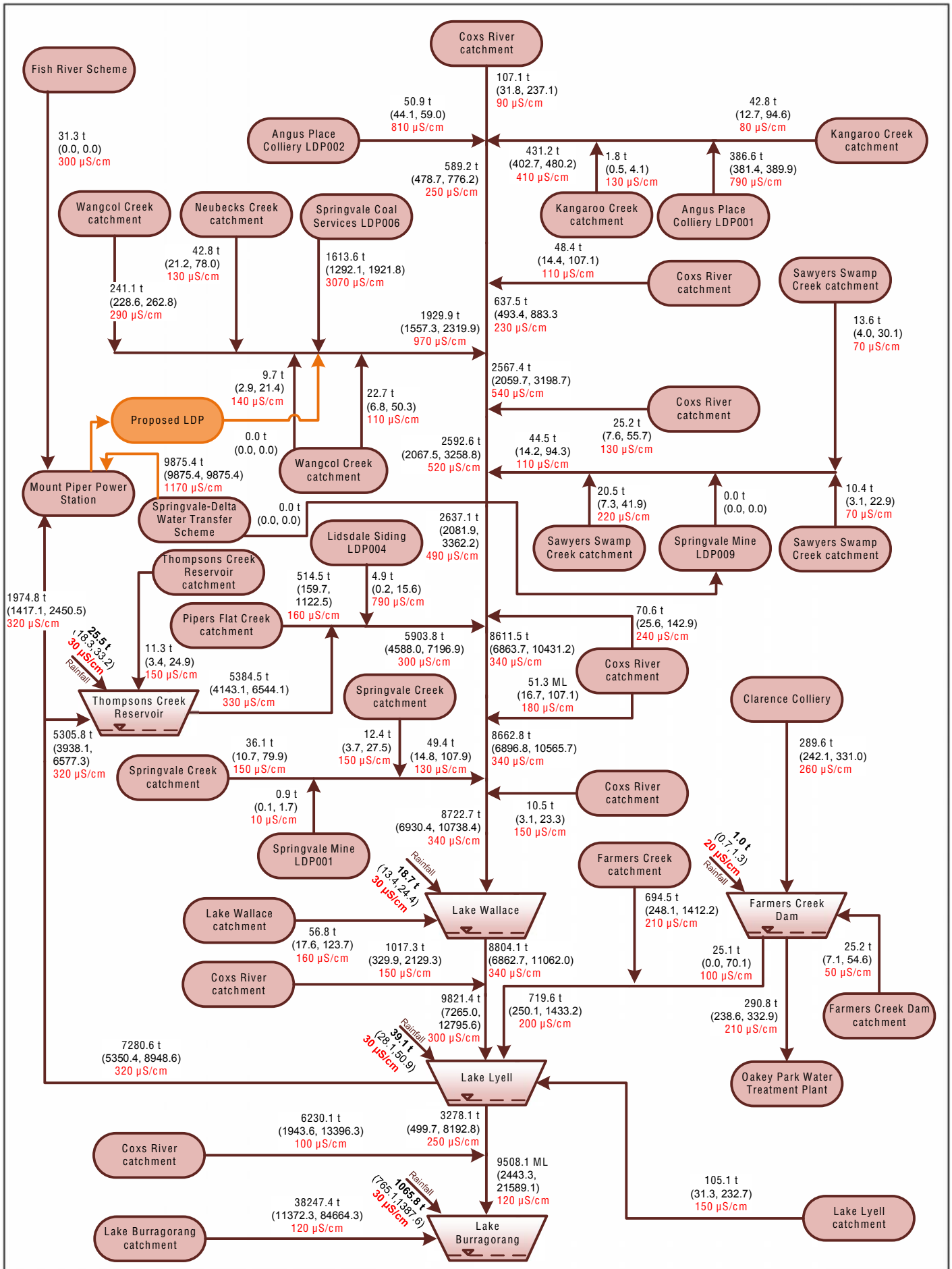
Springvale Water Treatment Project
Water Resources Impact Assessment

Annual salt transfers
Proposed conditions (2030)
Scenario 4

Centennial Coal
EnergyAustralia

DATE Jul 2016

Figure B-49



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LOCATION	Coxs River
SEAM	NA
DRAWN	SM
CHECKED	TD
APPROVED	LH
SCALE	NTS

Springvale Water Treatment Project
Water Resources Impact Assessment

Annual salt transfers
Proposed conditions (2030)
Scenario 5

Centennial Coal
EnergyAustralia

DATE Jul 2016

Figure B-50

Time series results

Monthly average time series results are presented for scenarios 1, 2, 4 and 5 are presented in Figure B-51 to B-82.

Scenario 1

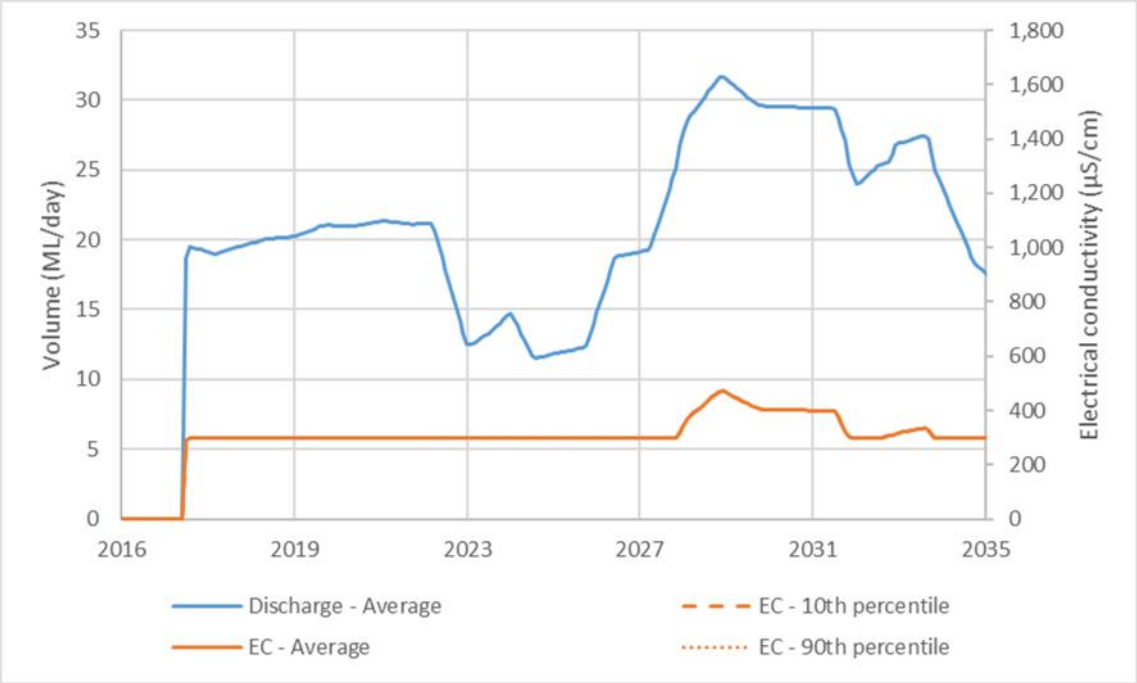


Figure B-51 Scenario 1 – Predicted EC of proposed LDP discharge

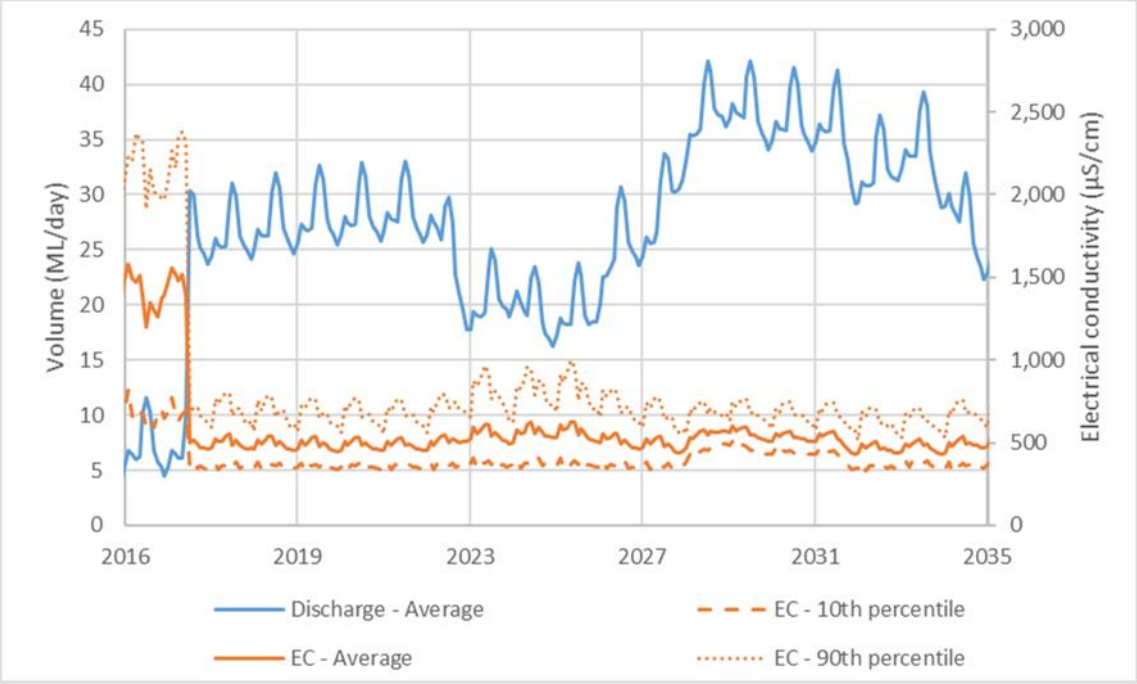


Figure B-52 Scenario 1 – Predicted EC of discharge of Wangcol Creek at LDPs

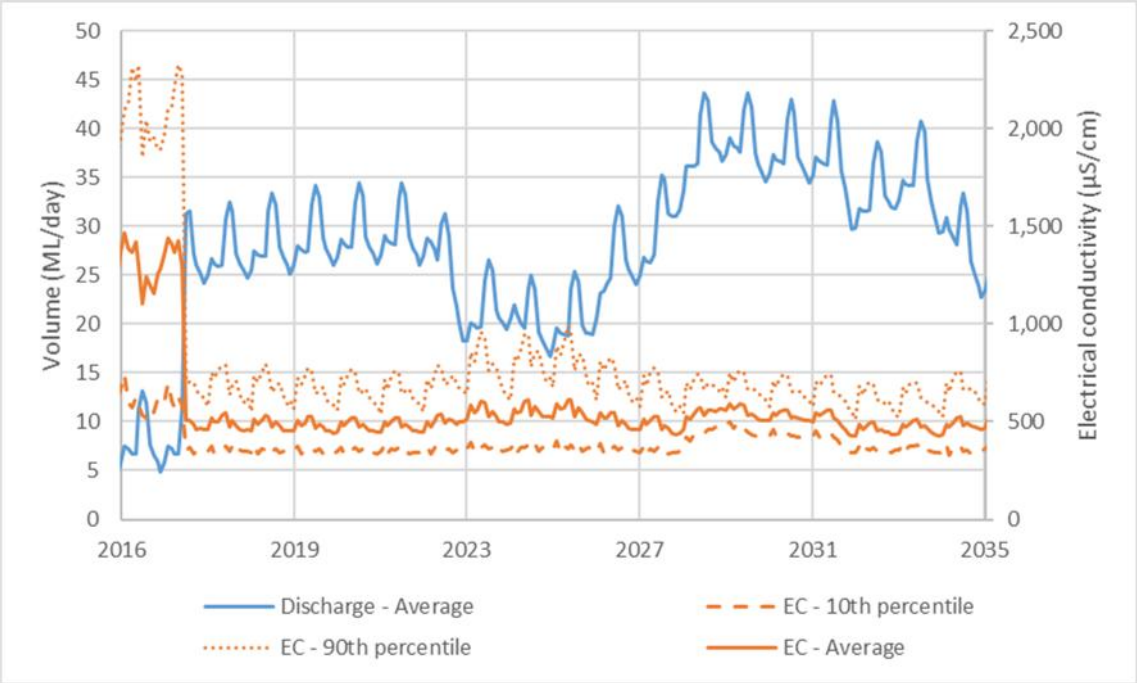


Figure B-53 Scenario 1 – Predicted EC of discharge from Wangcol Creek to Coxs River

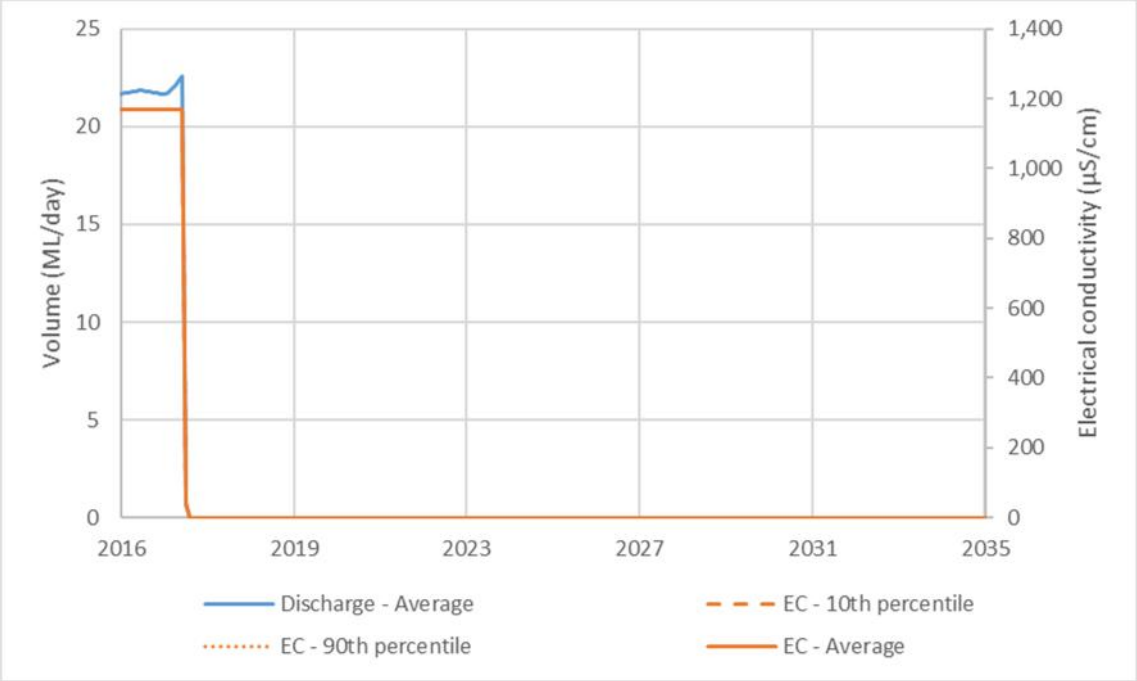


Figure B-54 Scenario 1 – Predicted EC of LDP009 discharge to Sawyers Swamp Creek

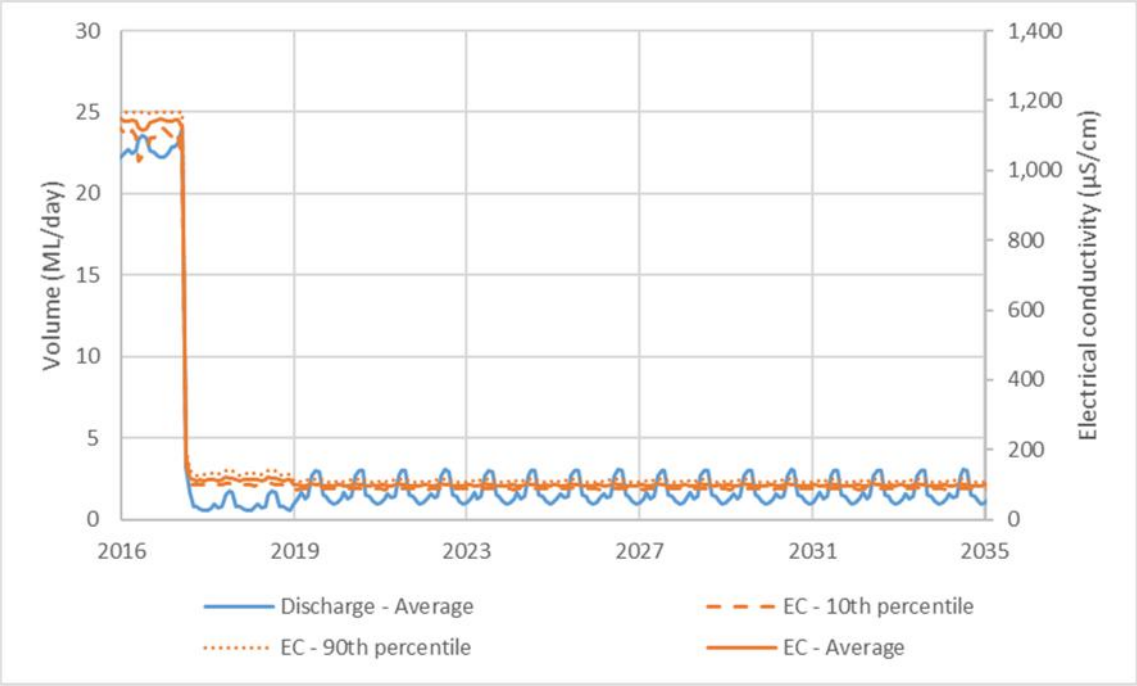


Figure B-55 Scenario 1 – Predicted EC of discharge from Sawyers Swamp Creek to Coxs River

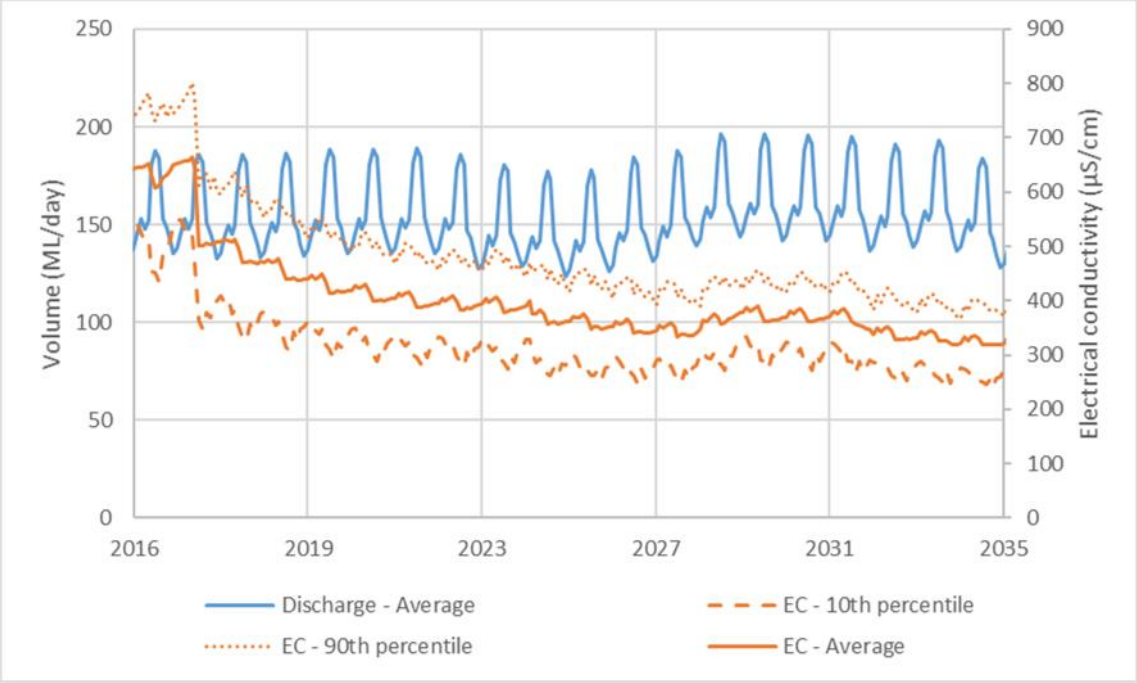


Figure B-56 Scenario 1 – Predicted EC of discharge from Coxs River to Lake Wallace

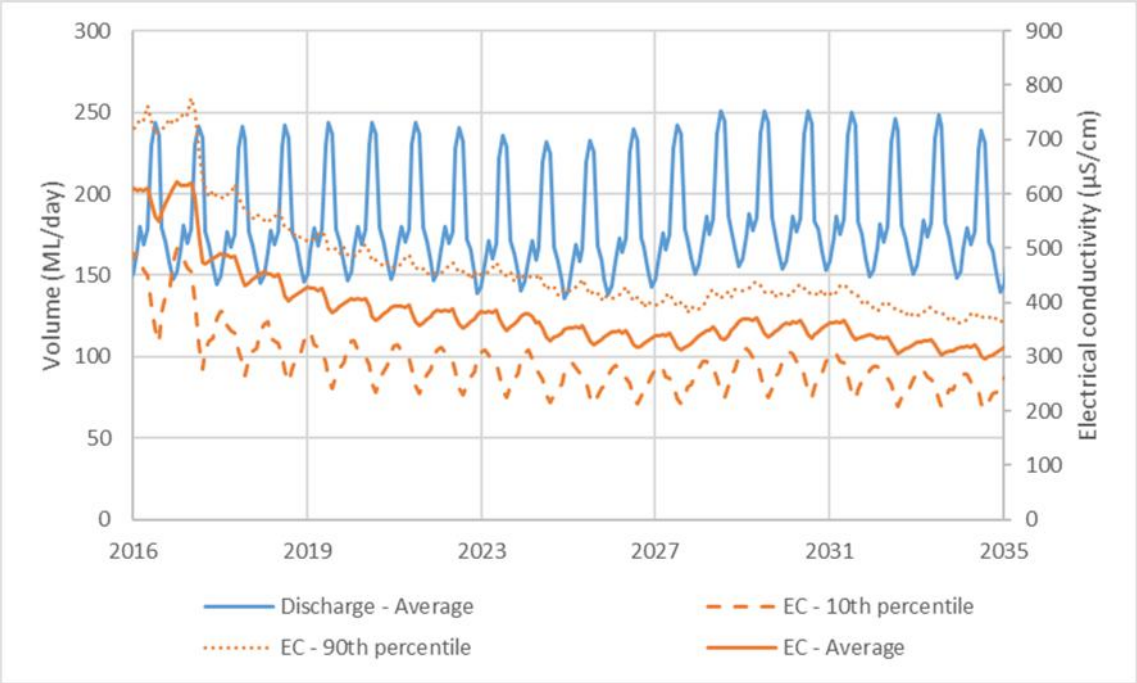


Figure B-57 Scenario 1 – Predicted EC of discharge from Coxs River to Lake Lyell

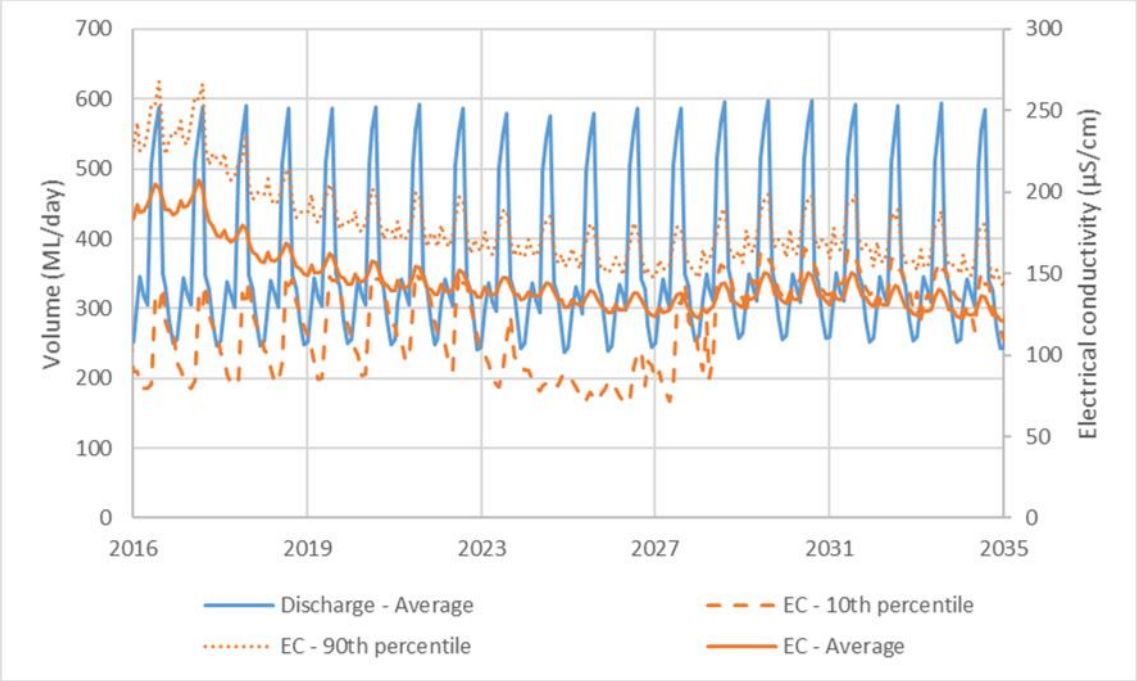


Figure B-58 Scenario 1 – Predicted EC of discharge from Coxs River to Lake Burragorang

Scenario 2

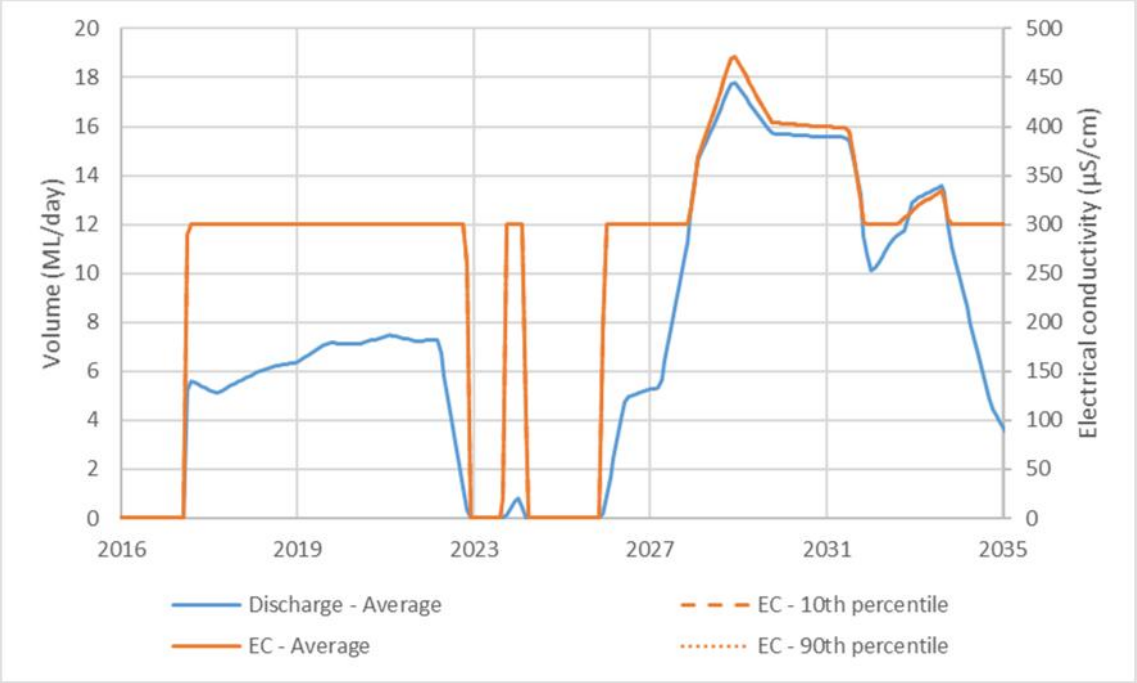


Figure B-59 Scenario 2 – Predicted EC of proposed LDP discharge

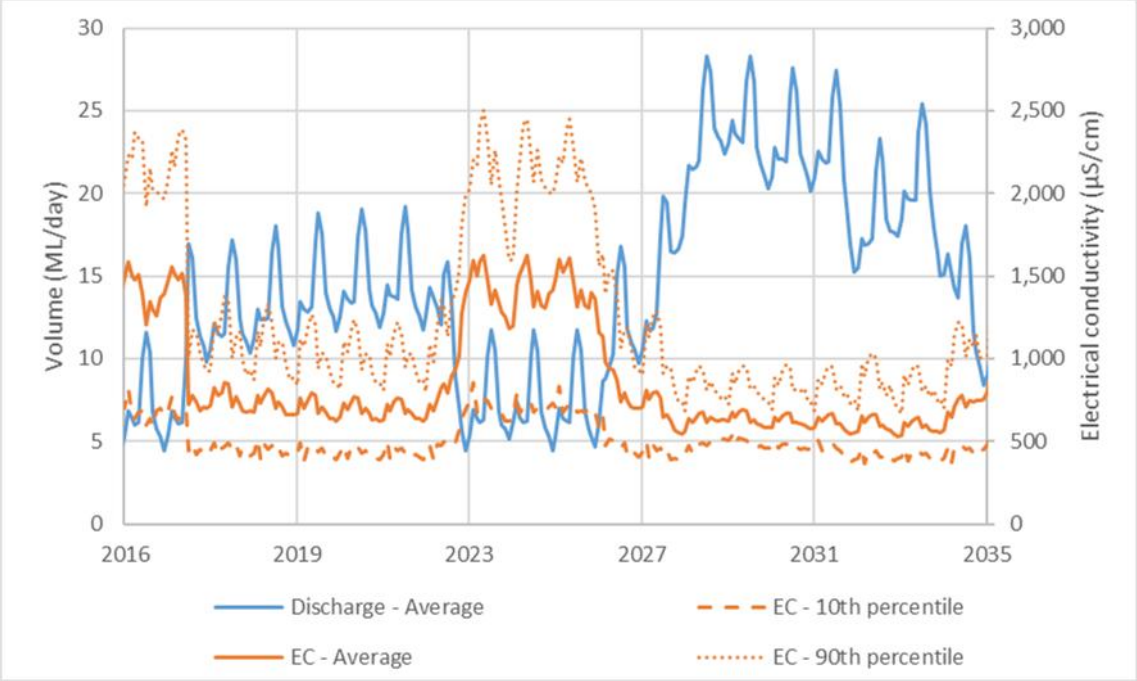


Figure B-60 Scenario 2 – Predicted EC of discharge of Wangcol Creek at LDPs

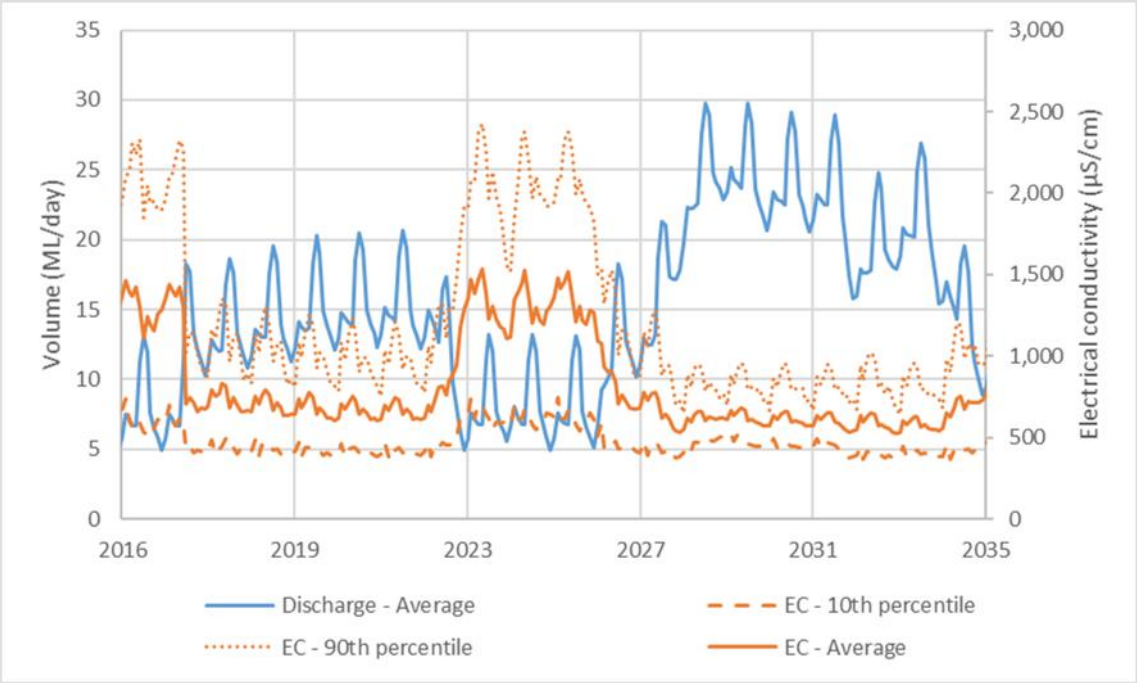


Figure B-61 Scenario 2 – Predicted EC of discharge from Wangcol Creek to Coxs River

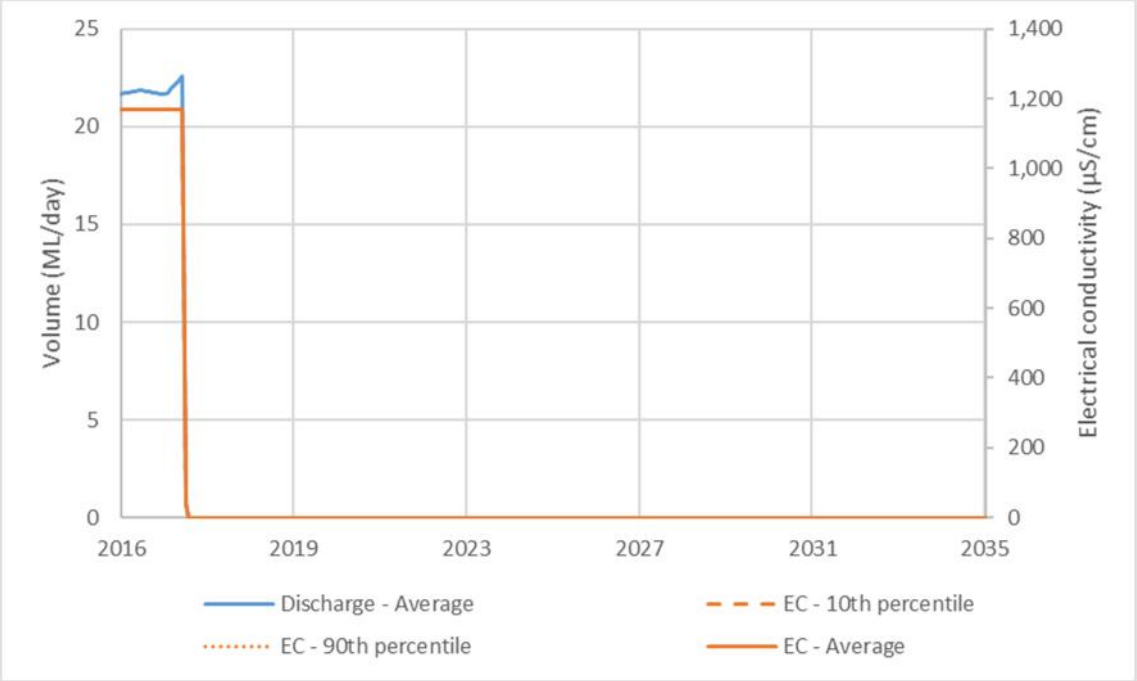


Figure B-62 Scenario 2 – Predicted EC of LDP009 discharge to Sawyers Swamp Creek

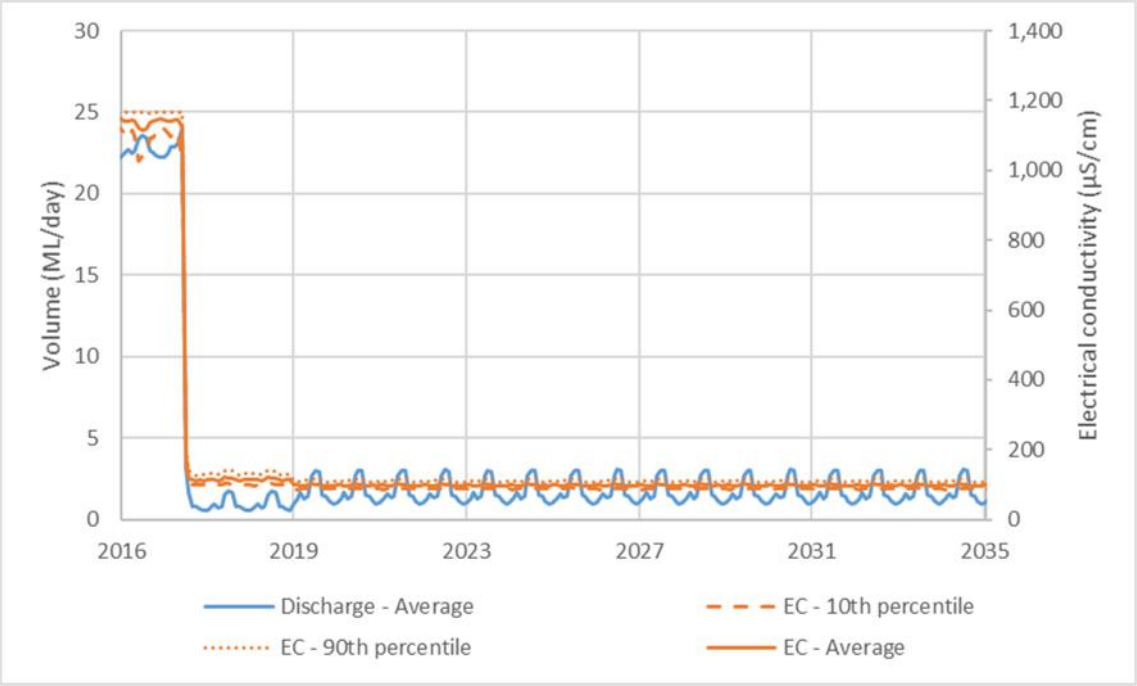


Figure B-63 Scenario 2 – Predicted EC of discharge from Sawyers Swamp Creek to Coxs River

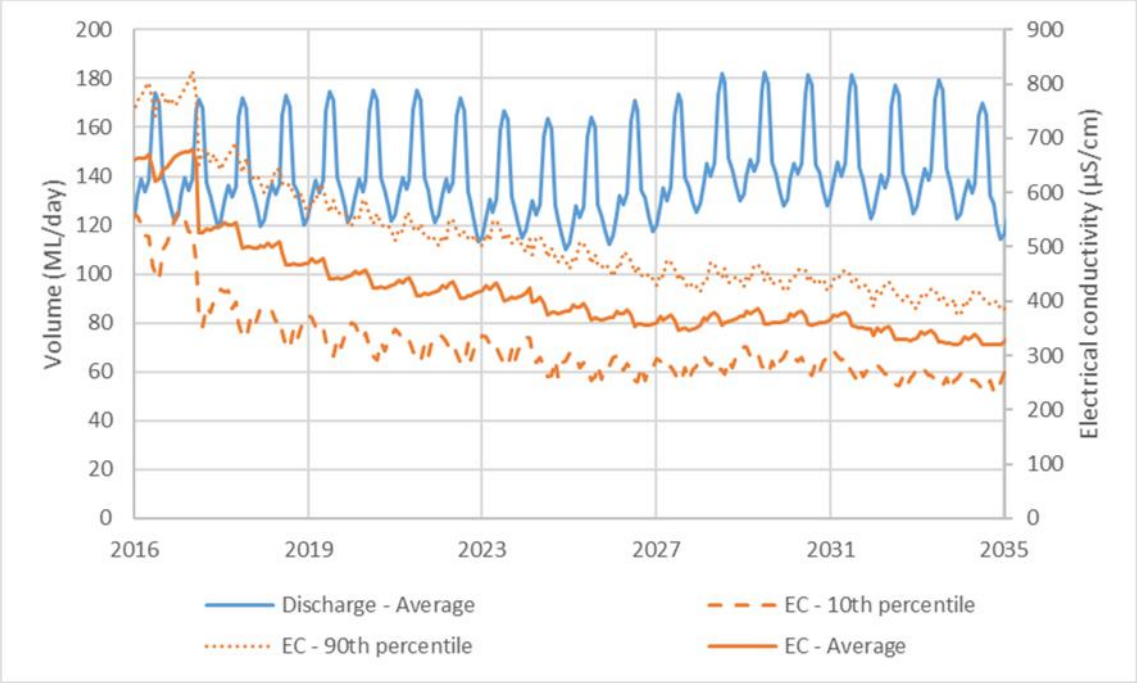


Figure B-64 Scenario 2 – Predicted EC of discharge from Coxs River to Lake Wallace

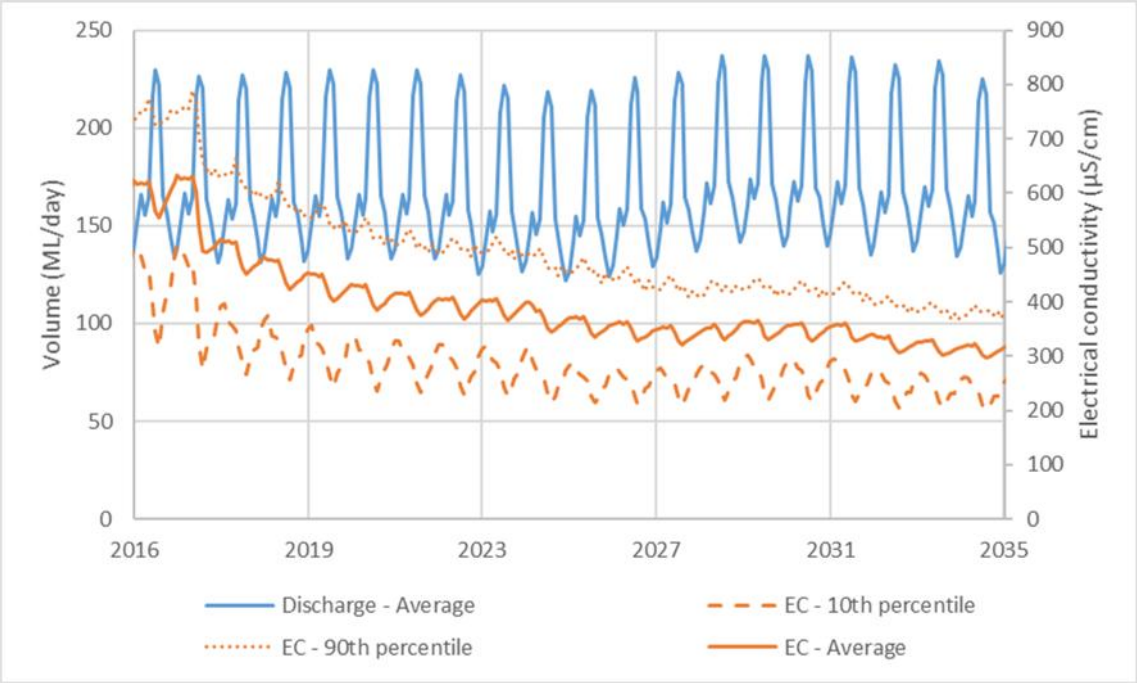


Figure B-65 Scenario 2 – Predicted EC of discharge from Coxs River to Lake Lyell

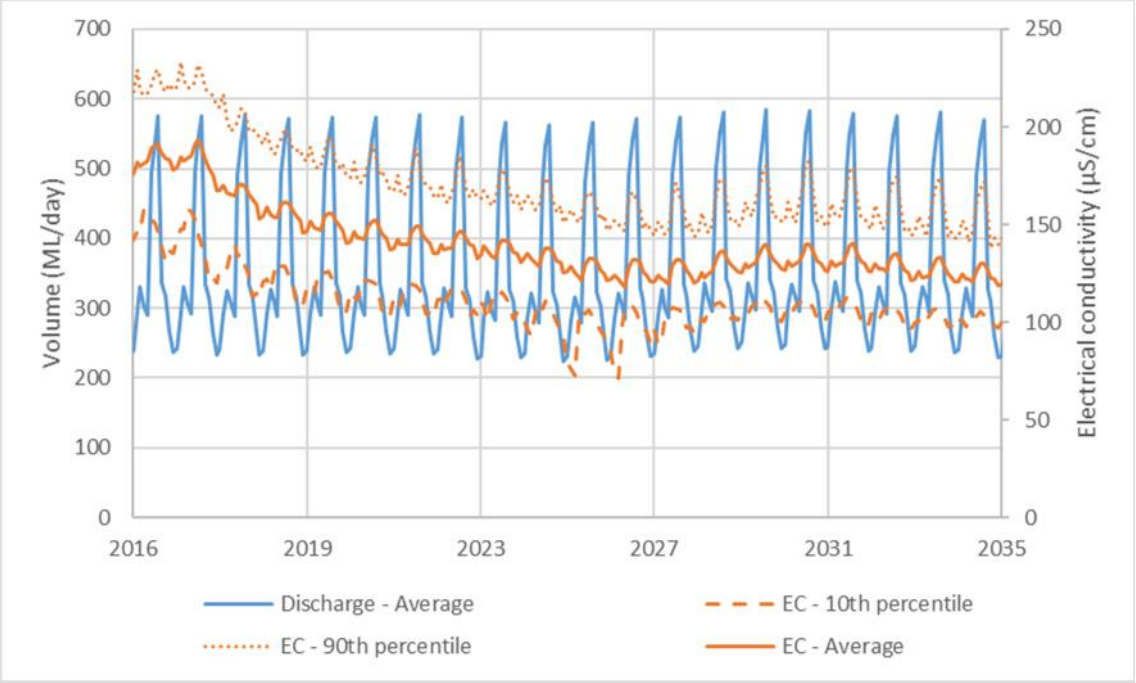


Figure B-66 Scenario 2 – Predicted EC of discharge from Coxs River to Lake Burragorang

Scenario 4

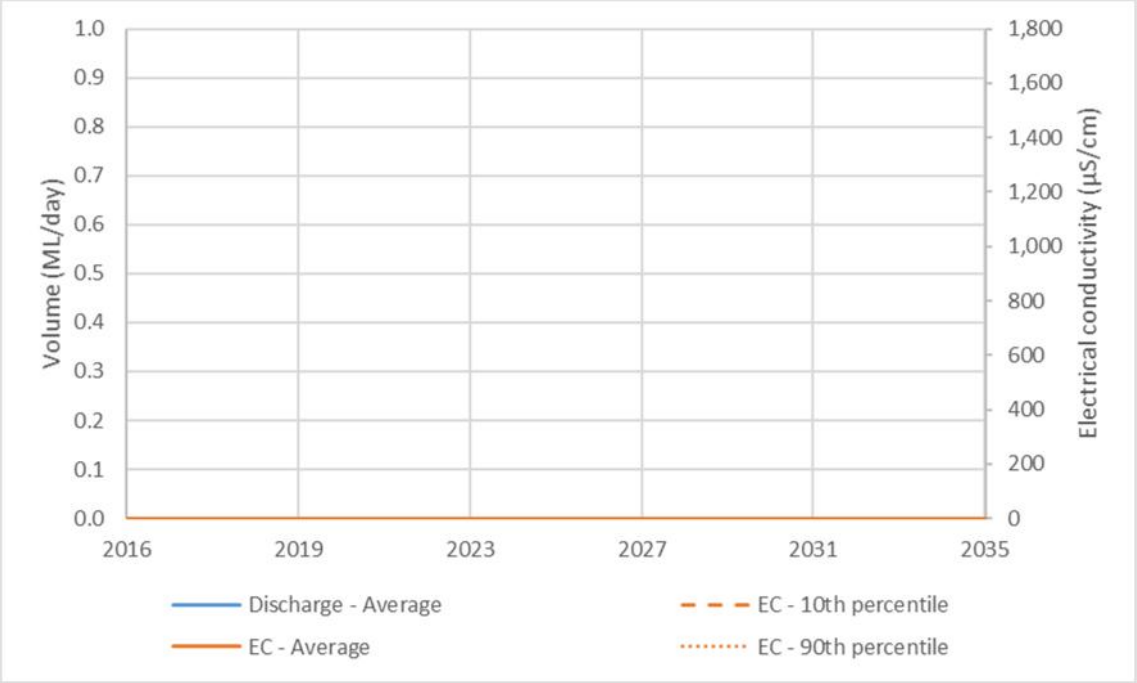


Figure B-67 Scenario 4 – Predicted EC of proposed LDP discharge

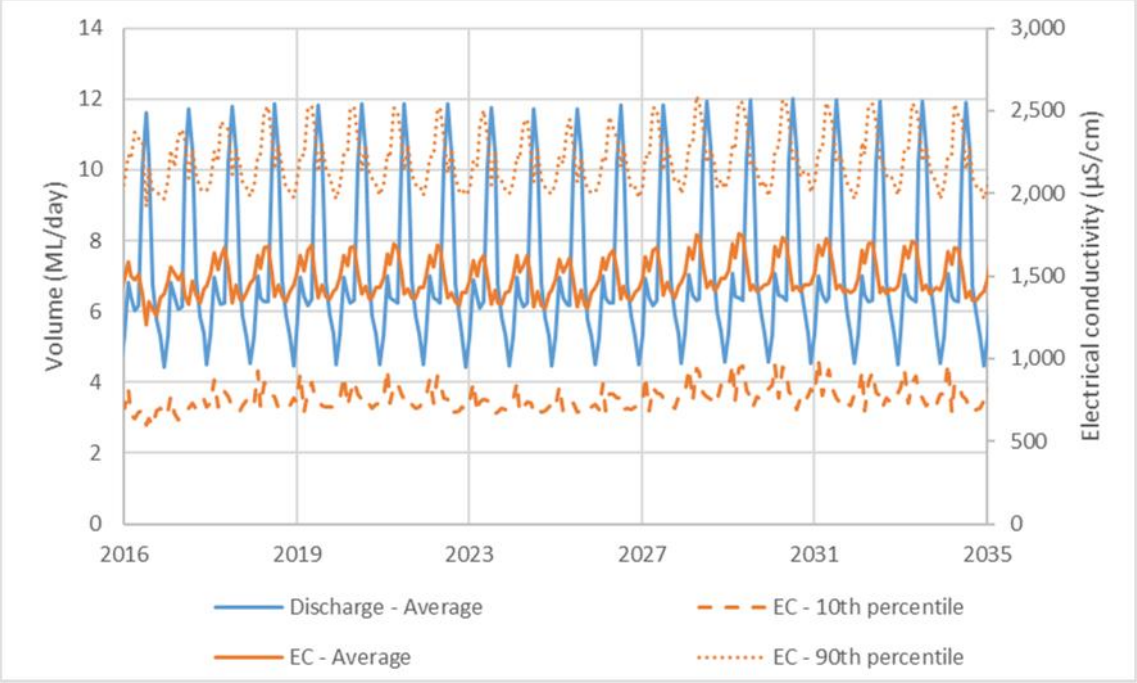


Figure B-68 Scenario 4 – Predicted EC of discharge of Wangcol Creek at LDPs

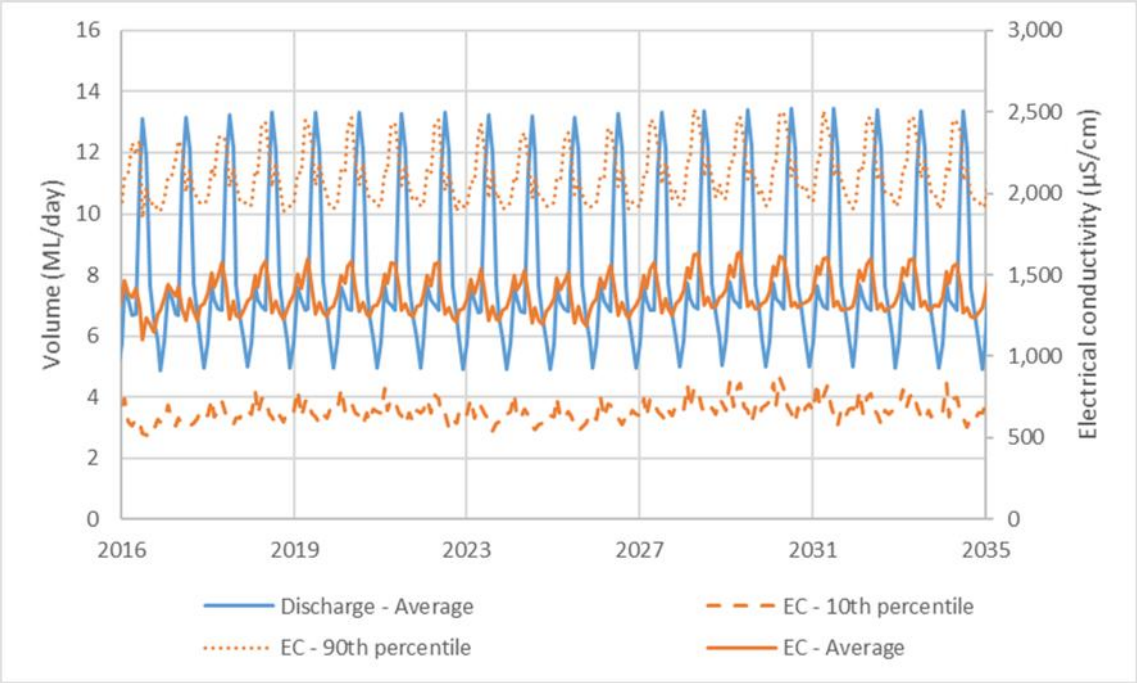


Figure B-69 Scenario 4 – Predicted EC of discharge from Wangcol Creek to Coxs River

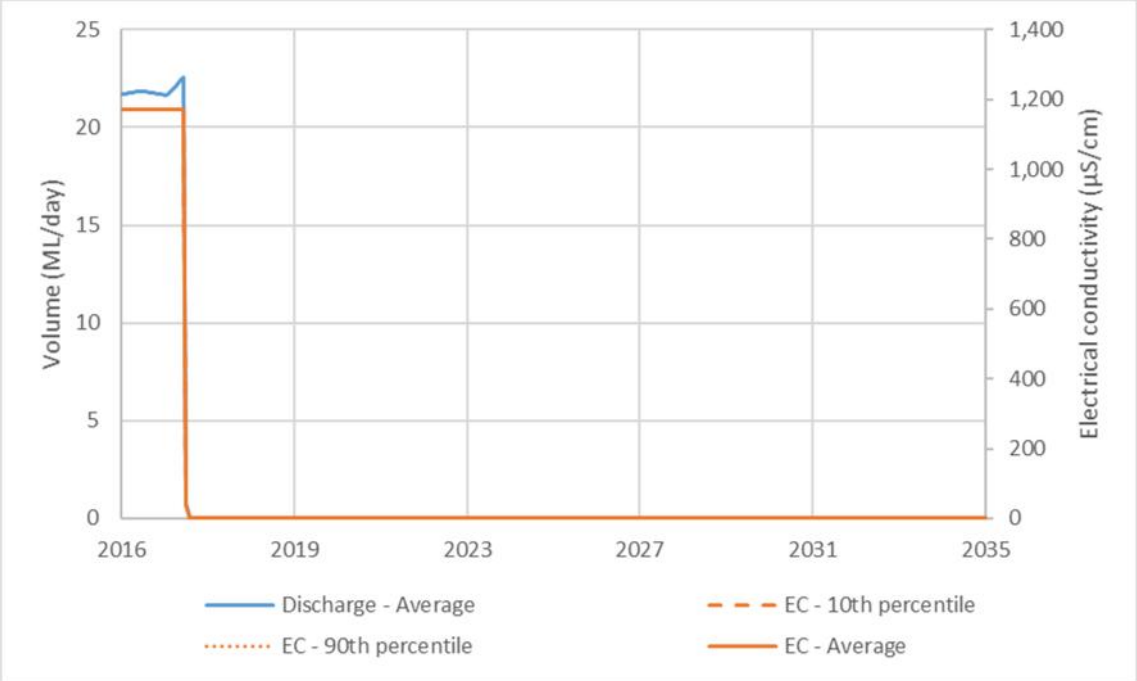


Figure B-70 Scenario 4 – Predicted EC of LDP009 discharge to Sawyers Swamp Creek

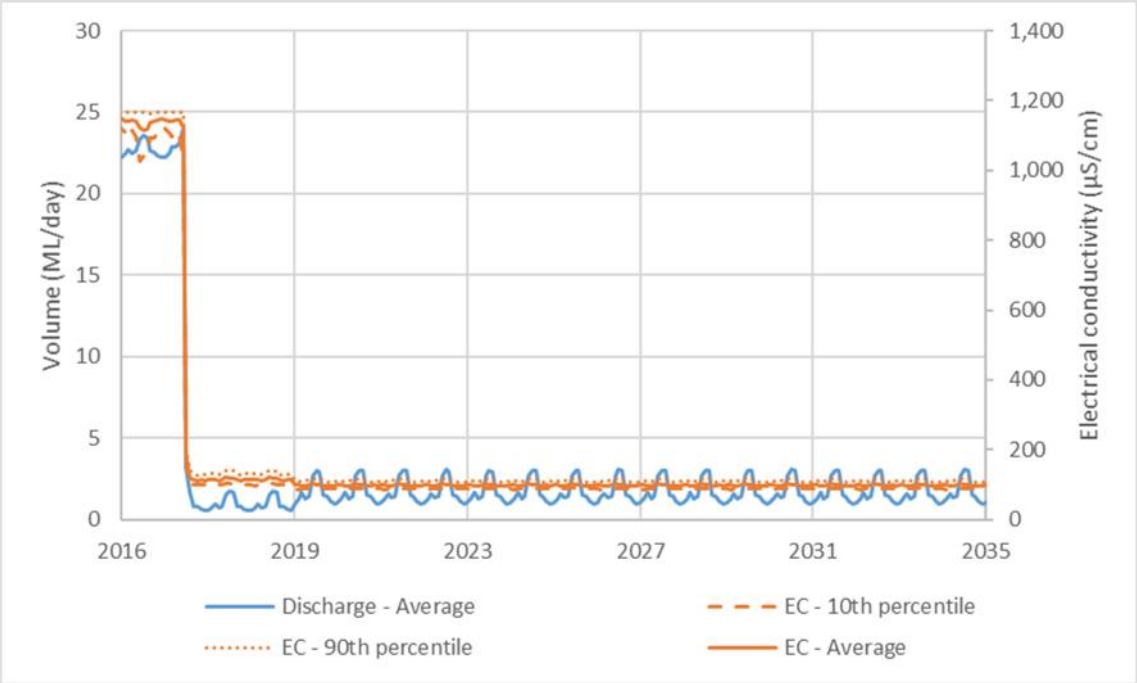


Figure B-71 Scenario 4 – Predicted EC of discharge from Sawyers Swamp Creek to Coxs River

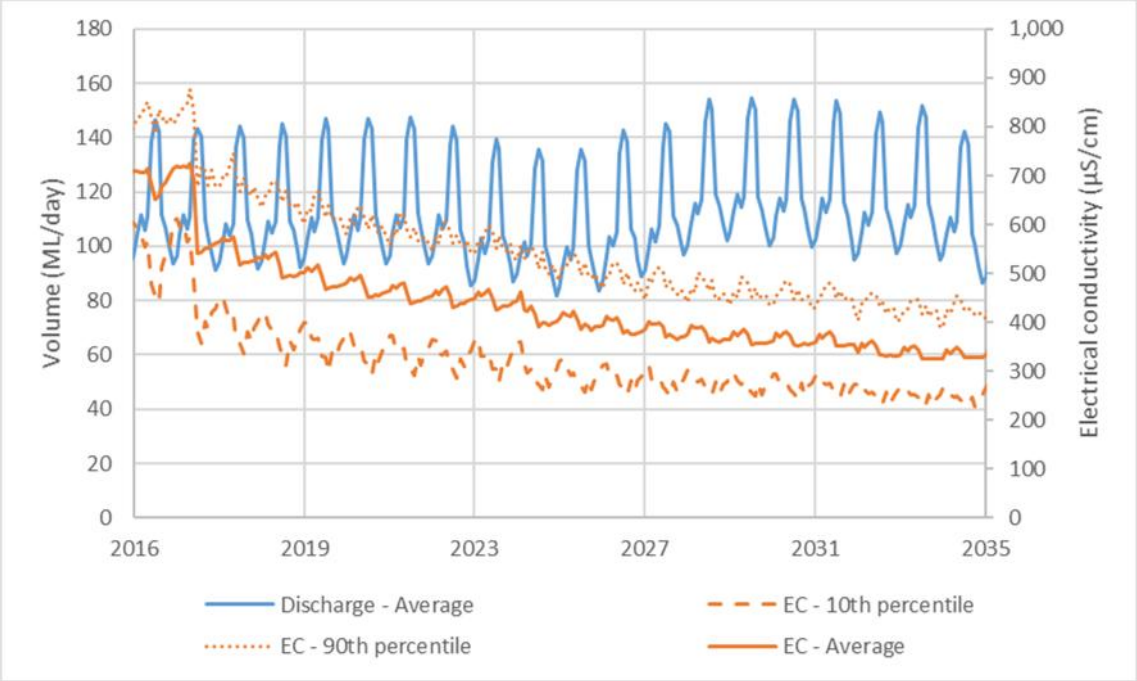


Figure B-72 Scenario 4 – Predicted EC of discharge from Coxs River to Lake Wallace

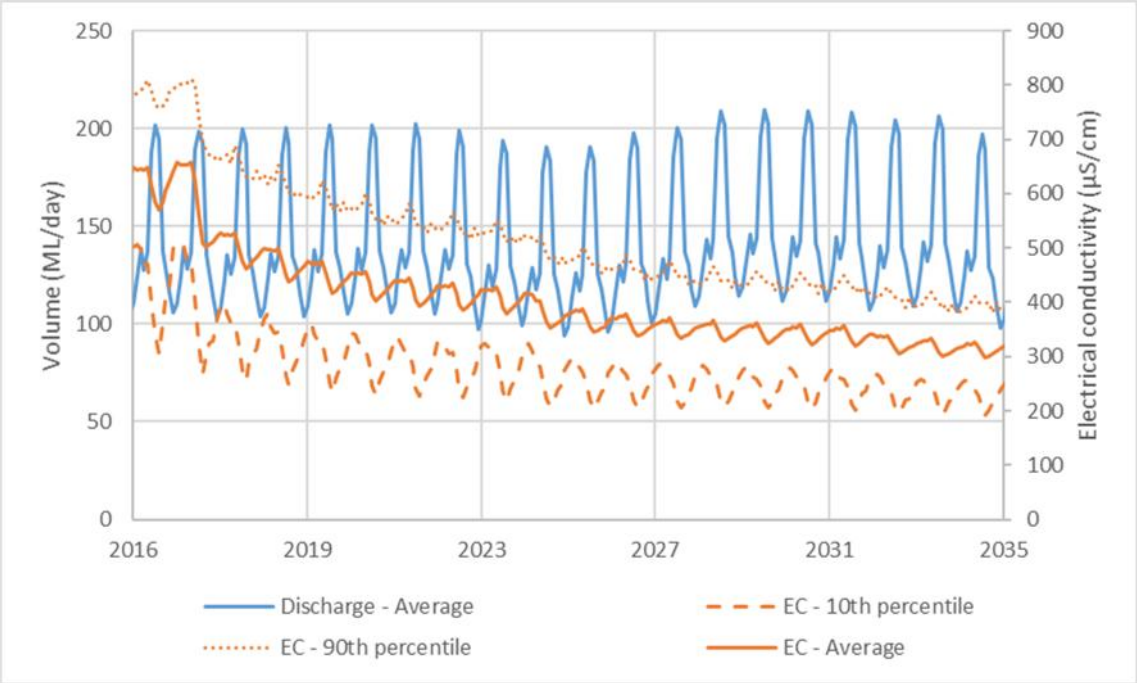


Figure B-73 Scenario 4 – Predicted EC of discharge from Coxs River to Lake Lyell

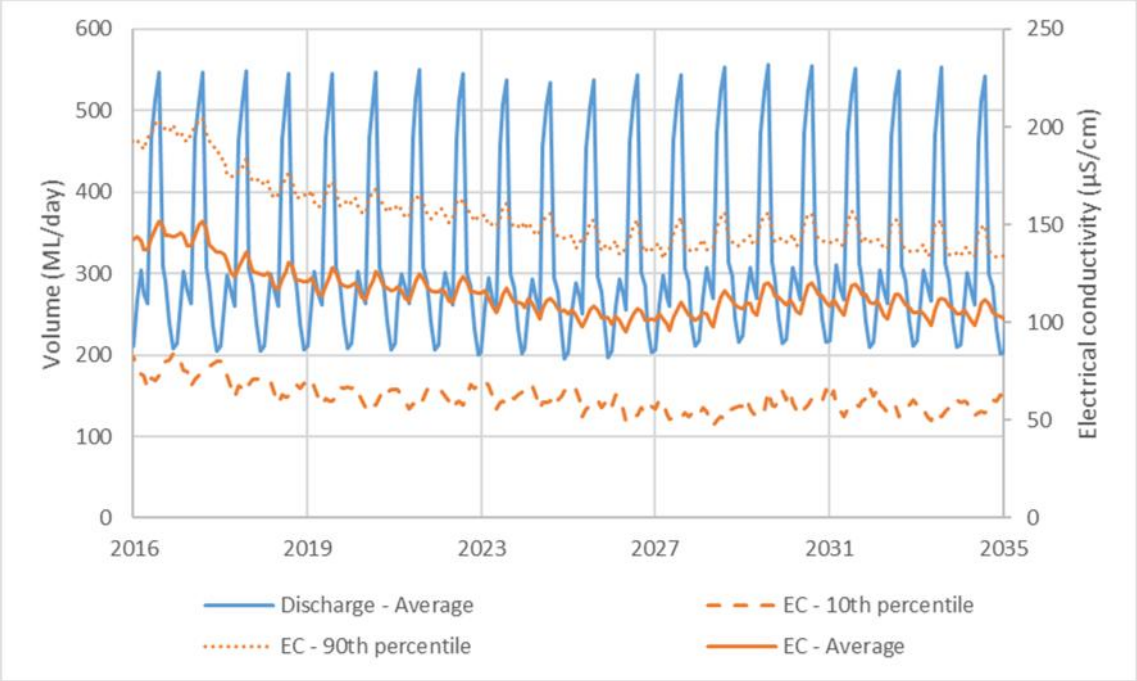


Figure B-74 Scenario 4 – Predicted EC of discharge from Coxs River to Lake Burragorang

Scenario 5

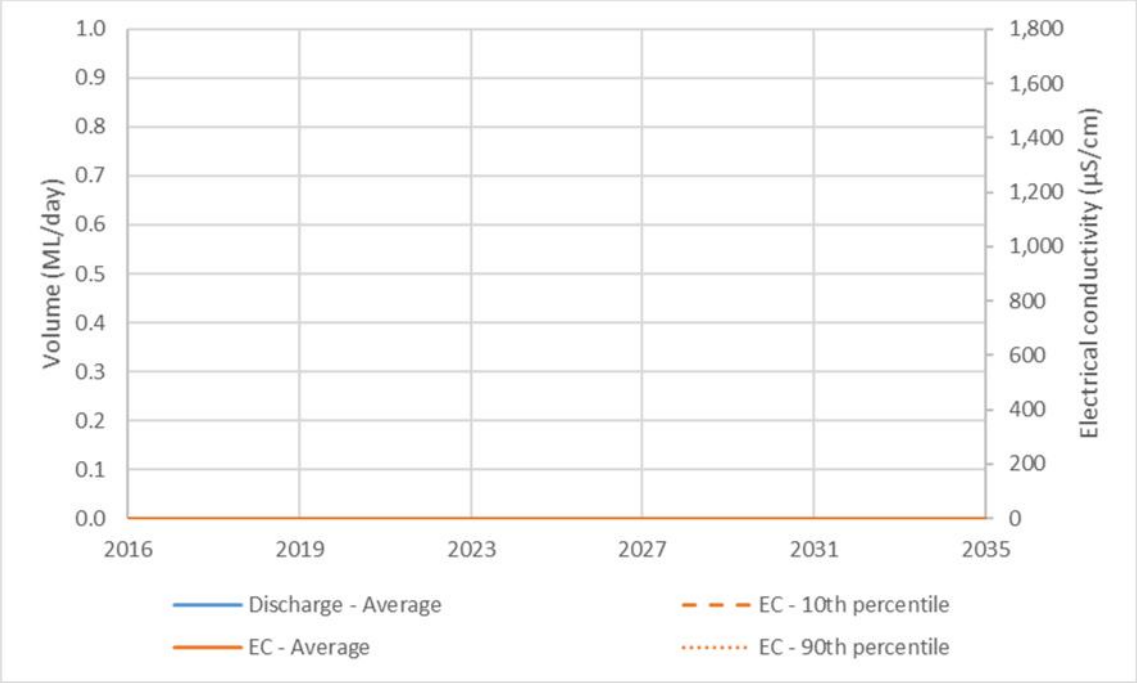


Figure B-75 Scenario 5 – Predicted EC of proposed LDP discharge

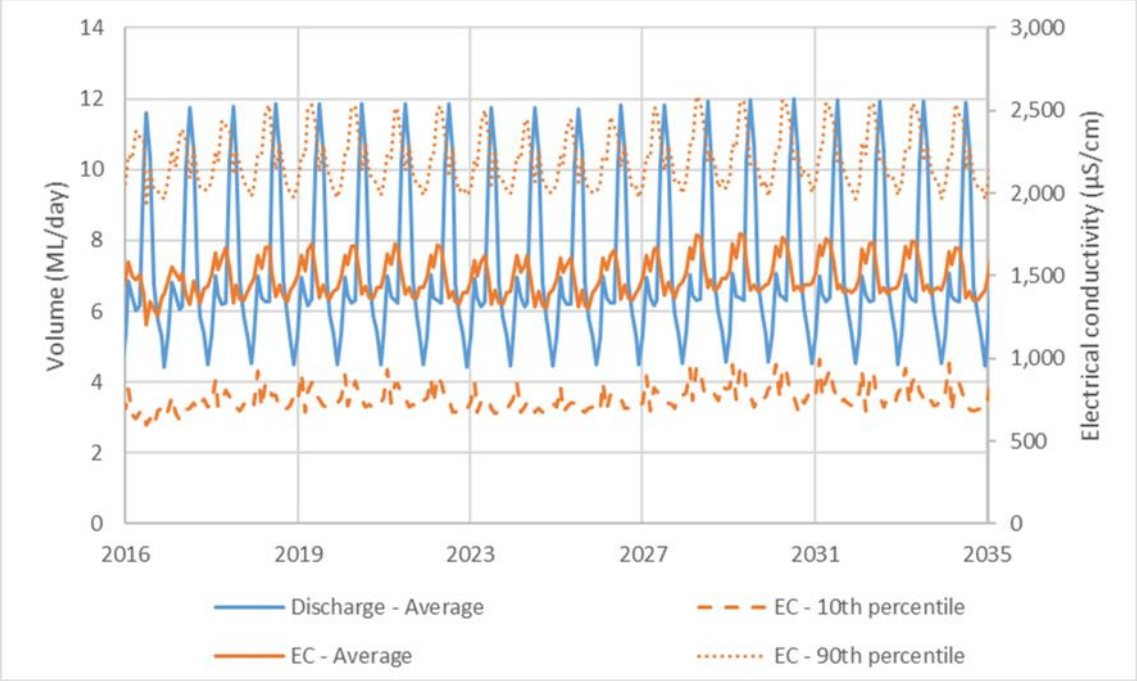


Figure B-76 Scenario 5 – Predicted EC of discharge of Wangcol Creek at LDPs

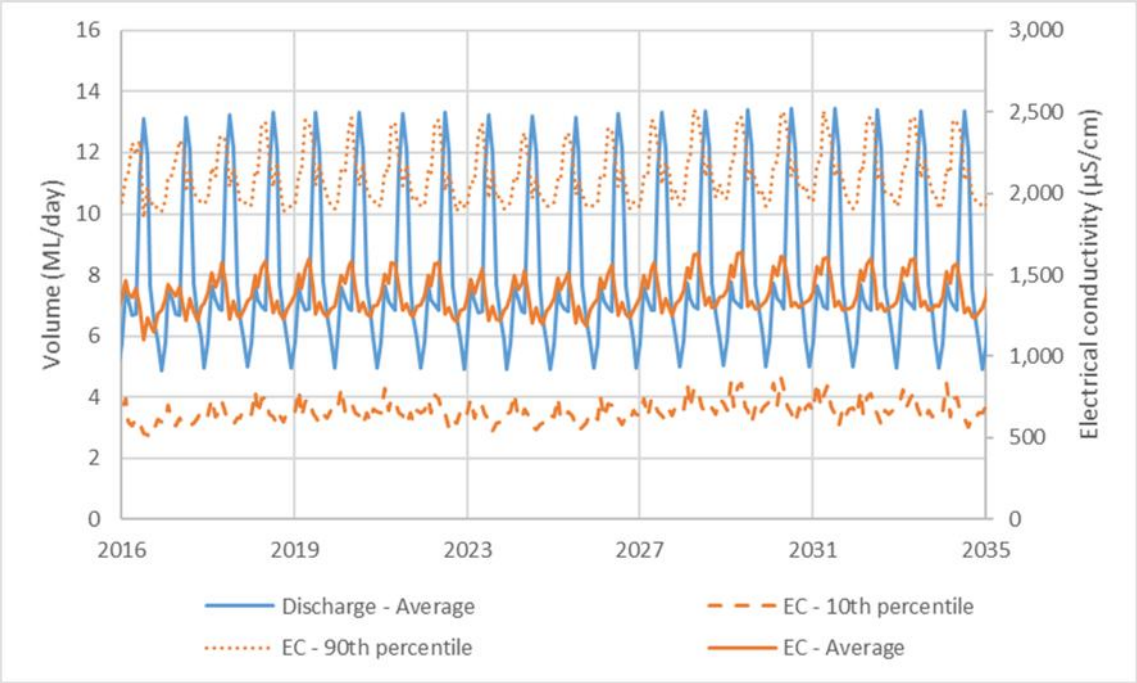


Figure B-77 Scenario 5 – Predicted EC of discharge from Wangcol Creek to Coxs River

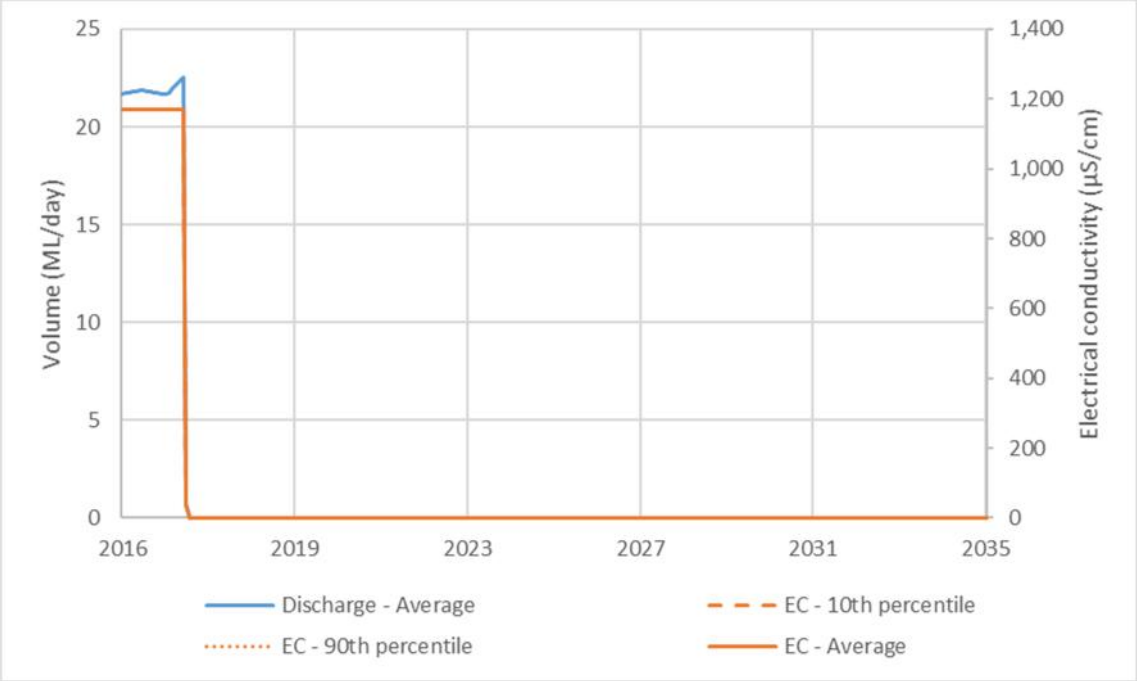


Figure B-78 Scenario 5 – Predicted EC of LDP009 discharge to Sawyers Swamp Creek

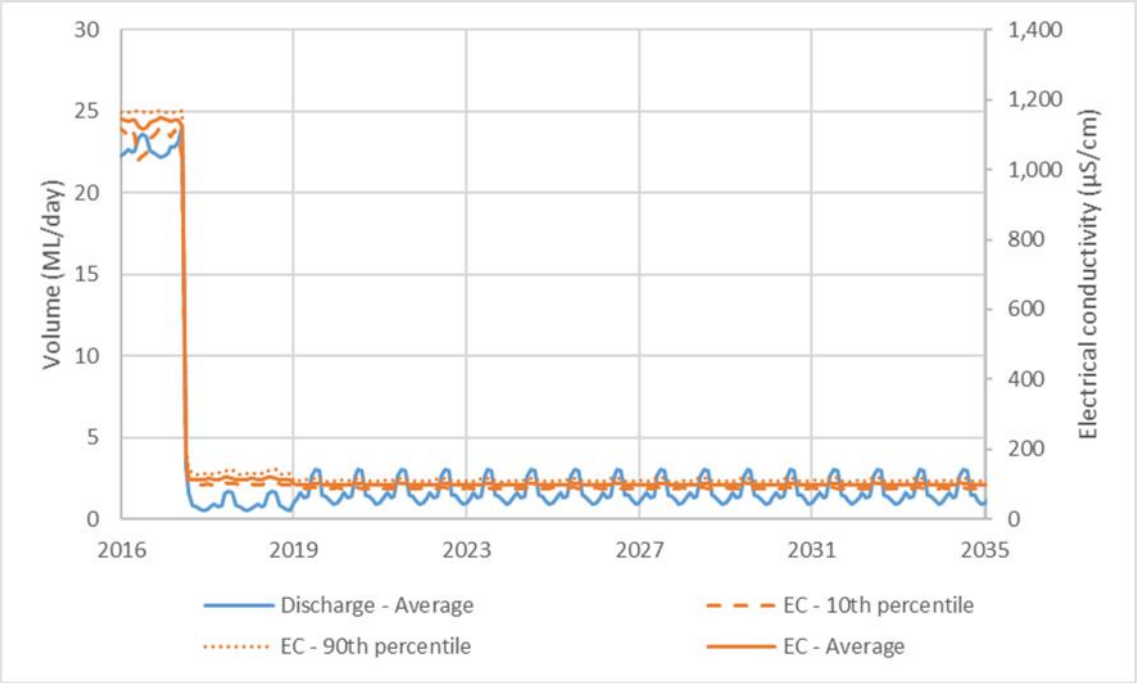


Figure B-79 Scenario 5 – Predicted EC of discharge from Sawyers Swamp Creek to Coxs River

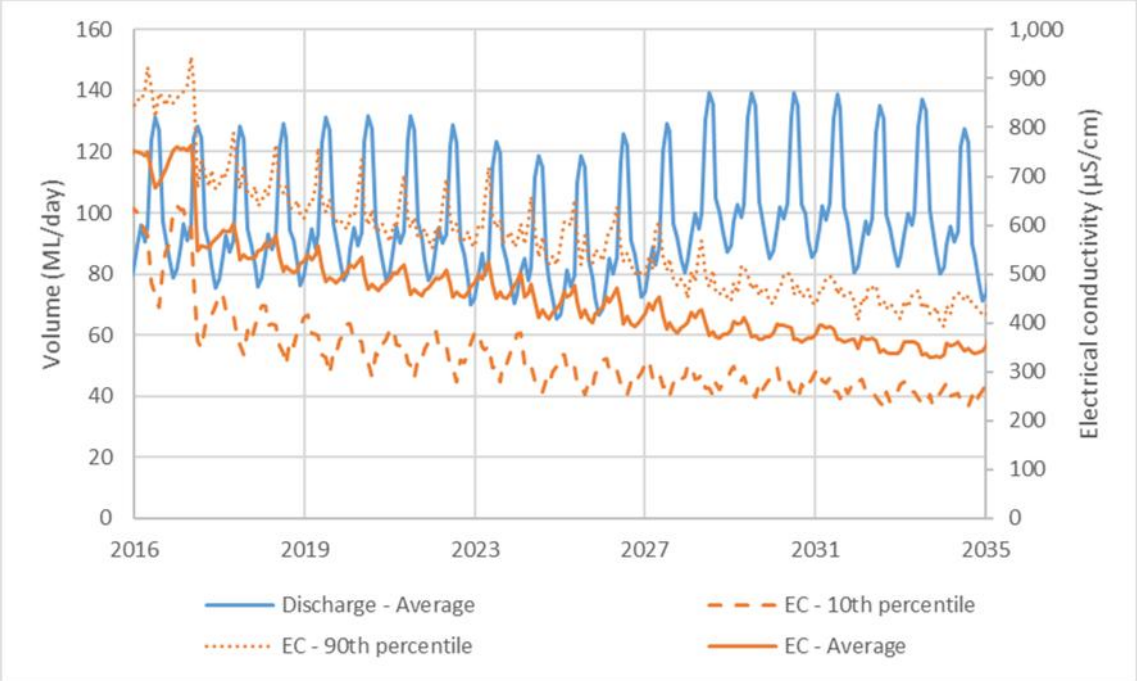


Figure B-80 Scenario 5 – Predicted EC of discharge from Coxs River to Lake Wallace

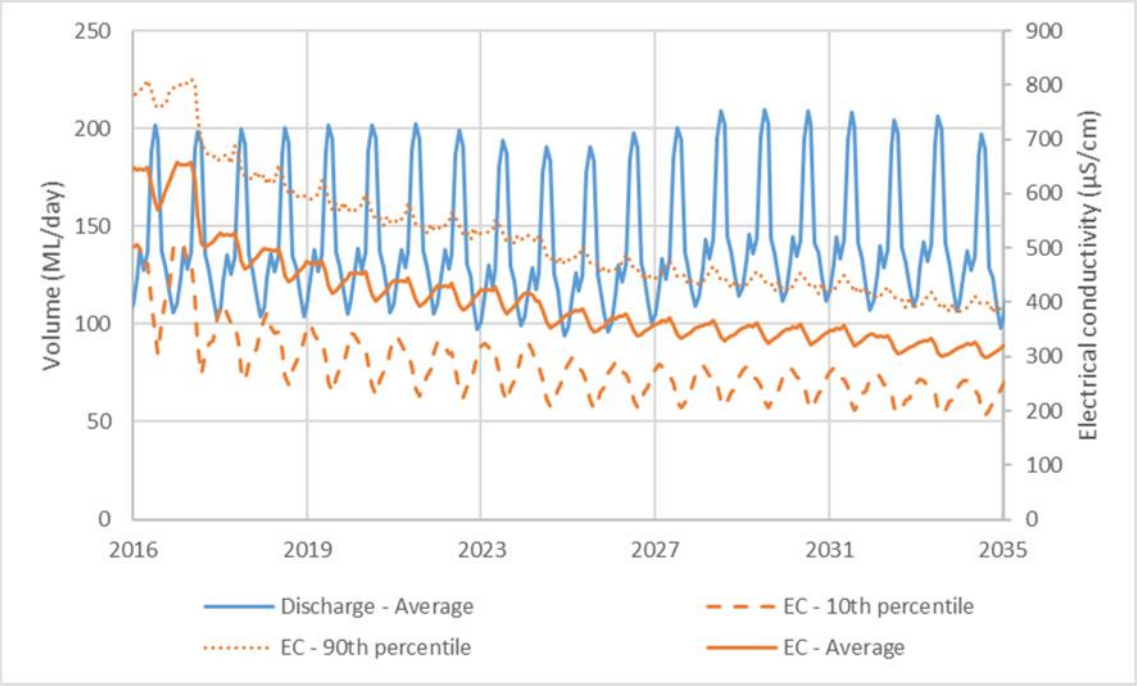


Figure B-71 Scenario 5 – Predicted EC of discharge from Coxs River to Lake Lyell

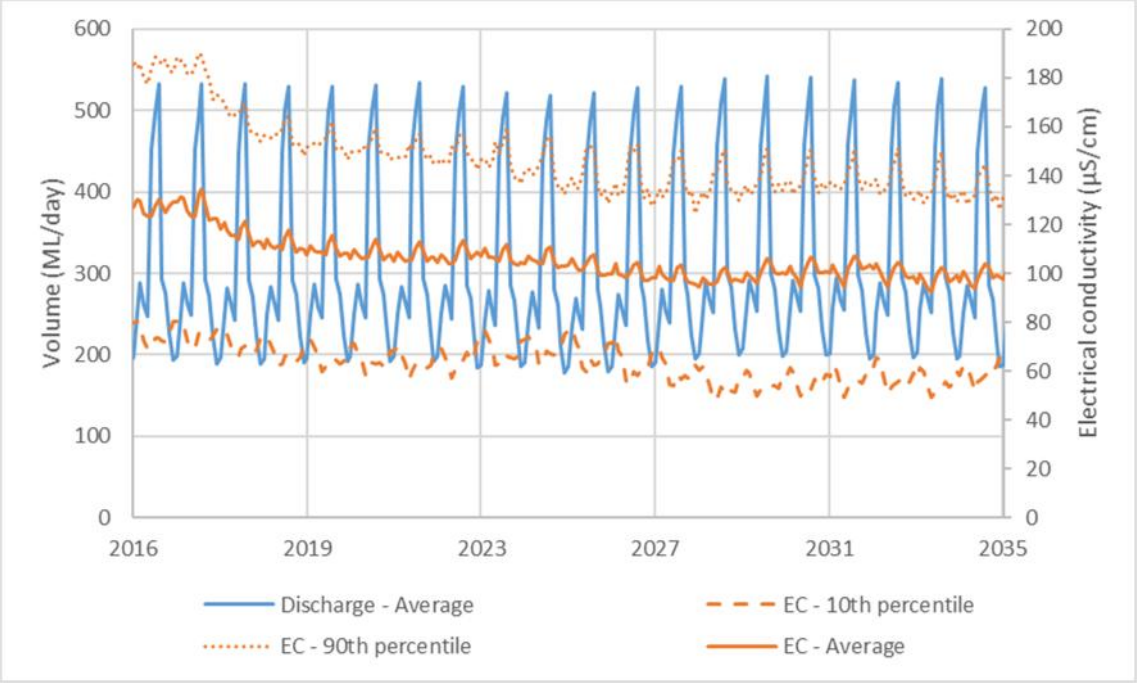


Figure B-72 Scenario 5 – Predicted EC of discharge from Coxs River to Lake Burragorang

Appendix C – Supporting catchment hydrology and hydraulics modelling information

C.1 Hydrology model input data

Data utilised in the establishment of the hydrology model for Wangcol Creek is provided in Table C-1 and Table C-2 below.

Table C-1 Intensity-frequency-duration input data

Parameter	Event		
	1 HR	12 HR	72 HR
2 YEAR ARI	23.6 mm/hr	5.06 mm/hr	1.76 mm/hr
50 YEAR ARI	45.2 mm/hr	9.22 mm/hr	2.77 mm/hr
F2	4.31		
F50	15.72		
Skew	0.17		

Table C-2 Hydrology model input data

Model Node	Catchment Area (ha)	Percentage Impervious Area (%)	Catchment Slope (%)	Catchment Roughness
Base1	111.22	30	2.3	0.05
Base11	11.54	10	2.7	0.05
Base12	60.26	5	12.2	0.05
Base13	44.40	10	2.6	0.05
Base14	45.25	0	7.2	0.05
Base15	158.79	10	2.3	0.05
Base16	54.46	0	7.7	0.05
Base17	385.24	60	1.4	0.05
Base18	64.27	0	8.9	0.05
Base19	98.00	0	6.5	0.05
Base20	178.70	0	6.1	0.05
Base21	2.20	10	4.1	0.05
Base22	25.34	10	4.6	0.05
Base23	17.72	10	5.6	0.05
Base24	12.77	10	7.3	0.05
Base25	47.48	10	1.1	0.05
Base26	87.23	5	7.6	0.05

Model Node	Catchment Area (ha)	Percentage Impervious Area (%)	Catchment Slope (%)	Catchment Roughness
Base27	60.71	5	4.6	0.05
Base28	10.20	30	1.0	0.05
Base30	25.38	10	1.0	0.05
Base31	8.63	10	4.0	0.05
Base33	21.61	0	14.6	0.05
Base34	6.79	0	22.4	0.05
Base35	13.66	0	30.0	0.05
Base36	29.06	30	2.7	0.05
Base37	283.91	0	6.2	0.05
Base4	84.32	0	8.8	0.05
Base43	142.68	0	5.4	0.05
Base45	71.39	30	15	0.05
Base46	82.87	0	6.1	0.05
Base47	312.76	10	0.4	0.05
Base5	34.98	5	9.8	0.05
Base51	18.05	30	2.2	0.05
Base52	44.46	30	6.4	0.05
Base53	137.98	30	2.8	0.05
Base55	7.13	30	2.6	0.05
Base8	54.96	0	7.3	0.05

C.2 Hydraulic model input data

The following Table C-3 and Table C-4, presents the input data for the hydraulic modelling undertaken for Wangcol Creek.

Table C-3 Input flows to hydraulic model

Model Sections	Hydrology Model Reference	1 Year – Existing (Proposed)	10 Year Existing (Proposed)	100 Yea Existing (Proposed)
3218.5 to 2872.4	Base30	25.0 m^3/s (25.0 m^3/s)	66.4 m^3/s (66.4 m^3/s)	119.2 m^3/s (119.2 m^3/s)
2872.4 to 2269.62	Base30	25.0 m^3/s (25.0 m^3/s)	66.4 m^3/s (66.4 m^3/s)	119.2 m^3/s (119.2 m^3/s)
2269.62 to 2178.52	Base28	33.2 m^3/s (33.6 m^3/s)	82.7 m^3/s (83 m^3/s)	143.6 m^3/s (144 m^3/s)
2178.52 to 877.84	Base28	33.2 m^3/s (33.6 m^3/s)	82.7 m^3/s (83 m^3/s)	143.6 m^3/s (144 m^3/s)
877.84 to 33.84	Base25	37.4 m^3/s (37.7 m^3/s)	91.5 m^3/s (91.8 m^3/s)	154.4 m^3/s (154.7 m^3/s)

Table C-4 Roughness assumptions for hydraulic model cross-sections

Model Sections	Left bank roughness	Centre roughness	Right bank roughness
3218.5	0.065	0.04	0.065
3168.5 to 1849.91	0.065	0.035	0.065
1822.24 to 200.38	0.04	0.03	0.04
196.53 to 33.84	0.04	0.015	0.04

Appendix D – Surface water quality assessment

D.1 Upstream locations

D.1.1 Physicochemical parameters

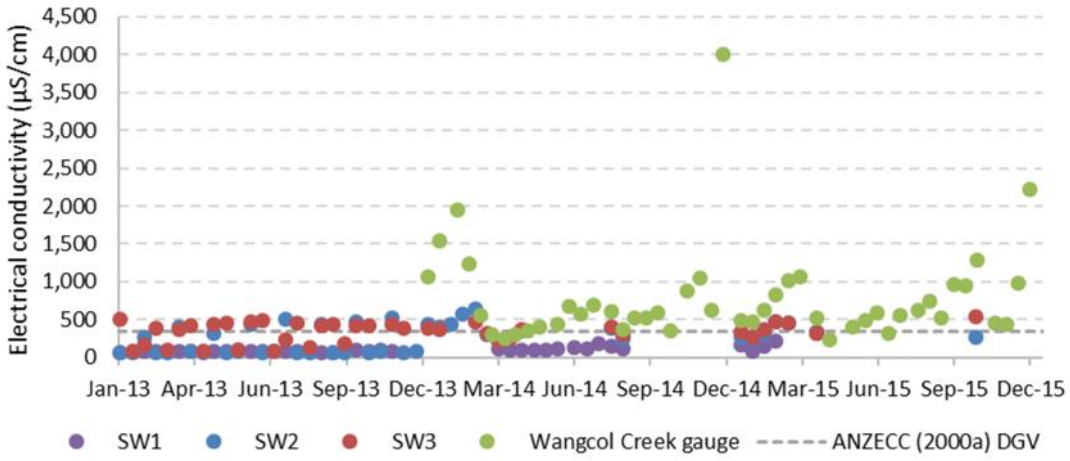


Figure D-1 Electrical conductivity recorded at upstream monitoring locations

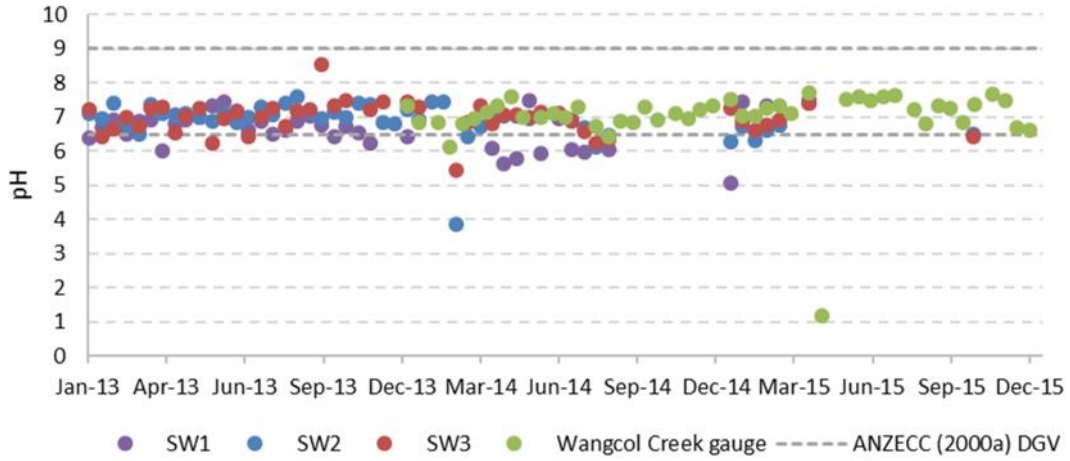


Figure D-2 pH recorded at upstream monitoring locations

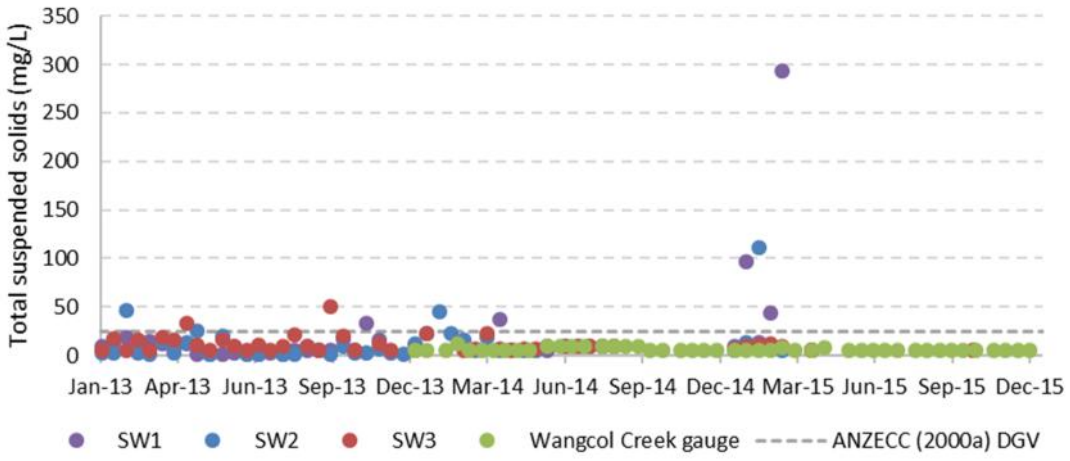


Figure D-3 Total suspended solids recorded at upstream monitoring locations

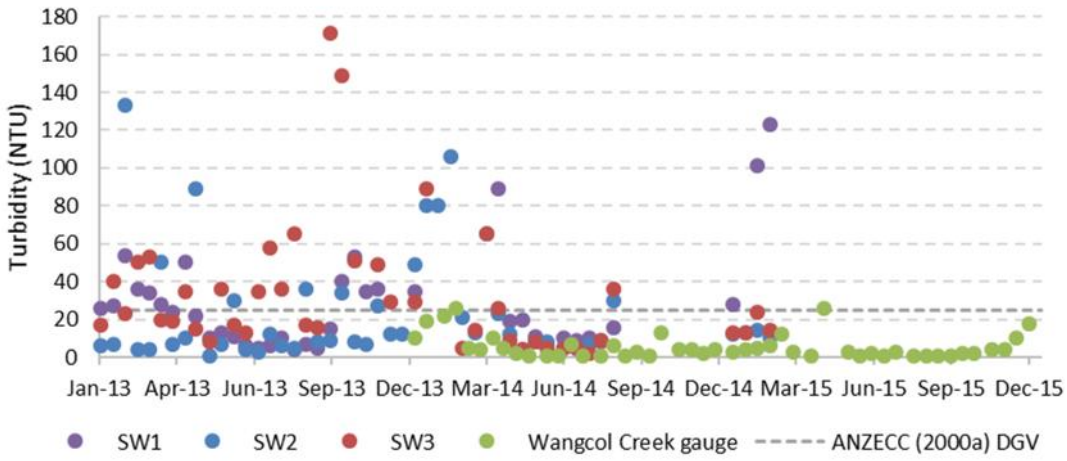


Figure D-4 Turbidity recorded at upstream monitoring locations

D.1.2 Nutrients

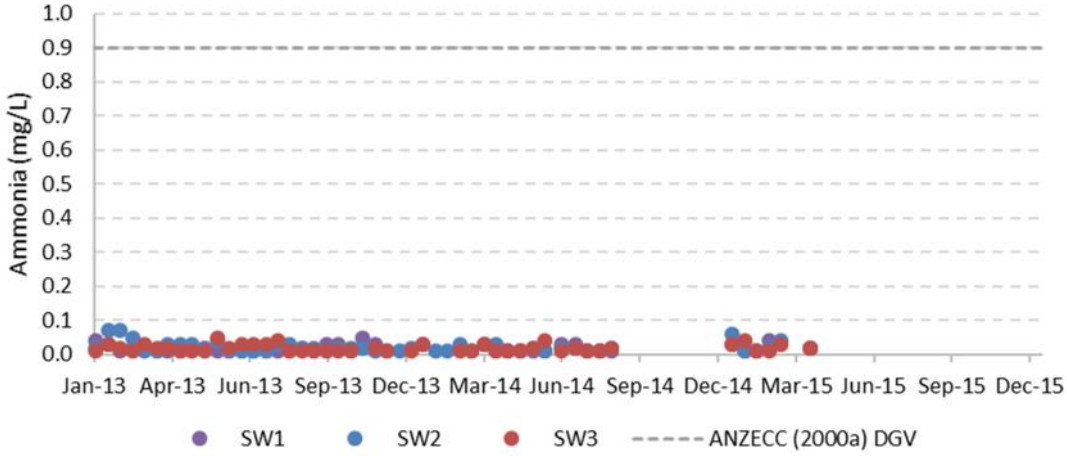


Figure D-5 Ammonia recorded at upstream monitoring locations

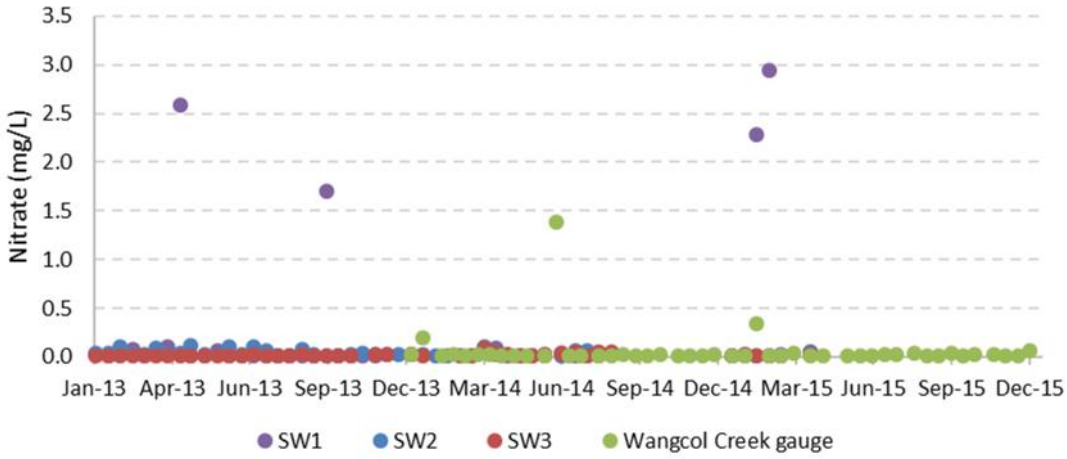


Figure D-6 Nitrate recorded at upstream monitoring locations

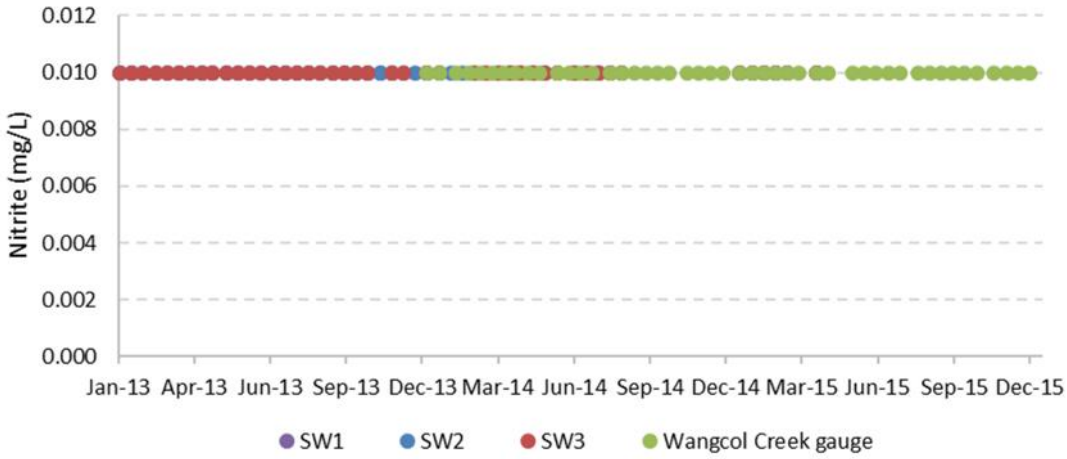


Figure D-7 Nitrite recorded at upstream monitoring locations

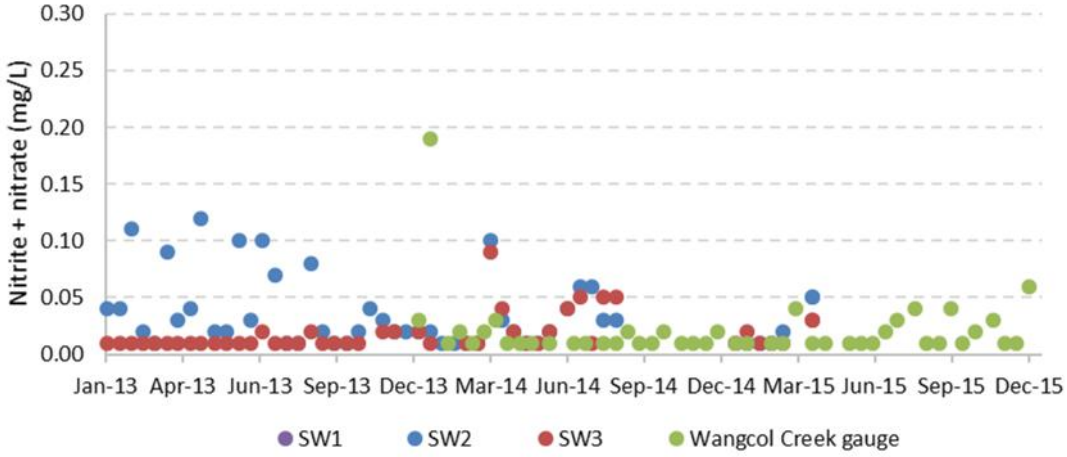


Figure D-8 Nitrite + nitrate recorded at upstream monitoring locations

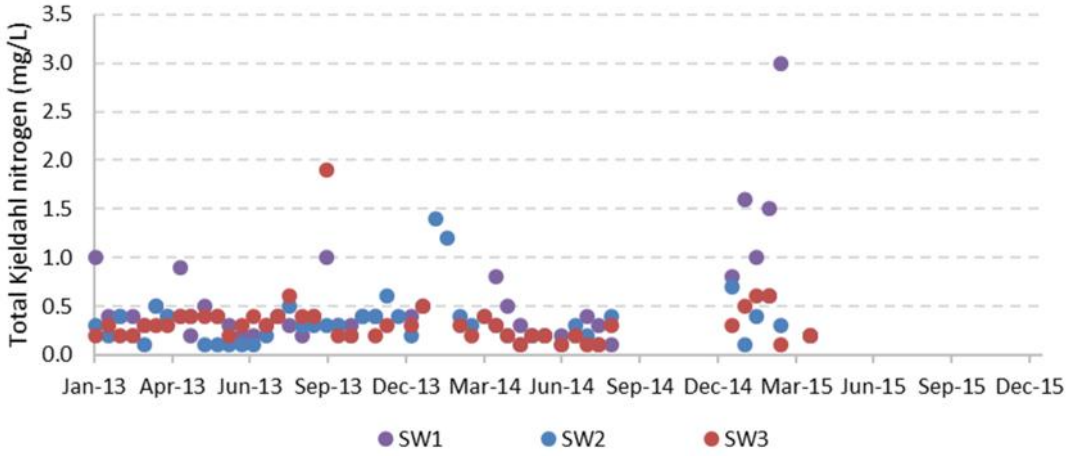


Figure D-9 Total Kjeldahl nitrogen recorded at upstream monitoring locations

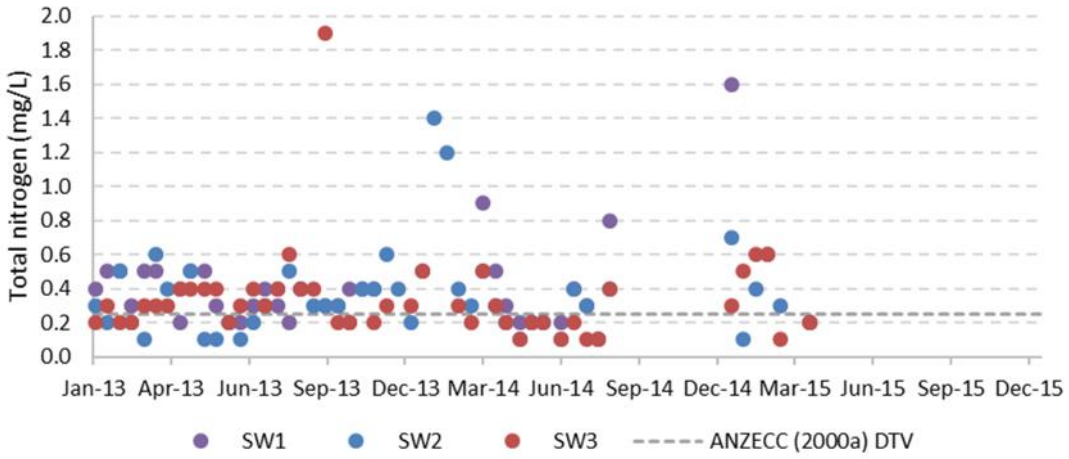


Figure D-10 Total nitrogen recorded at upstream monitoring locations

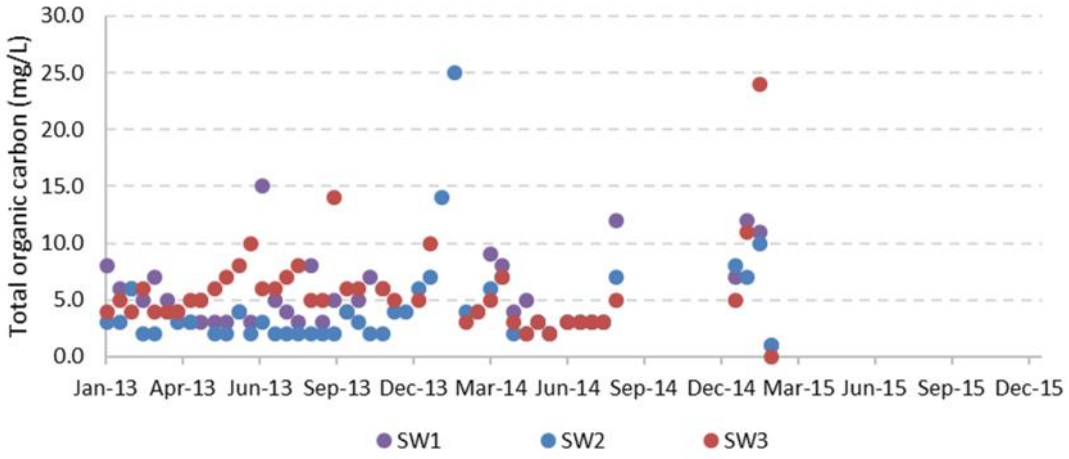


Figure D-11 Total organic carbon recorded at upstream monitoring locations

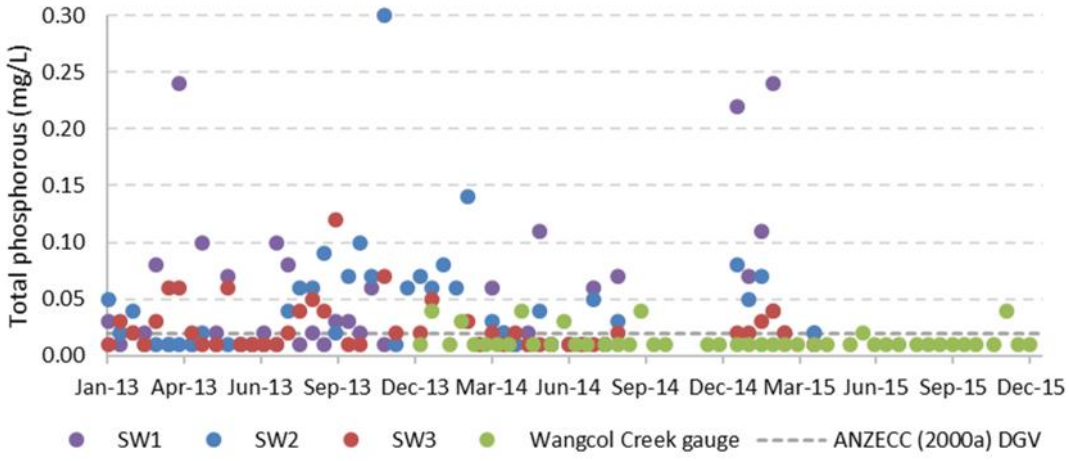


Figure D-12 Total phosphorus recorded at upstream monitoring locations

D.1.3 Anions

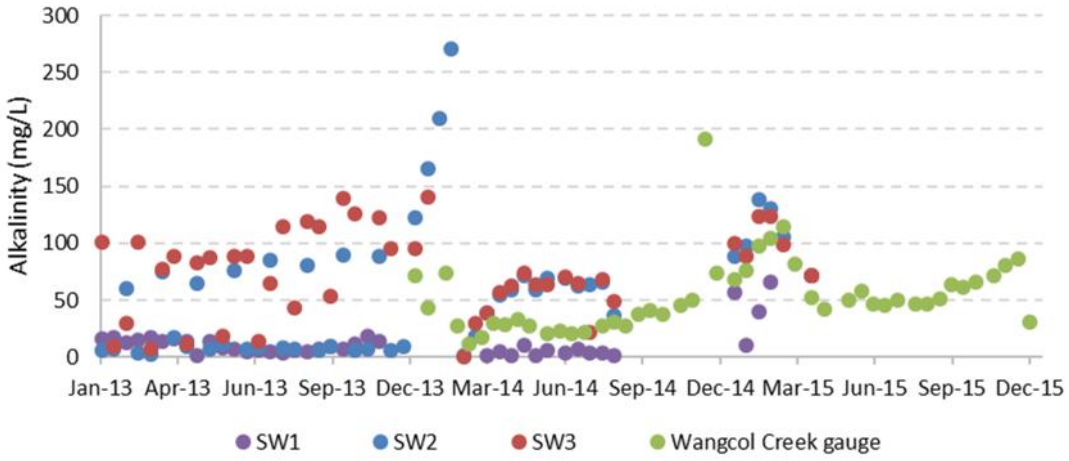


Figure D-13 Alkalinity recorded at upstream monitoring locations

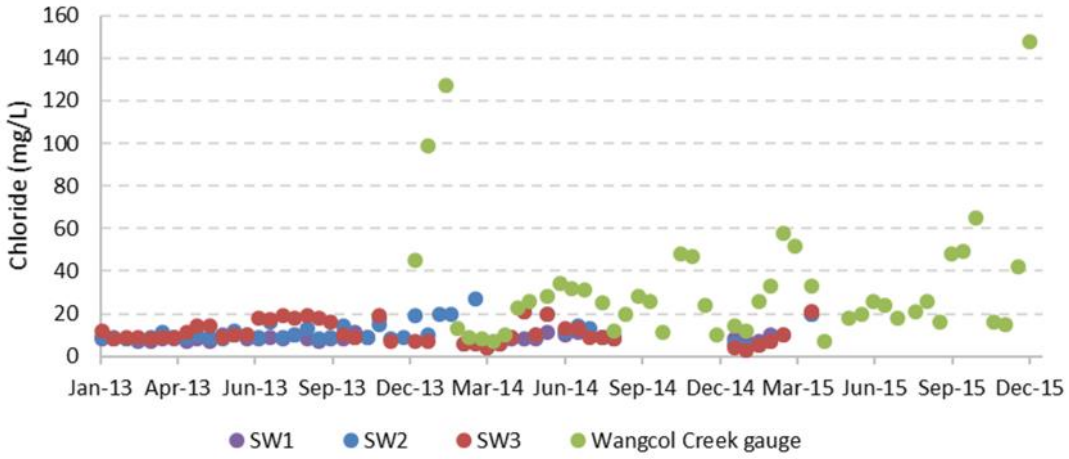


Figure D-14 Chloride recorded at upstream monitoring locations

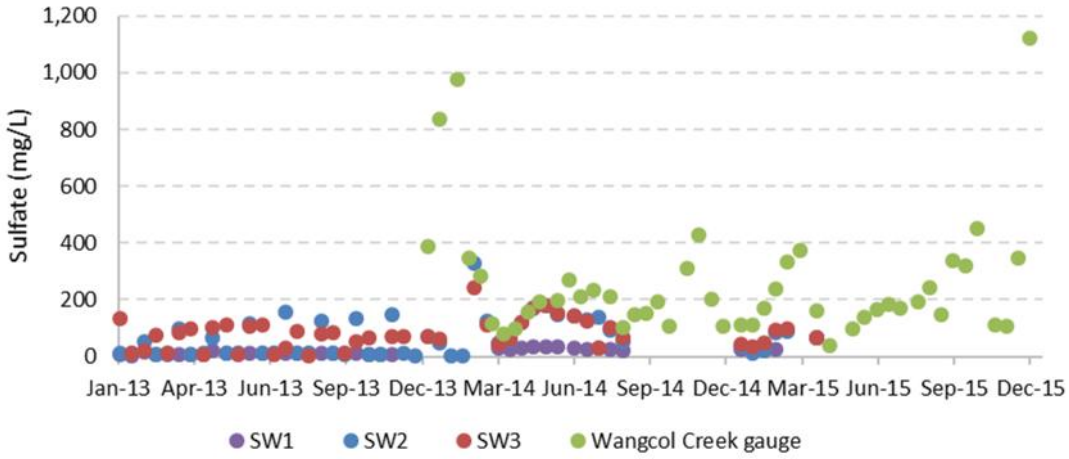


Figure D-15 Sulfate recorded at upstream monitoring locations

D.1.4 Cations

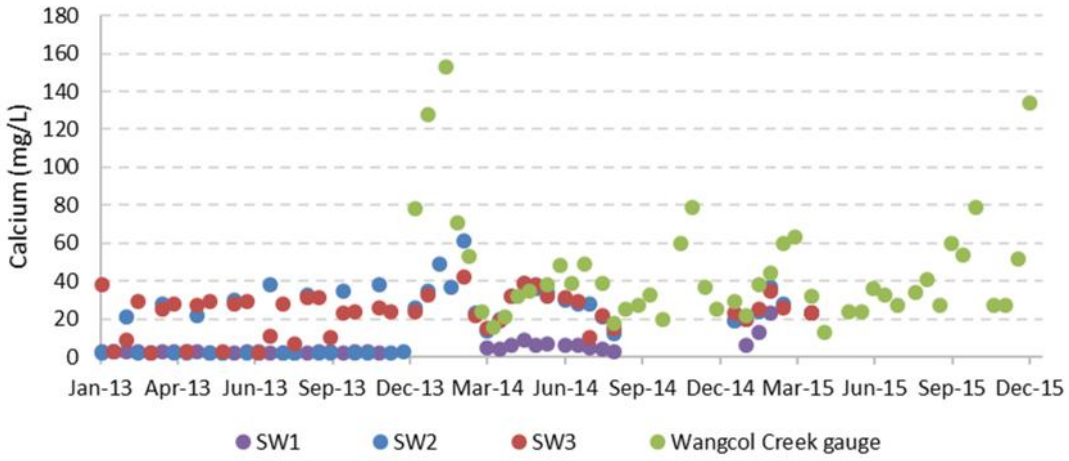


Figure D-16 Calcium recorded at upstream monitoring locations

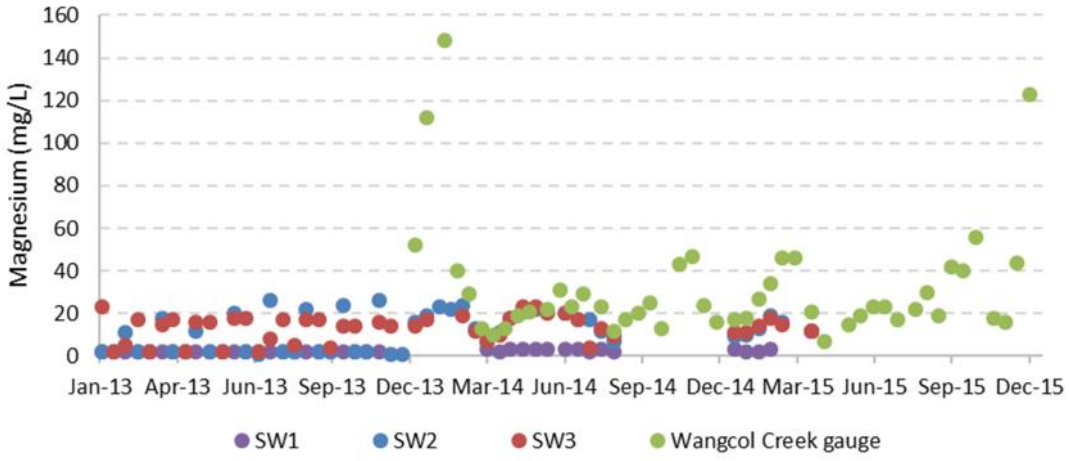


Figure D-17 Magnesium recorded at upstream monitoring locations

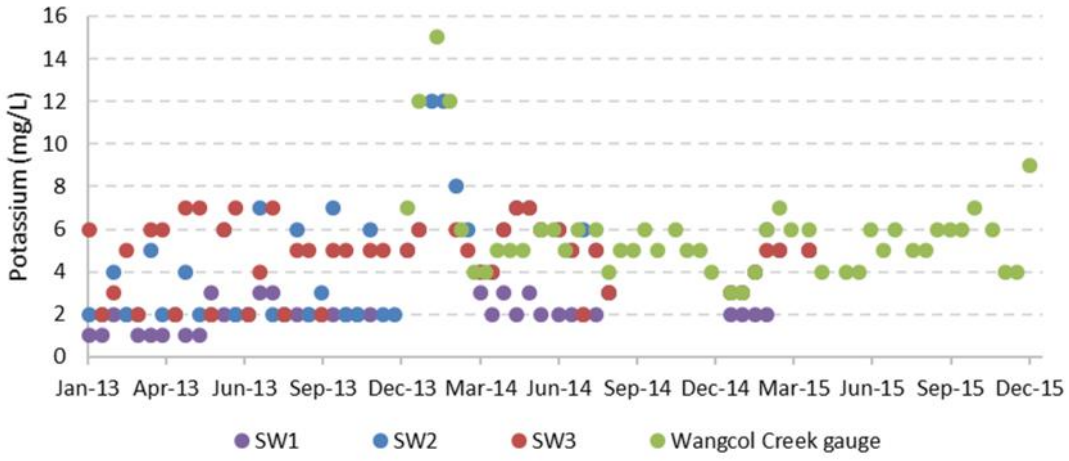


Figure D-18 Potassium recorded at upstream monitoring locations

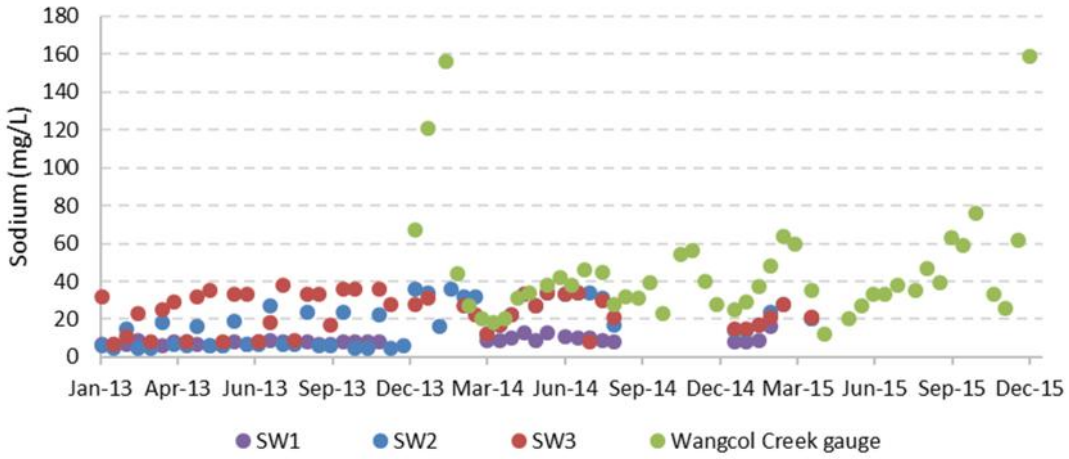


Figure D-19 Sodium recorded at upstream monitoring locations

D.1.5 Metals

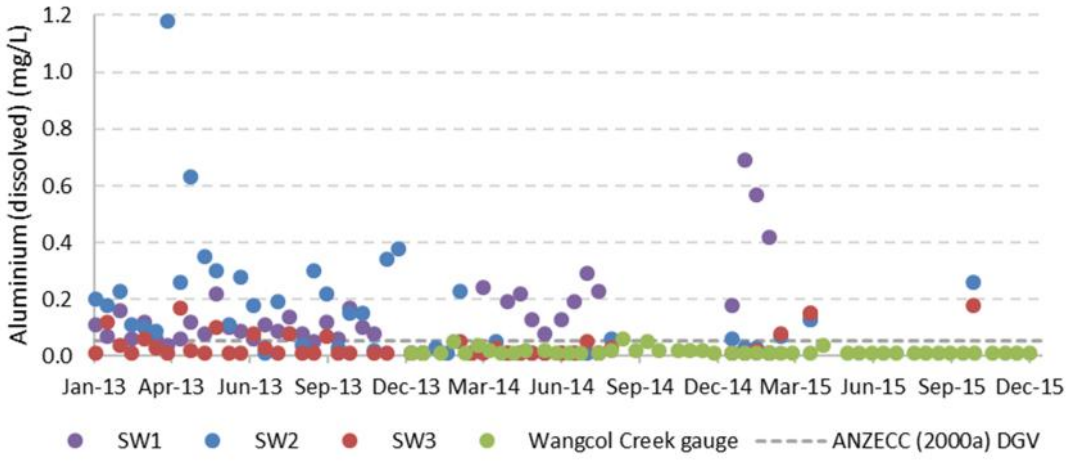


Figure D-20 Aluminium (dissolved) recorded at upstream monitoring locations



Figure D-21 Antimony (dissolved) recorded at upstream monitoring locations

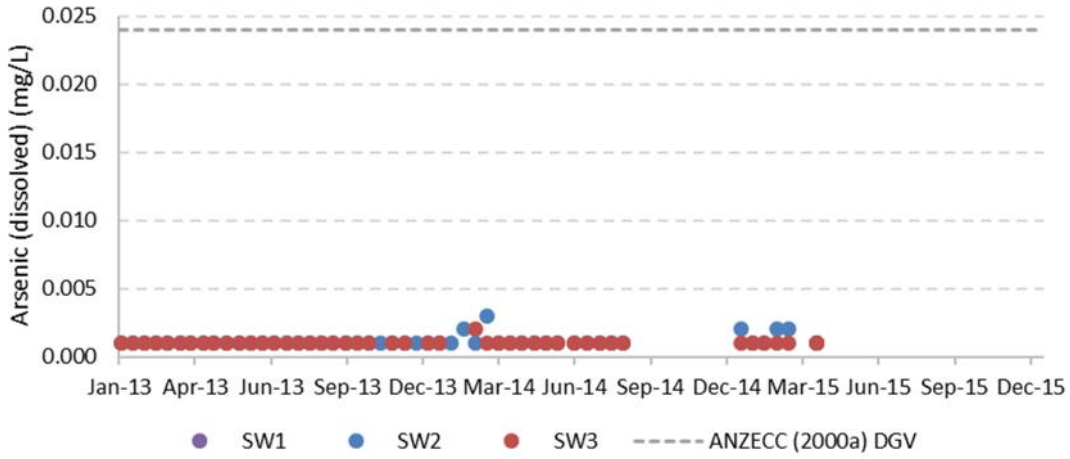


Figure D-22 Arsenic (dissolved) recorded at upstream monitoring locations

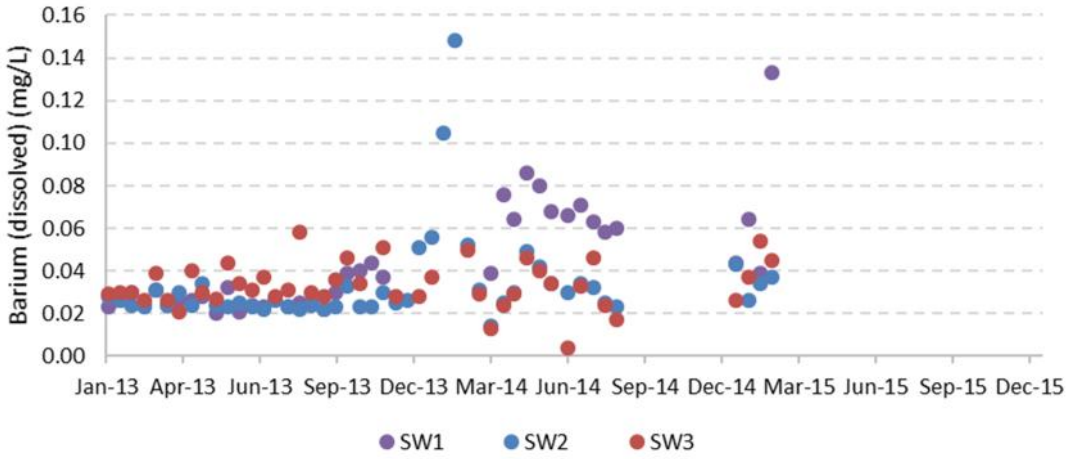


Figure D-23 Barium (dissolved) recorded at upstream monitoring locations

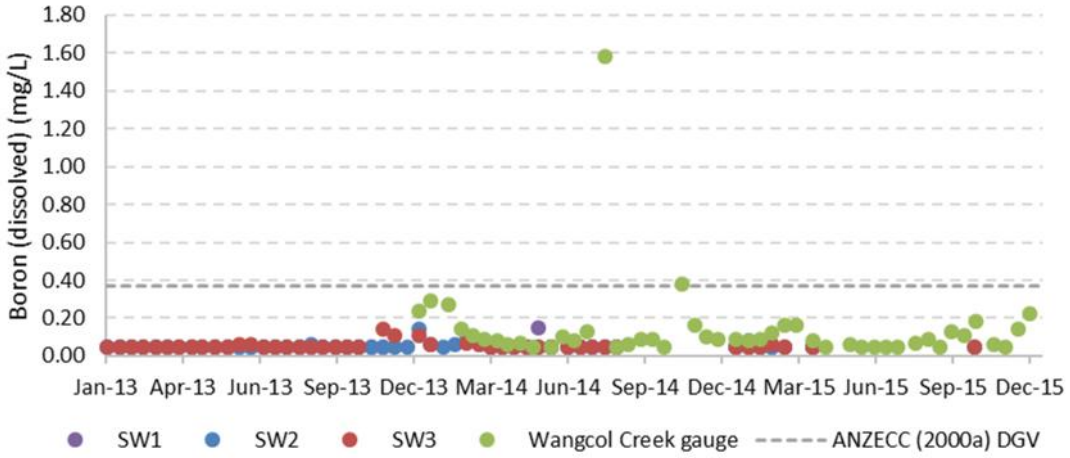


Figure D-24 Boron (dissolved) recorded at upstream monitoring locations

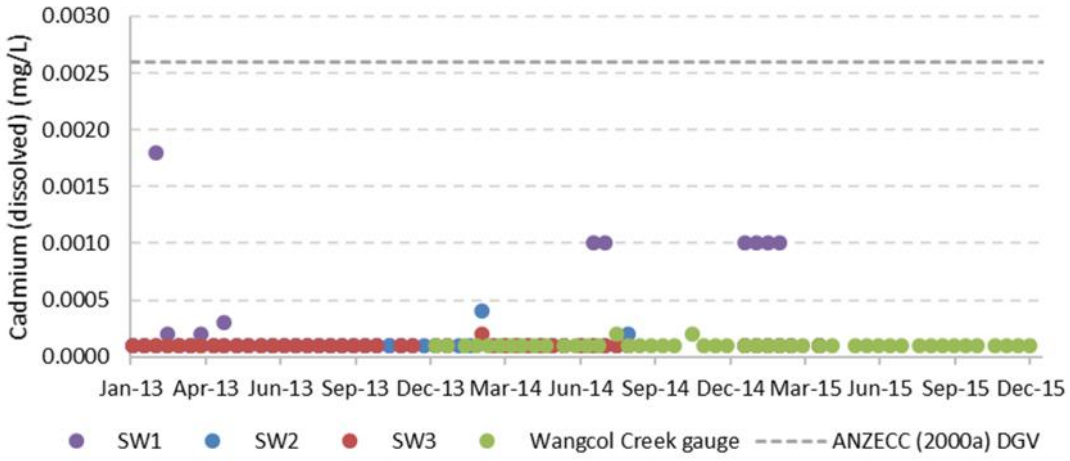


Figure D-25 Cadmium (dissolved) recorded at upstream monitoring locations

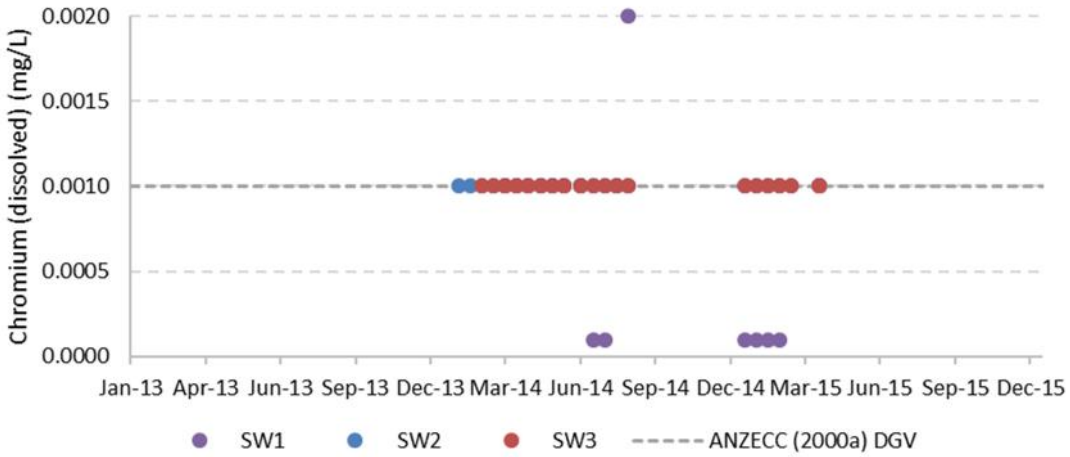


Figure D-26 Chromium (dissolved) recorded at upstream monitoring locations

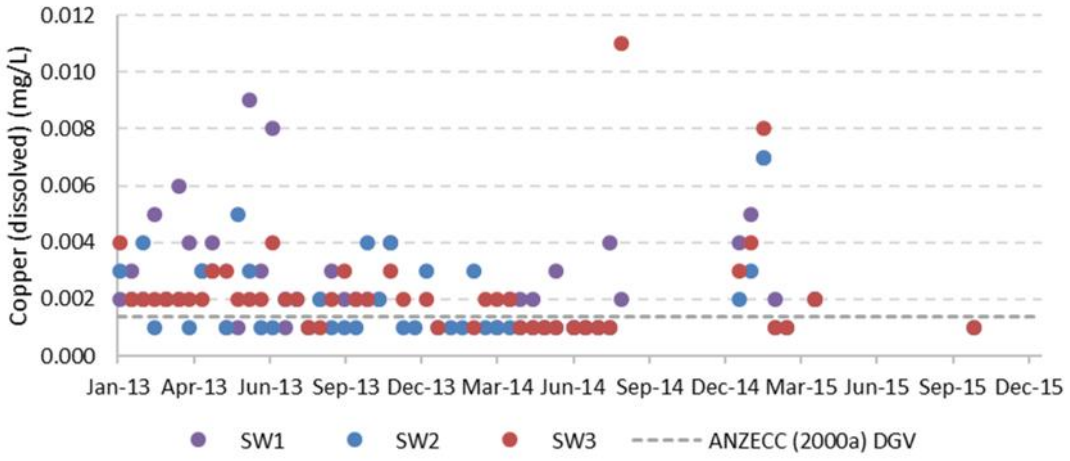


Figure D-27 Copper (dissolved) recorded at upstream monitoring locations

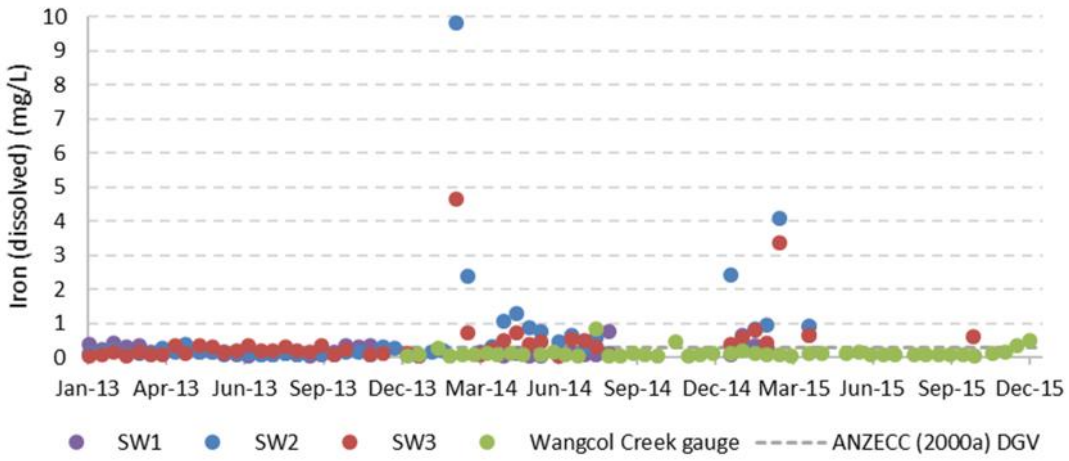


Figure D-28 Iron (dissolved) recorded at upstream monitoring locations

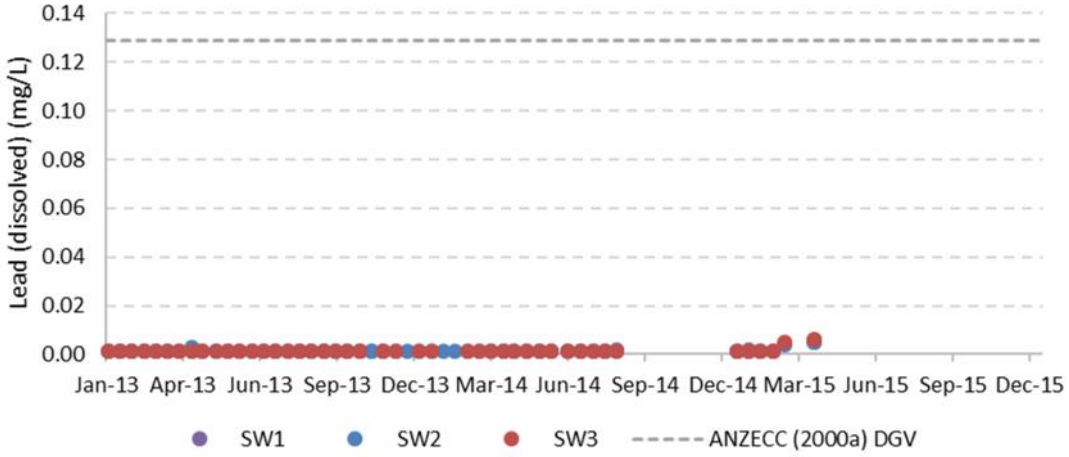


Figure D-29 Lead (dissolved) recorded at upstream monitoring locations

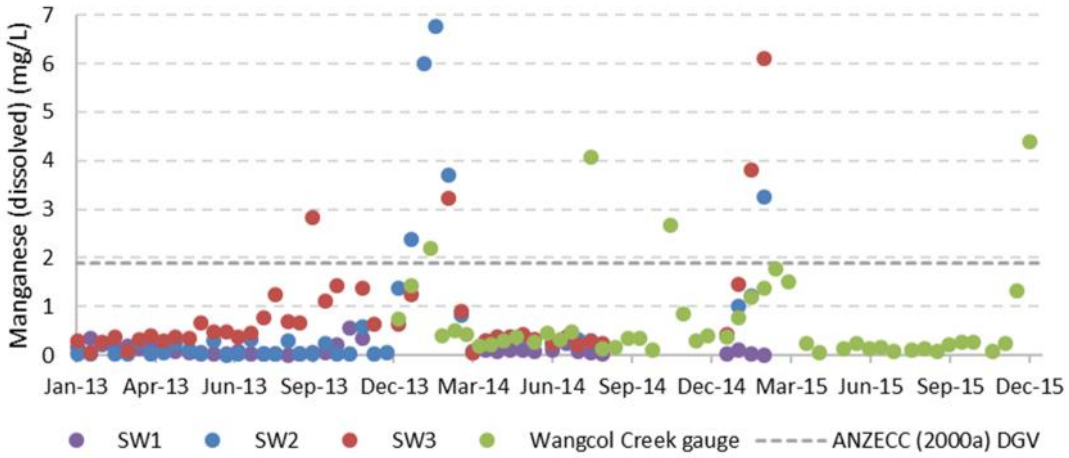


Figure D-30 Manganese (dissolved) recorded at upstream monitoring locations

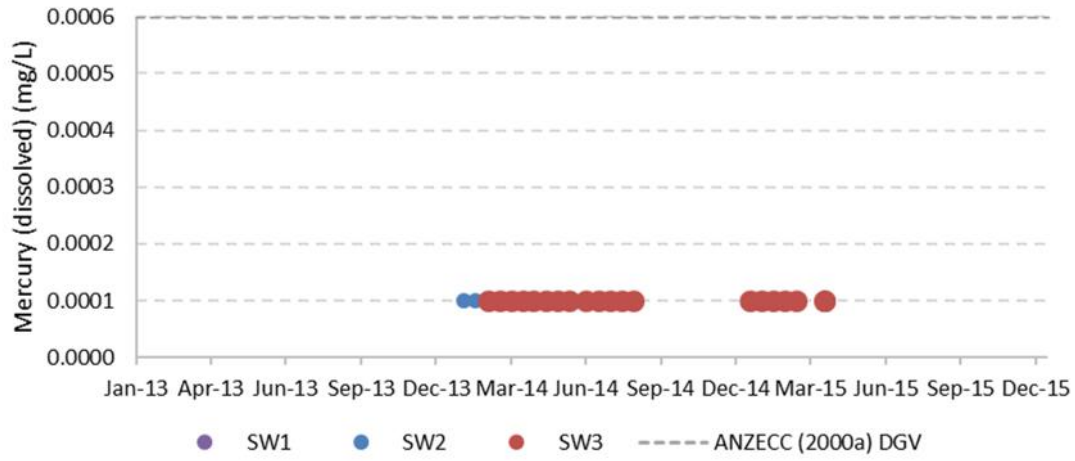


Figure D-31 Mercury (dissolved) recorded at upstream monitoring locations

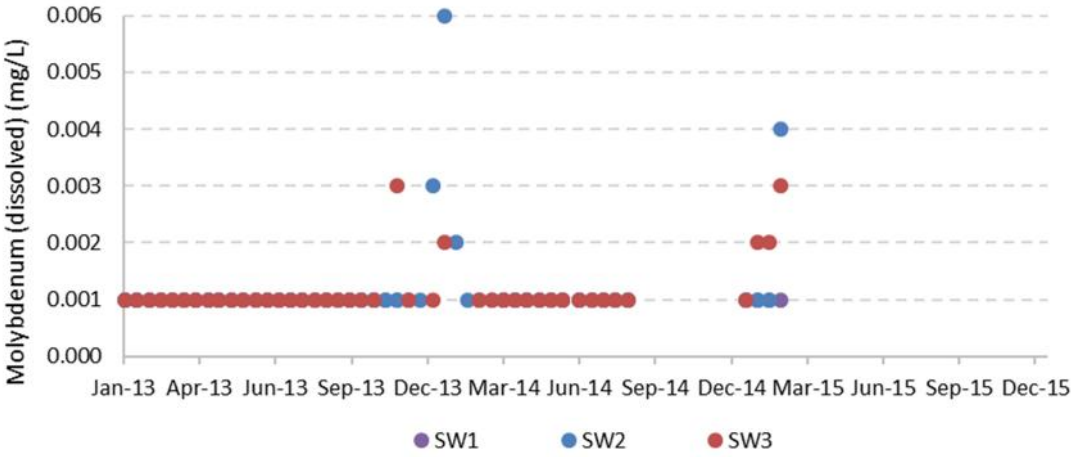


Figure D-32 Molybdenum (dissolved) recorded at upstream monitoring locations

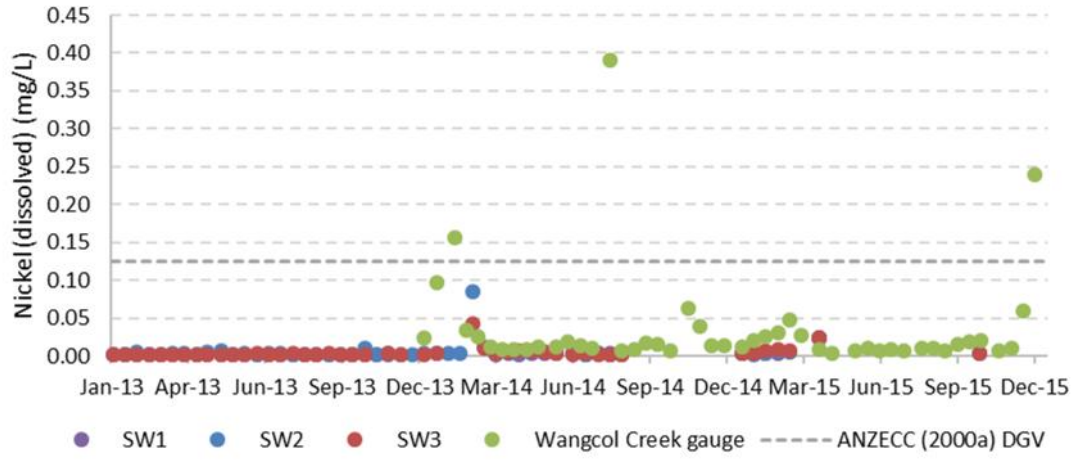


Figure D-33 Nickel (dissolved) recorded at upstream monitoring locations

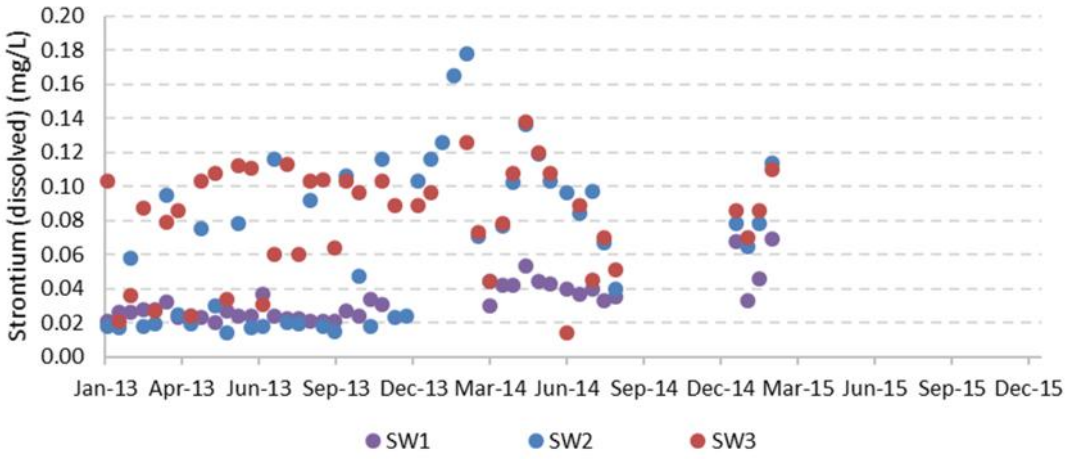


Figure D-34 Strontium (dissolved) recorded at upstream monitoring locations

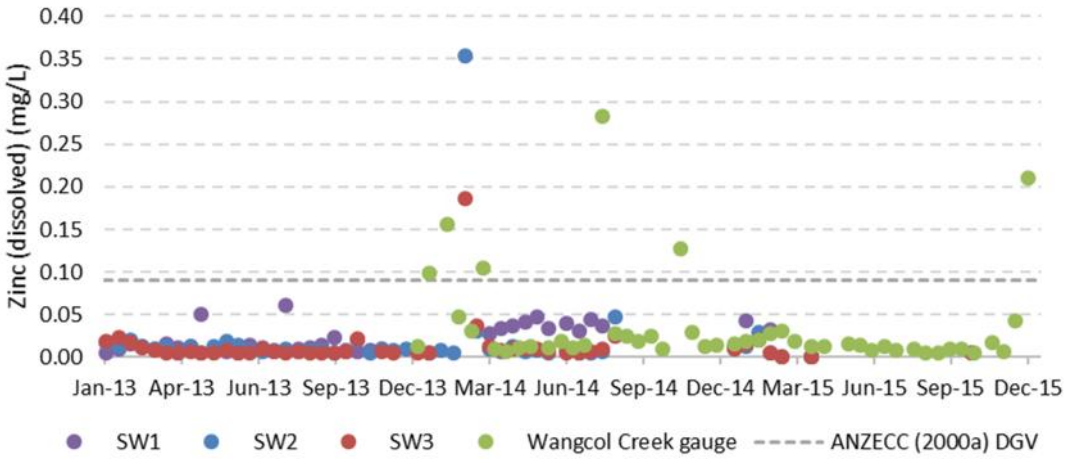


Figure D-35 Zinc (dissolved) recorded at upstream monitoring locations

D.1.6 Other parameters

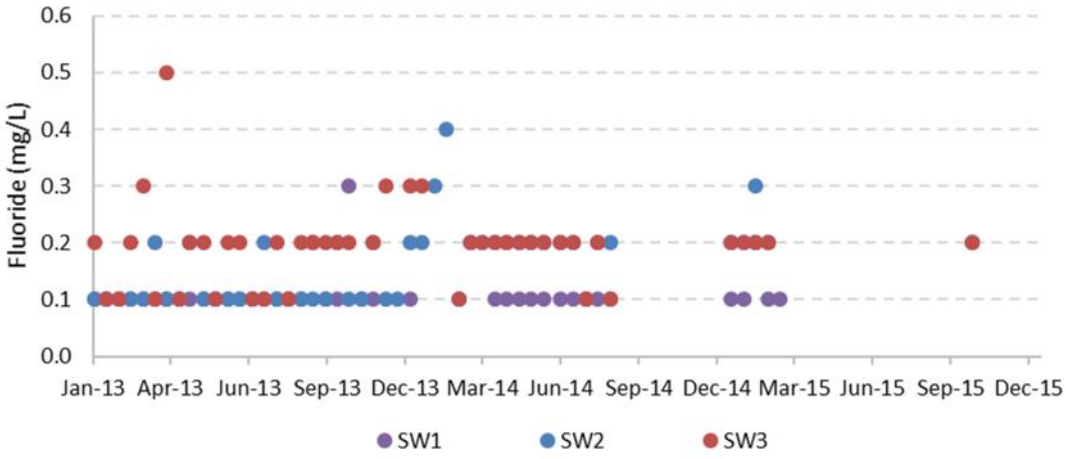


Figure D-36 Fluoride recorded at upstream monitoring locations

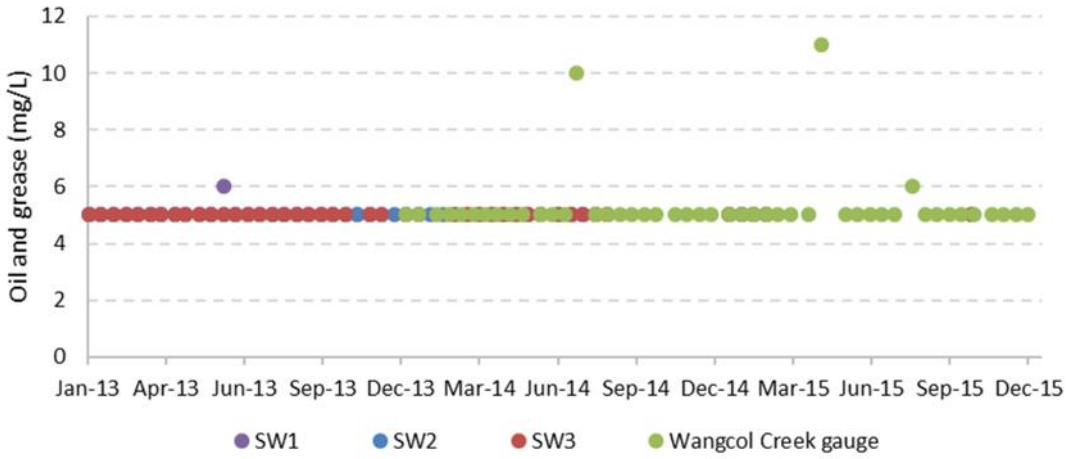


Figure D-37 Oil and grease recorded at upstream monitoring locations

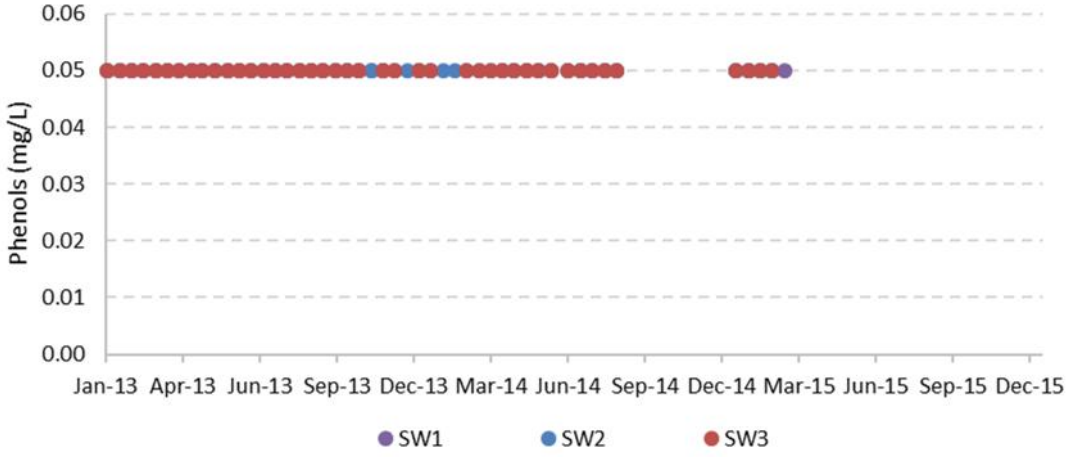


Figure D-38 Phenols recorded at upstream monitoring locations

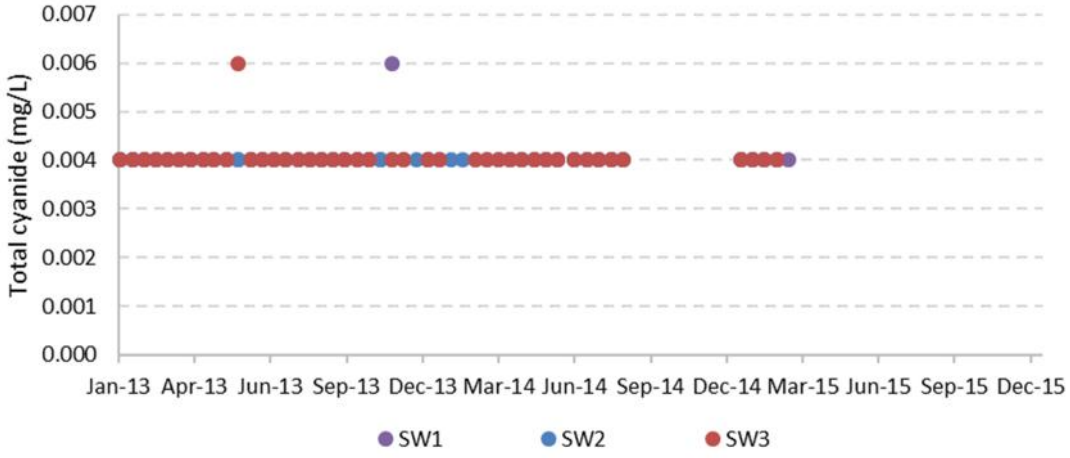


Figure D-39 Total cyanide recorded at upstream monitoring locations

D.2 Discharge locations

D.2.1 Physicochemical parameters

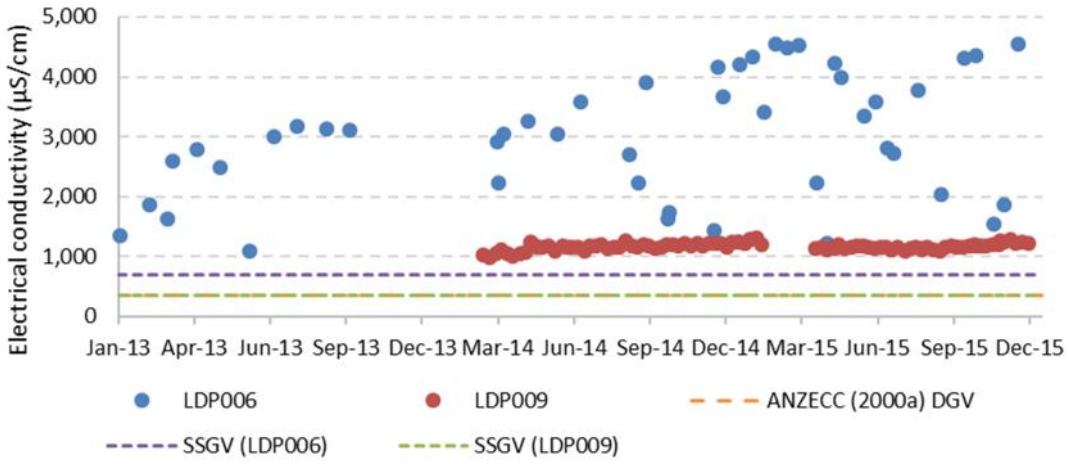


Figure D-40 Electrical conductivity recorded at LDP006 and LDP009

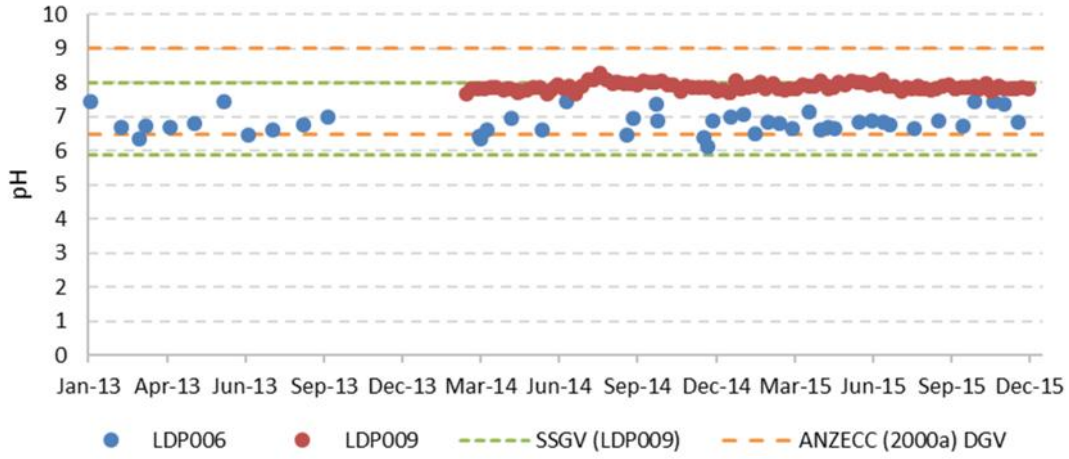


Figure D-41 pH recorded at LDP006 and LDP009

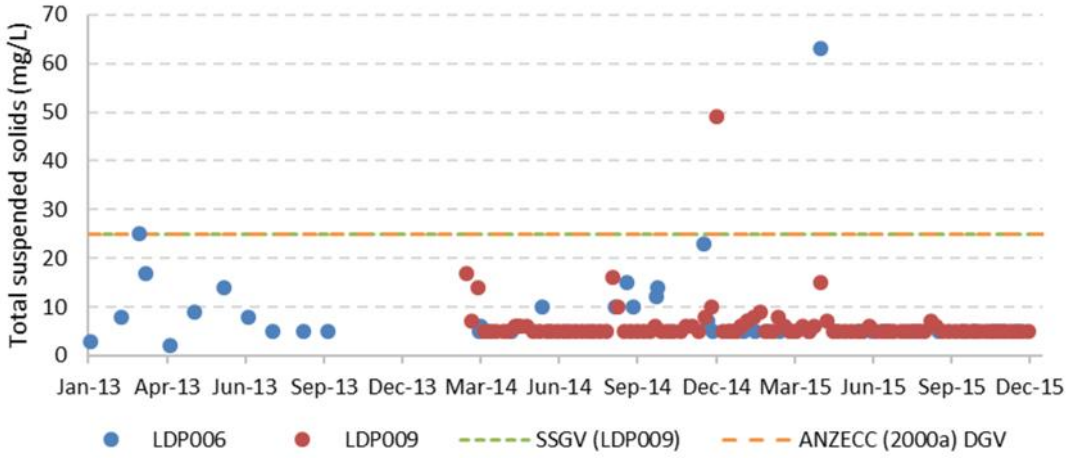


Figure D-42 Total suspended solids recorded at LDP006 and LDP009

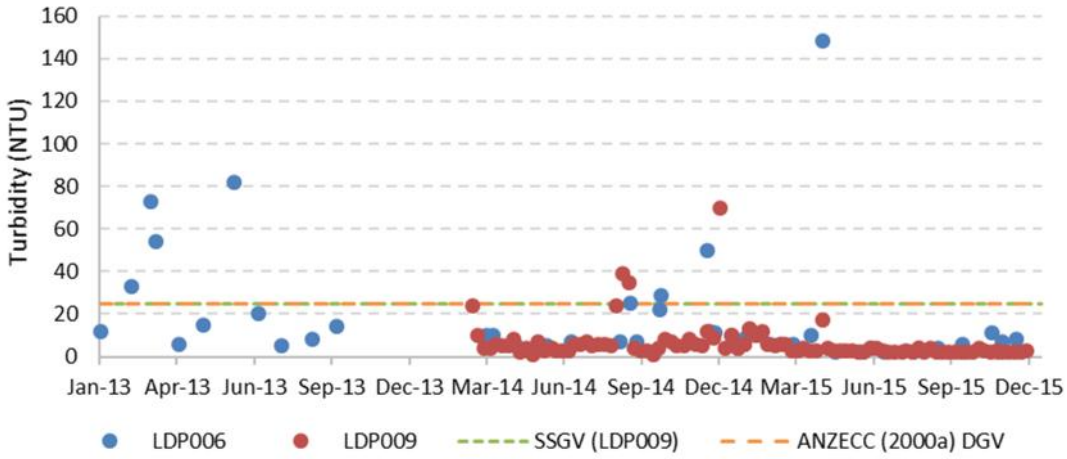


Figure D-43 Turbidity recorded at LDP006 and LDP009

D.2.2 Nutrients

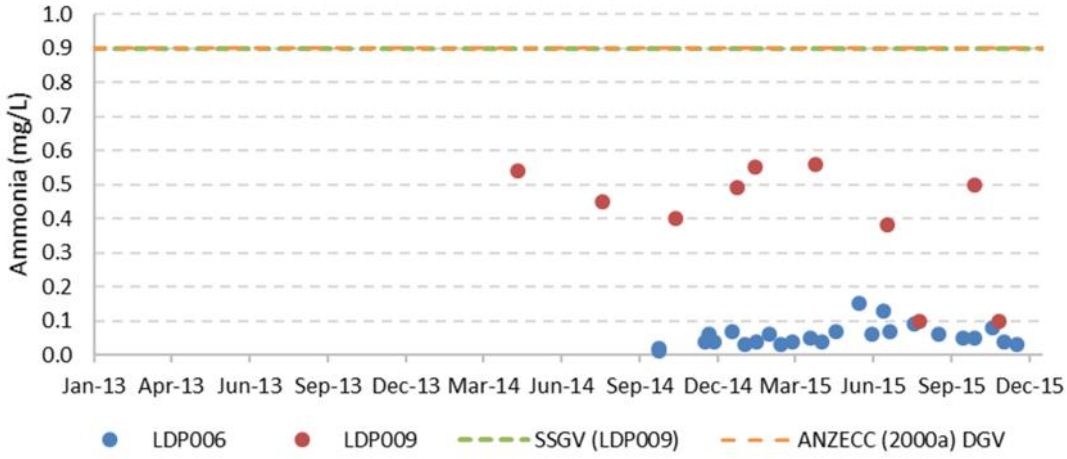


Figure D-44 Ammonia recorded at LDP006 and LDP009

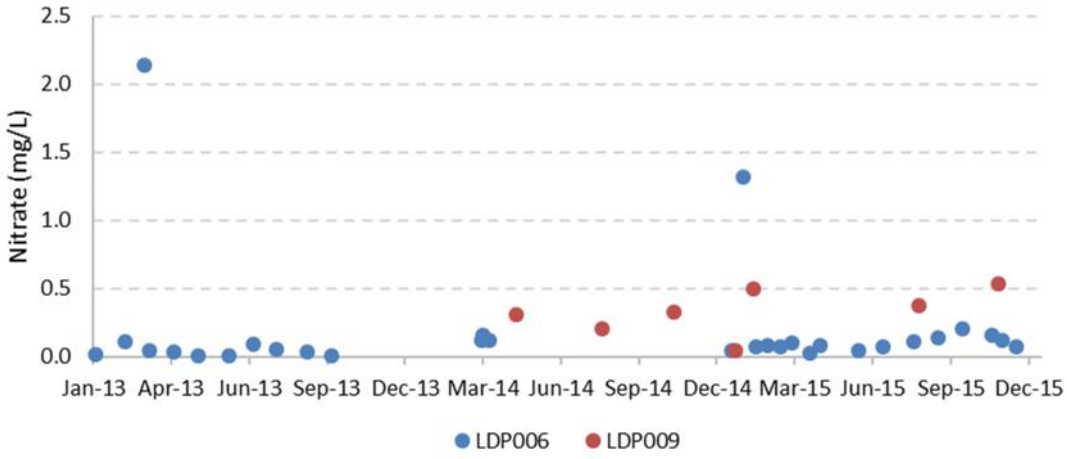


Figure D-45 Nitrate recorded at LDP006 and LDP009

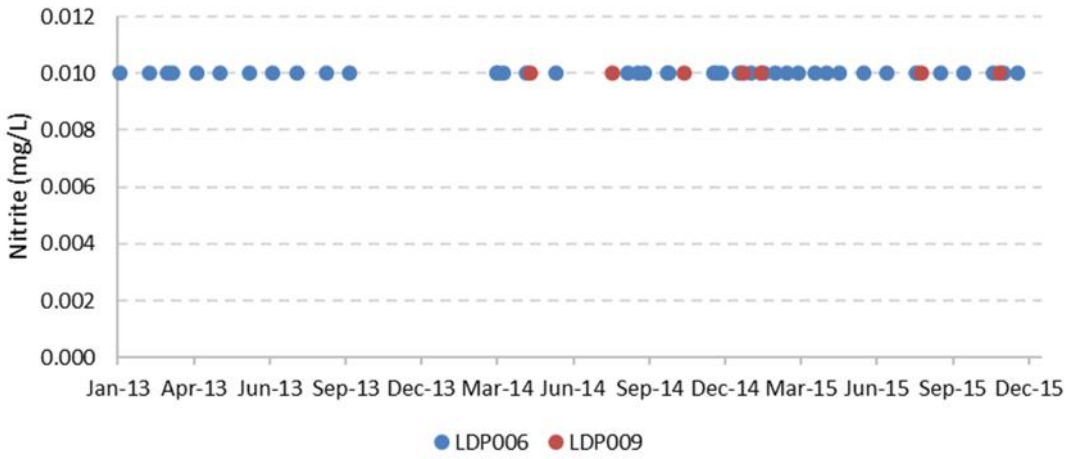


Figure D-46 Nitrite recorded at LDP006 and LDP009

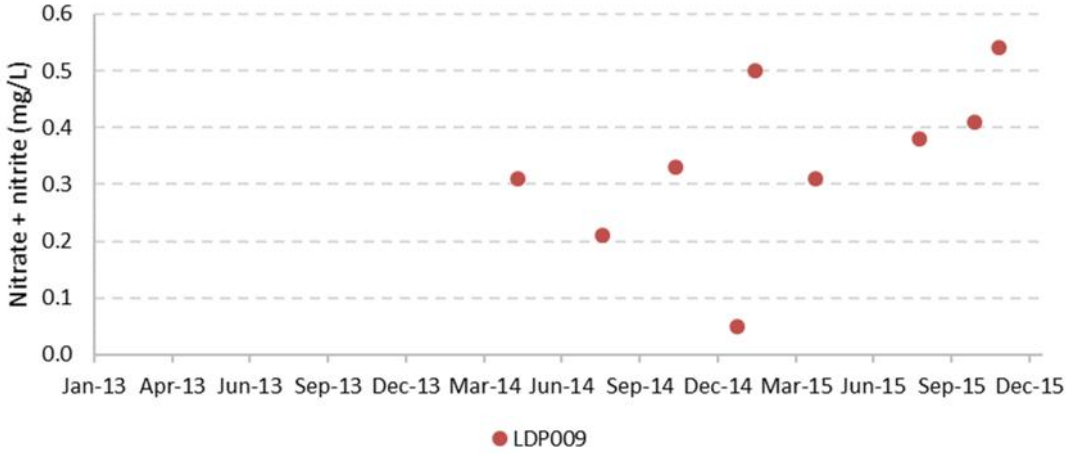


Figure D-47 Nitrite + nitrate recorded at LDP009

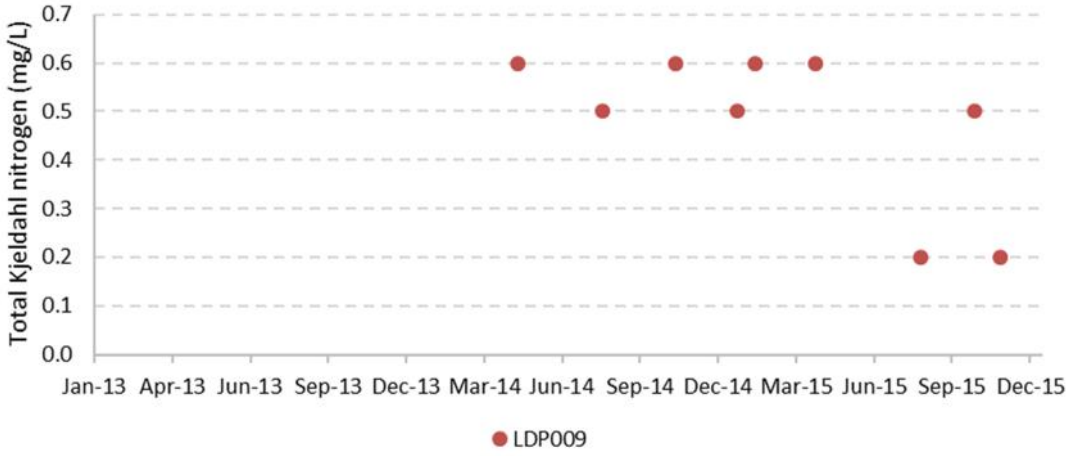


Figure D-48 Total Kjeldahl nitrogen recorded at LDP009

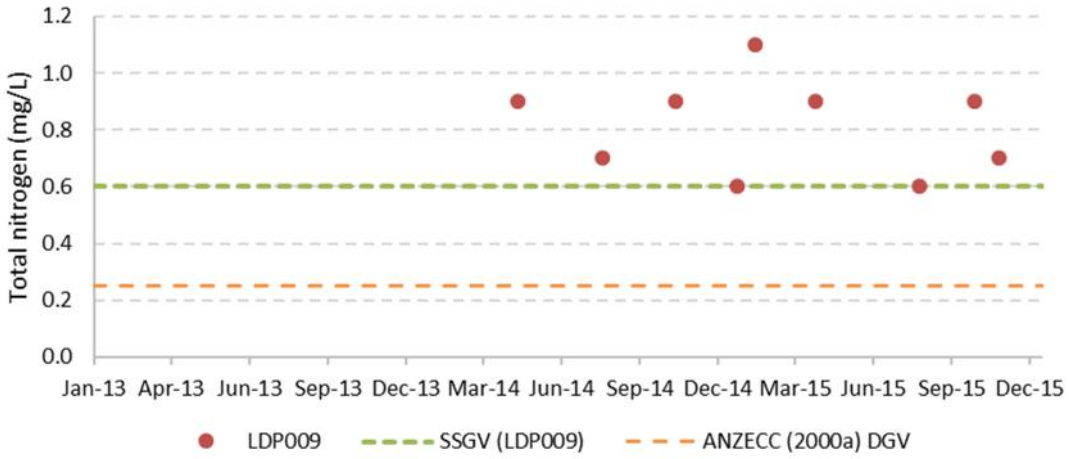


Figure D-49 Total nitrogen recorded at LDP009

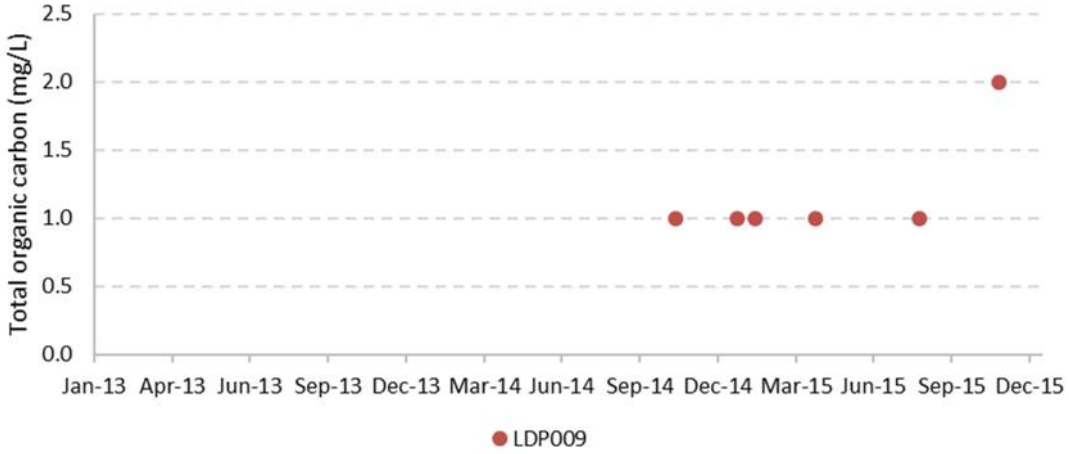


Figure D-50 Total organic carbon recorded at LDP009

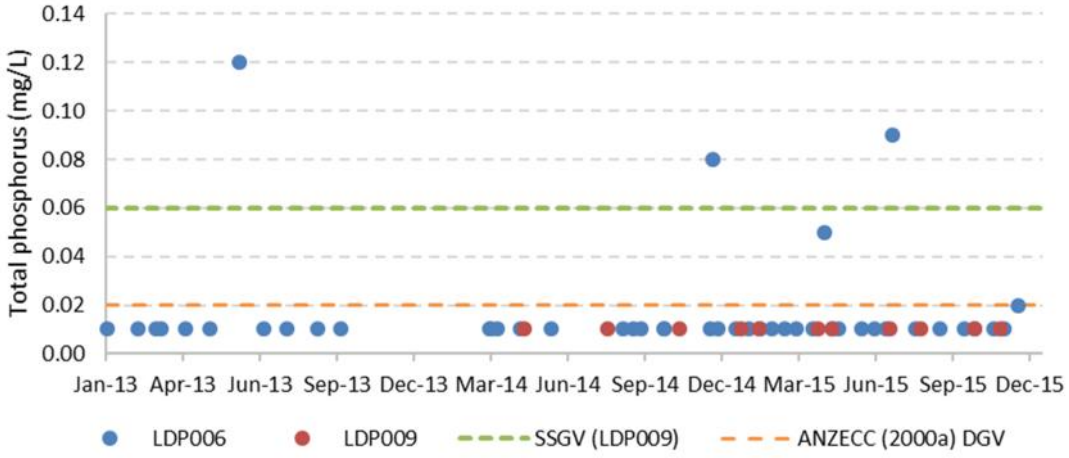


Figure D-51 Total phosphorus recorded at LDP006 and LDP009

D.2.3 Anions

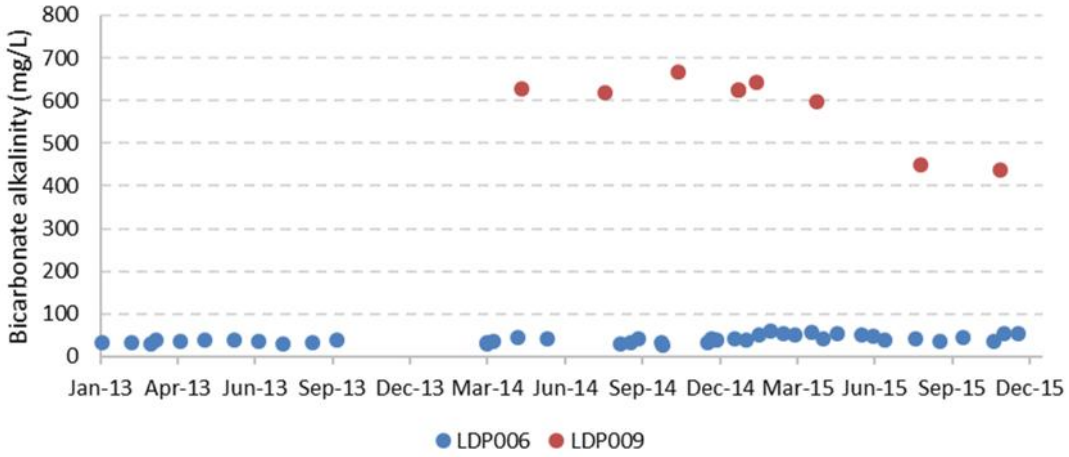


Figure D-52 Bicarbonate alkalinity recorded at LDP006 and LDP009

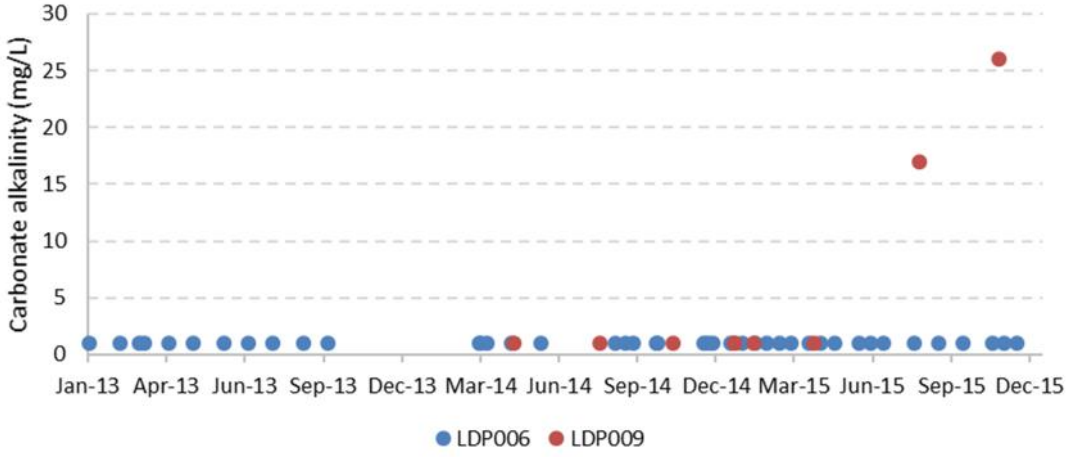


Figure D-53 Carbonate alkalinity recorded at LDP006 and LDP009

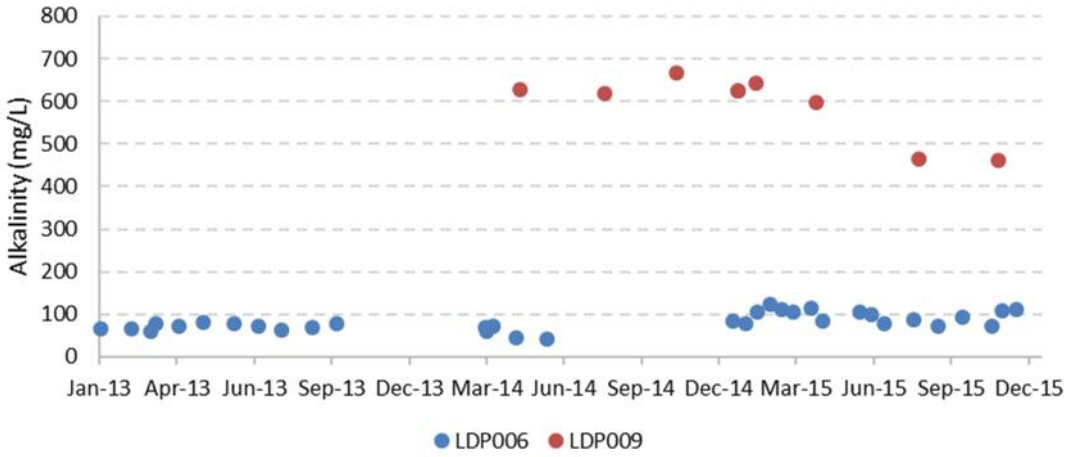


Figure D-54 Total alkalinity recorded at LDP006 and LDP009

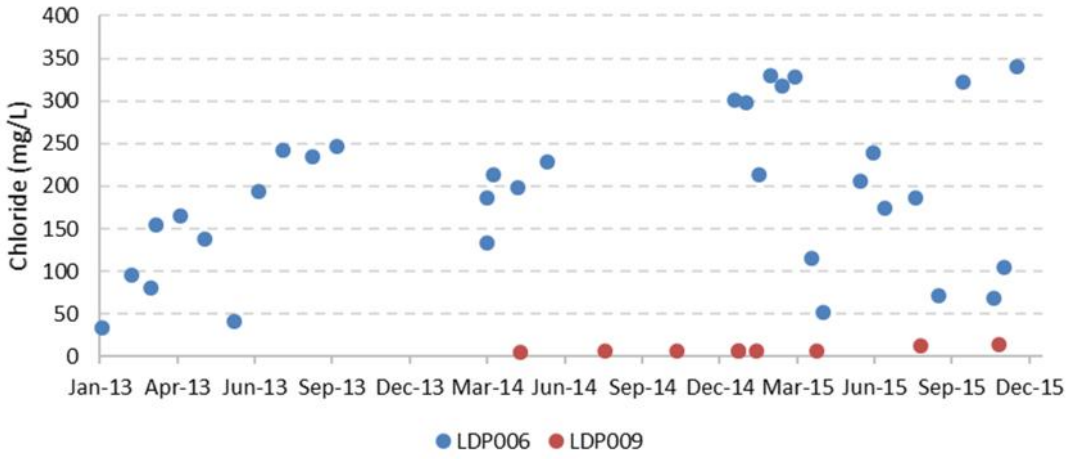


Figure D-55 Chloride recorded at LDP006 and LDP009

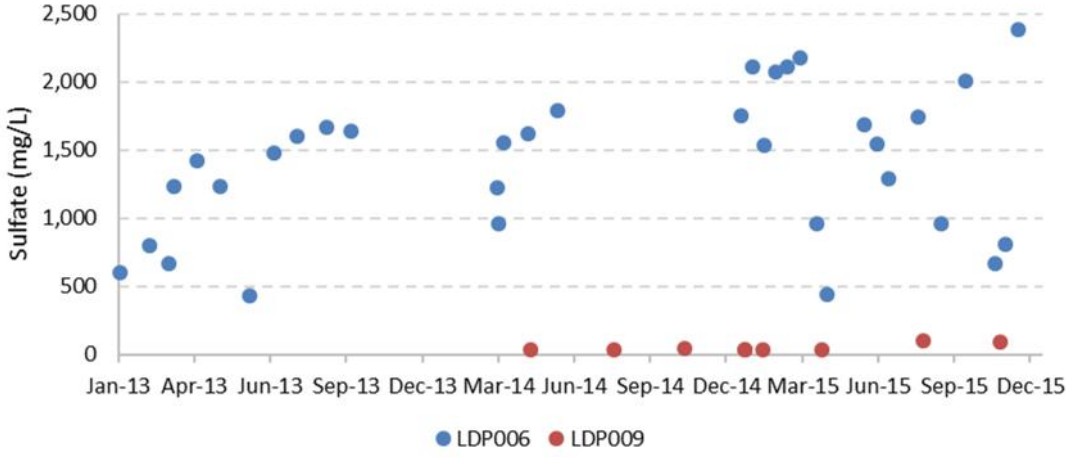


Figure D-56 Sulfate recorded at LDP006 and LDP009

D.2.4 Cations

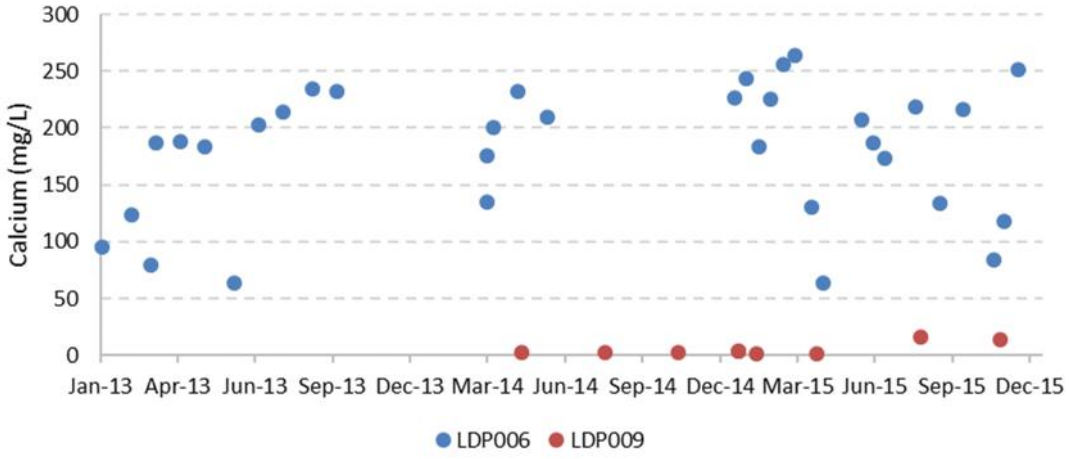


Figure D-57 Calcium recorded at LDP006 and LDP009

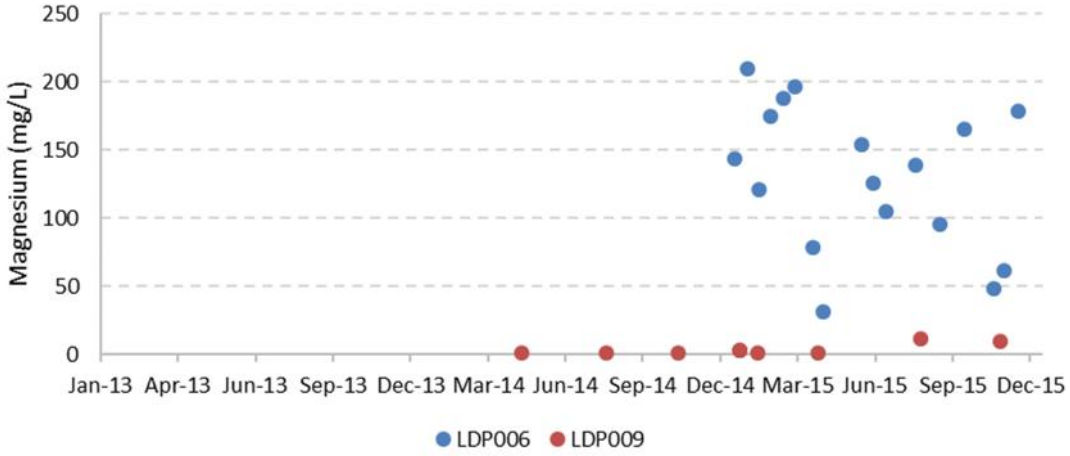


Figure D-58 Magnesium recorded at LDP006 and LDP009

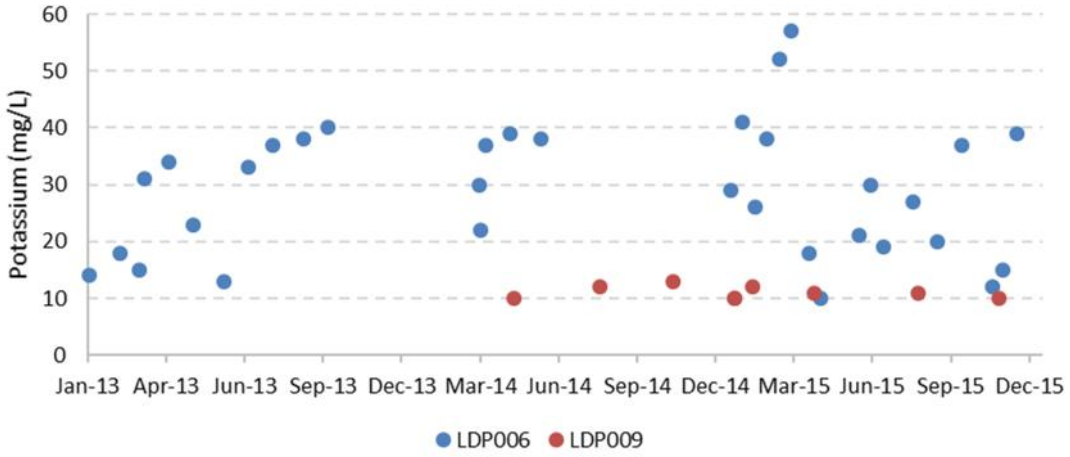


Figure D-59 Potassium recorded at LDP006 and LDP009

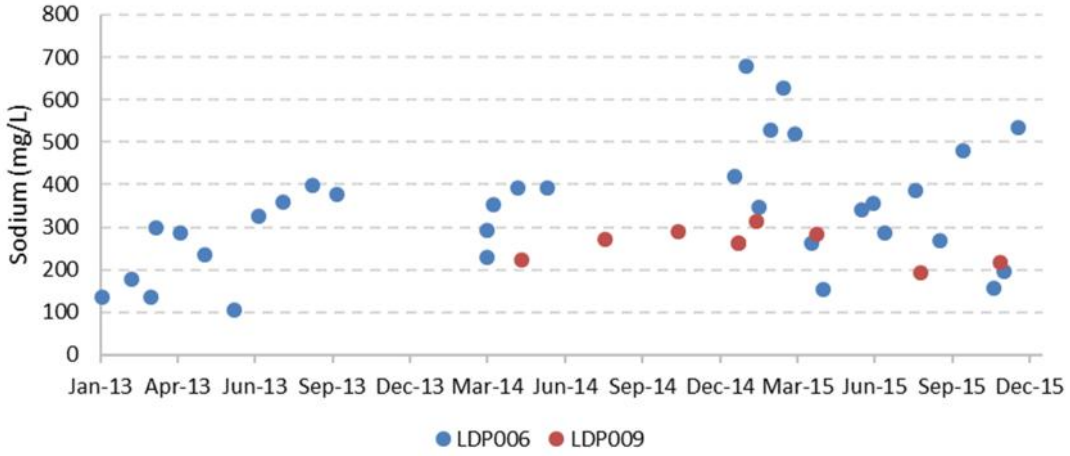


Figure D-60 Sodium recorded at LDP006 and LDP009

D.2.5 Metals

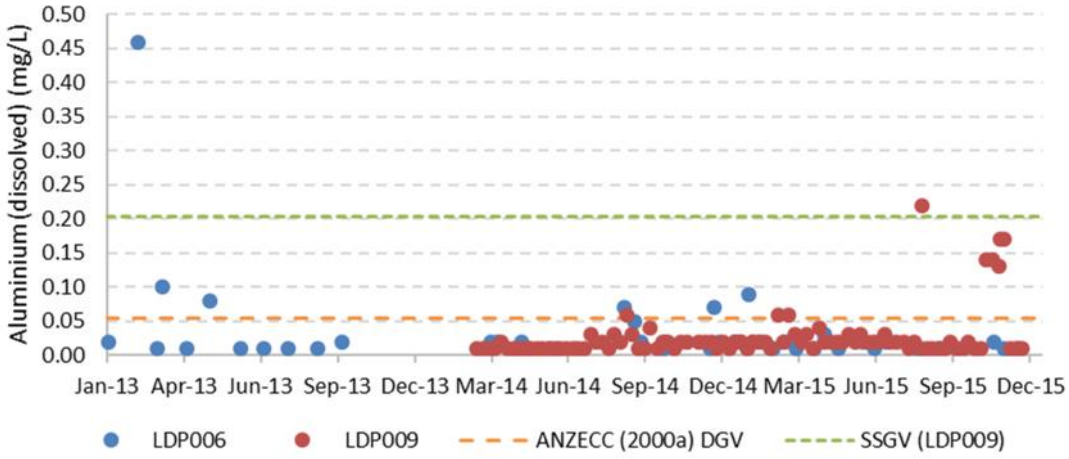


Figure D-61 Aluminium (dissolved) recorded at LDP006 and LDP009

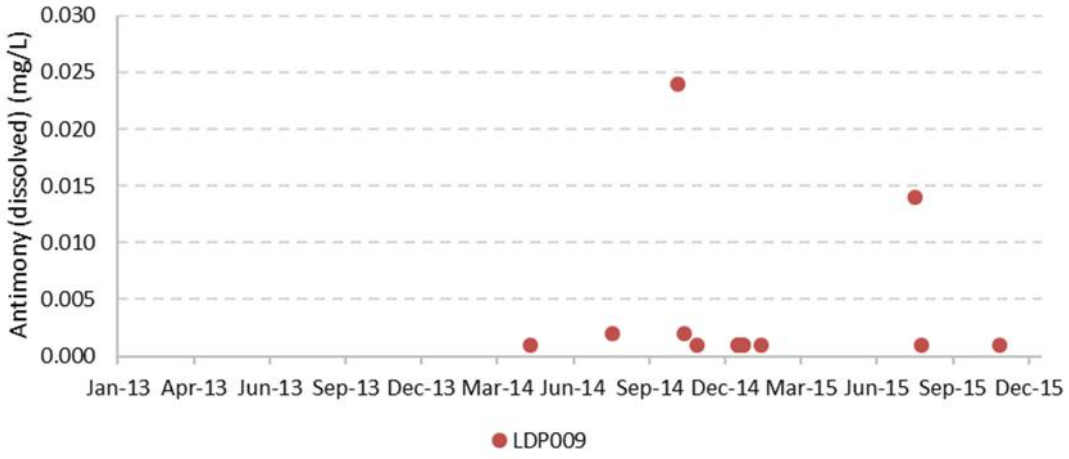


Figure D-62 Antimony (dissolved) recorded at LDP009

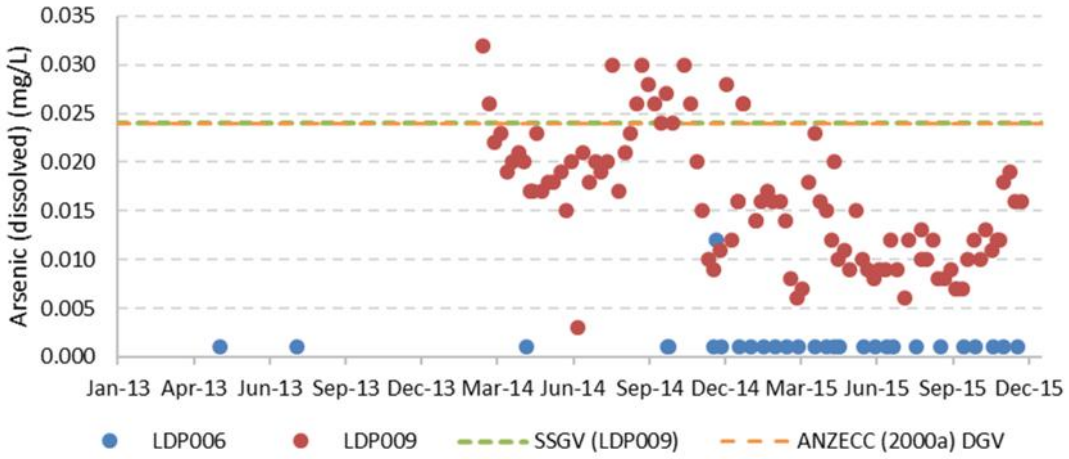


Figure D-63 Arsenic (dissolved) recorded at LDP006 and LDP009

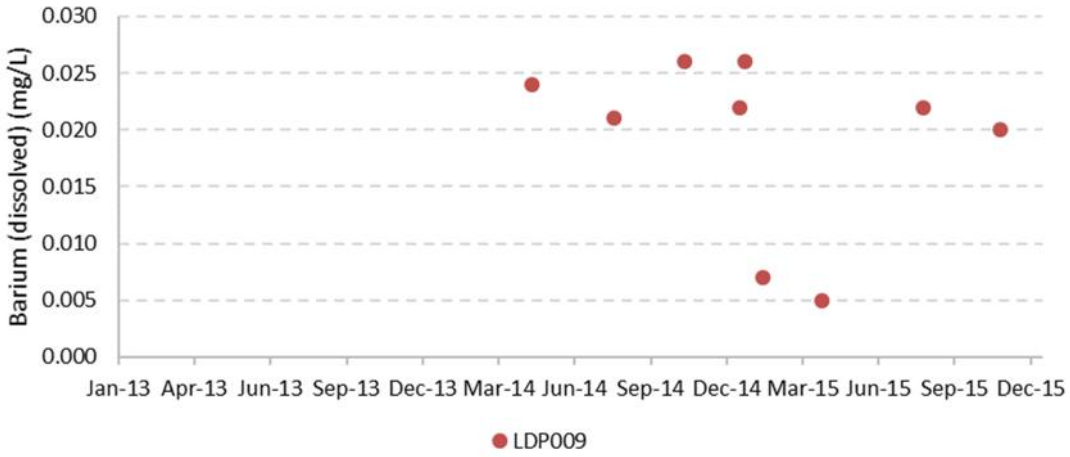


Figure D-64 Barium (dissolved) recorded at LDP009

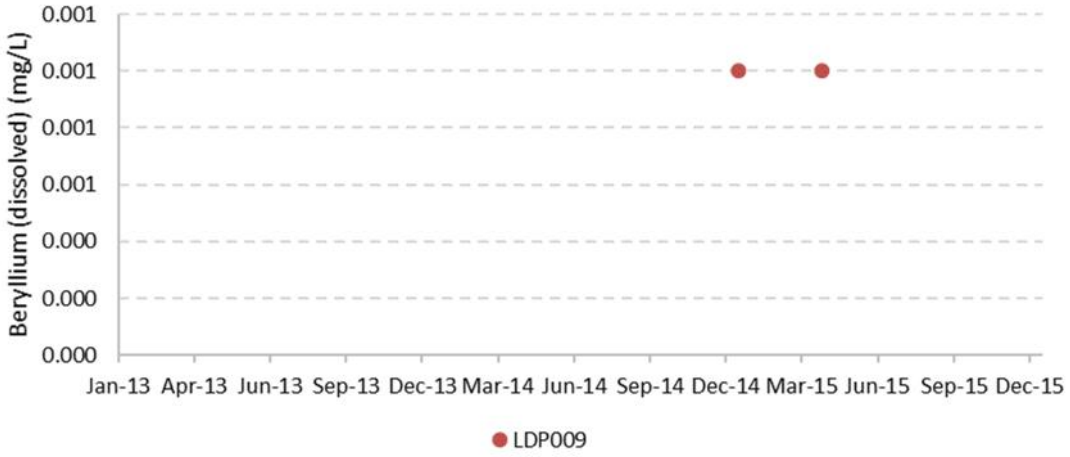


Figure D-65 Beryllium (dissolved) recorded at LDP009

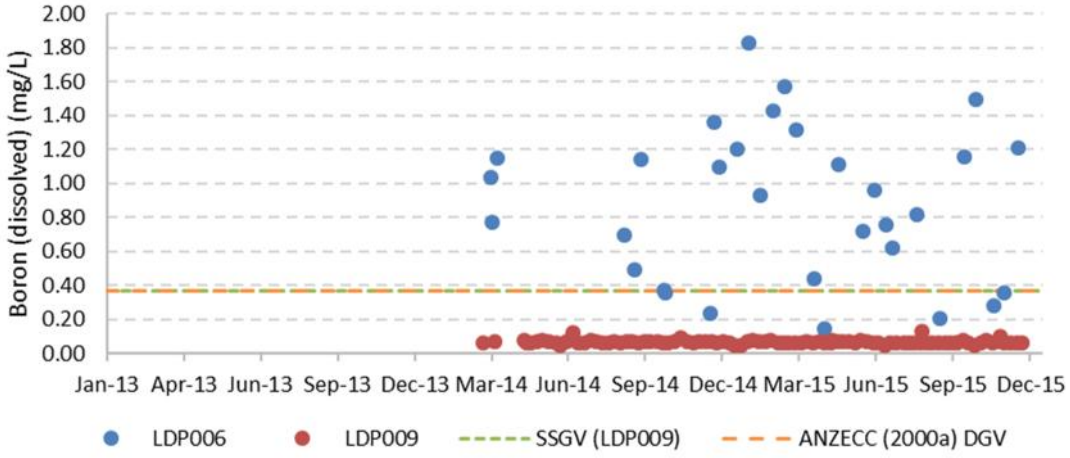


Figure D-66 Boron (dissolved) recorded at LDP006 and LDP009

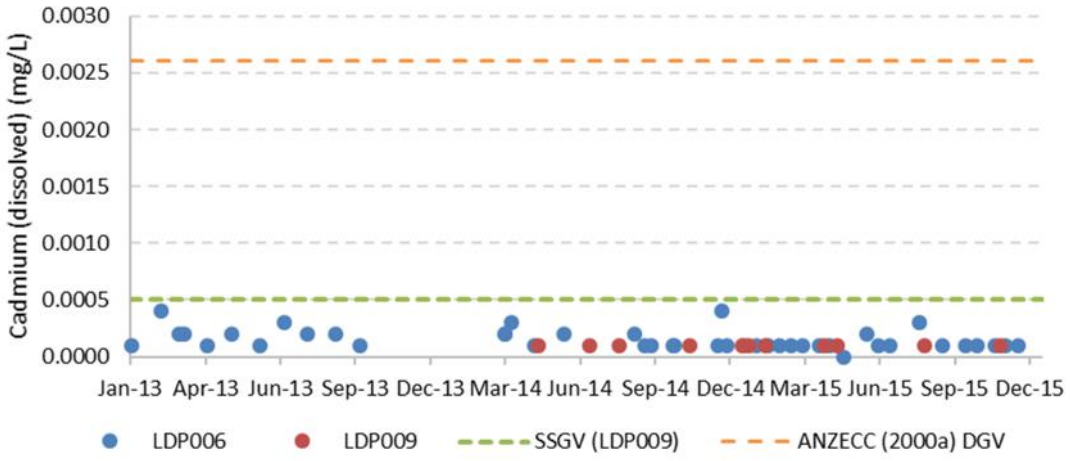


Figure D-67 Cadmium (dissolved) recorded at LDP006 and LDP009

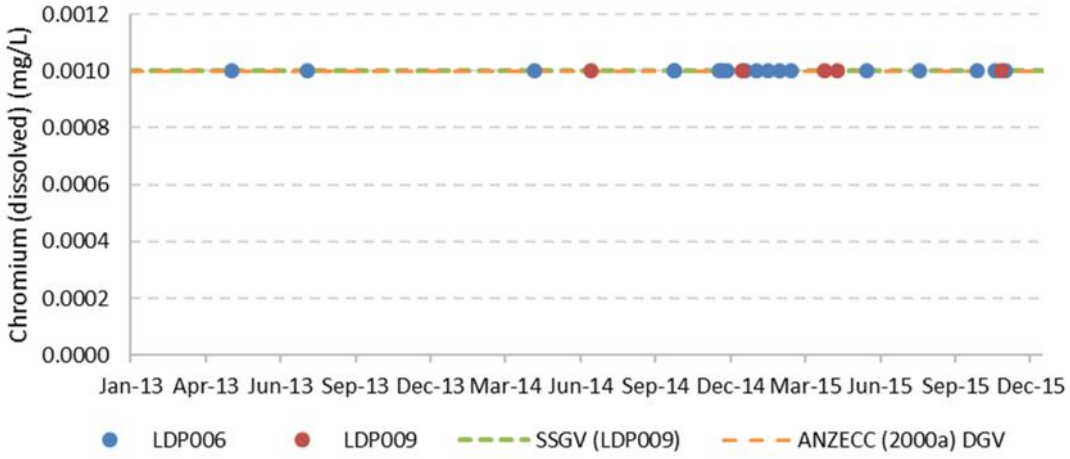


Figure D-68 Chromium (dissolved) recorded at LDP006 and LDP009

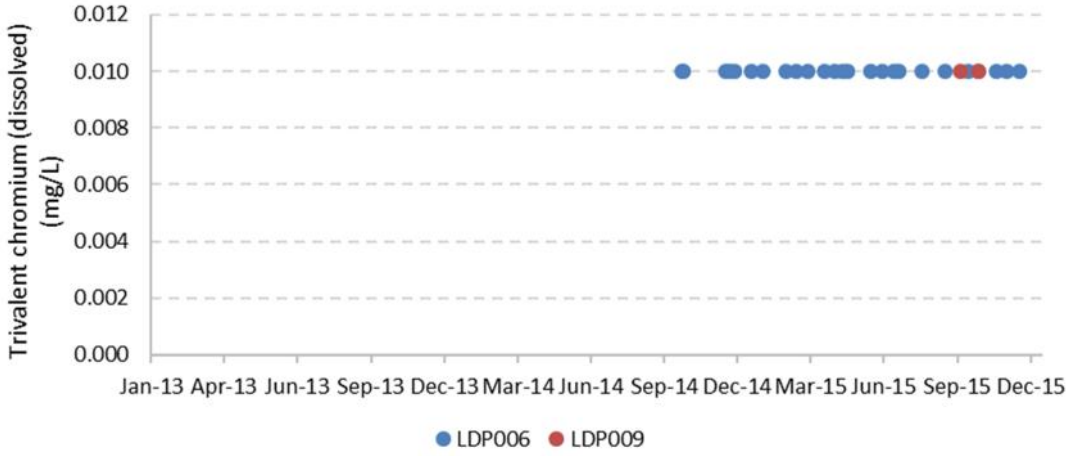


Figure D-69 Trivalent chromium (dissolved) recorded at LDP006 and LDP009

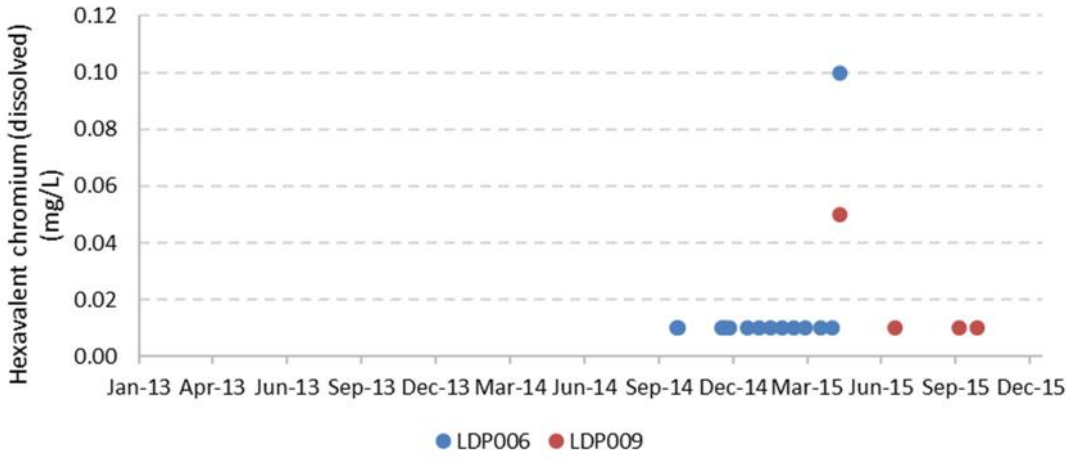


Figure D-70 Hexavalent chromium (dissolved) recorded at LDP006 and LDP009

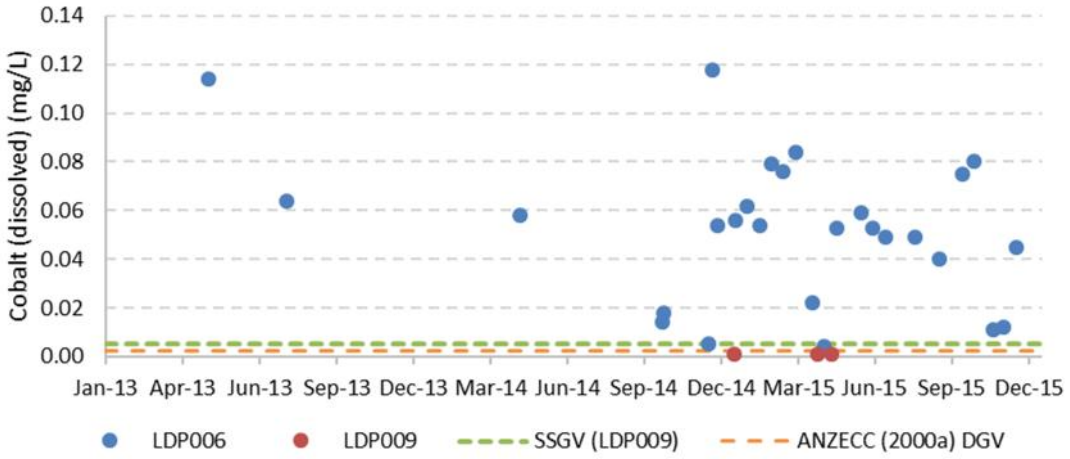


Figure D-71 Cobalt (dissolved) recorded at LDP006 and LDP009

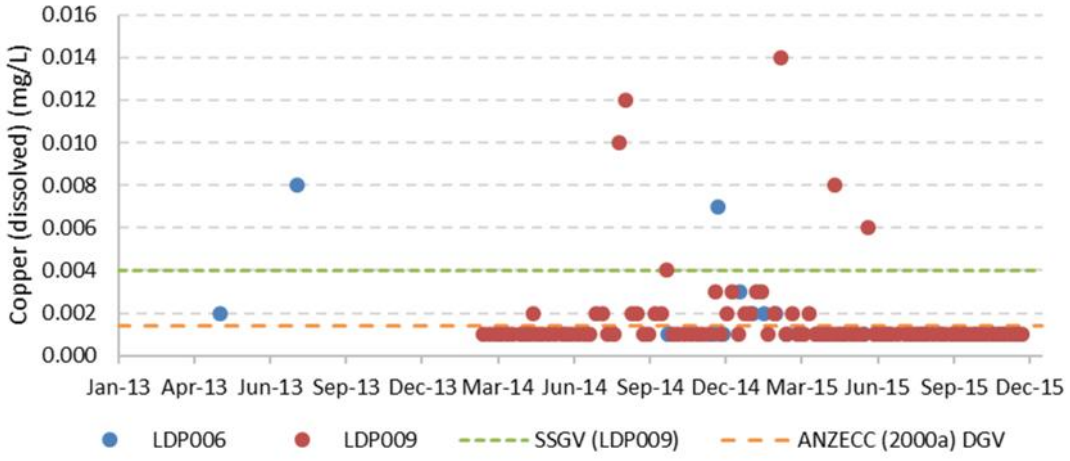


Figure D-72 Copper (dissolved) recorded at LDP006 and LDP009

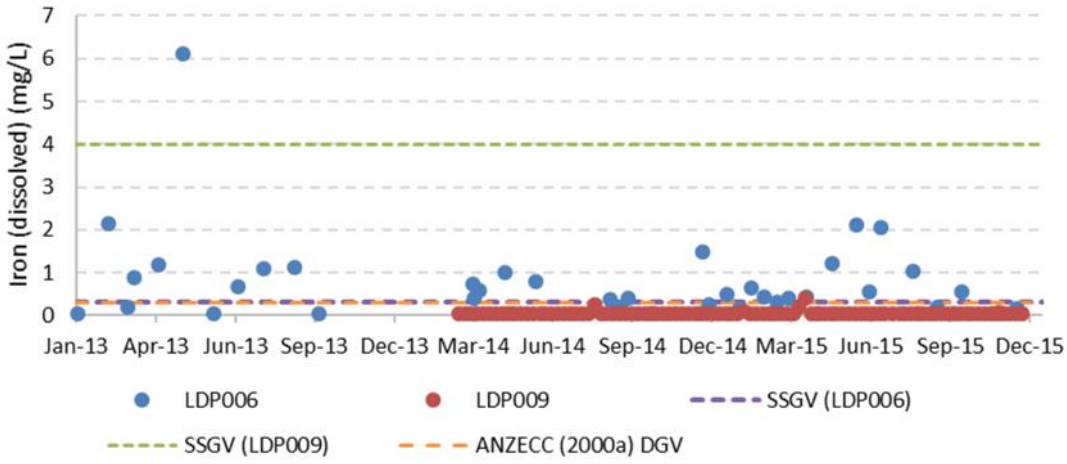


Figure D-73 Iron (dissolved) recorded at LDP006 and LDP009

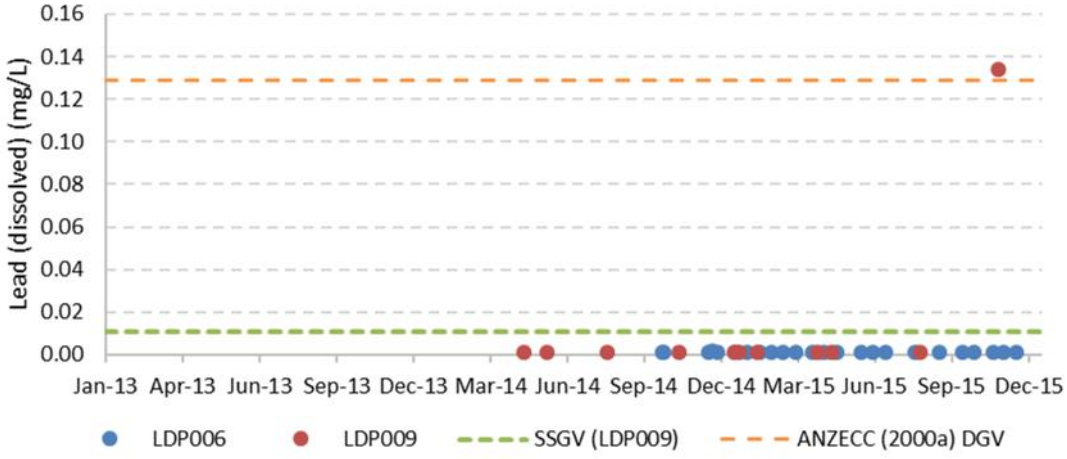


Figure D-74 Lead (dissolved) recorded at LDP006 and LDP009

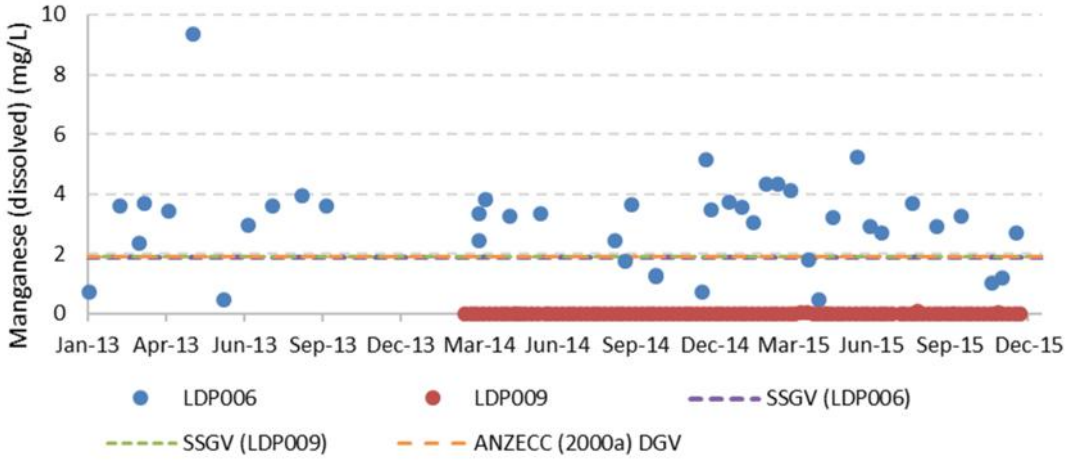


Figure D-75 Manganese (dissolved) recorded at LDP006 and LDP009

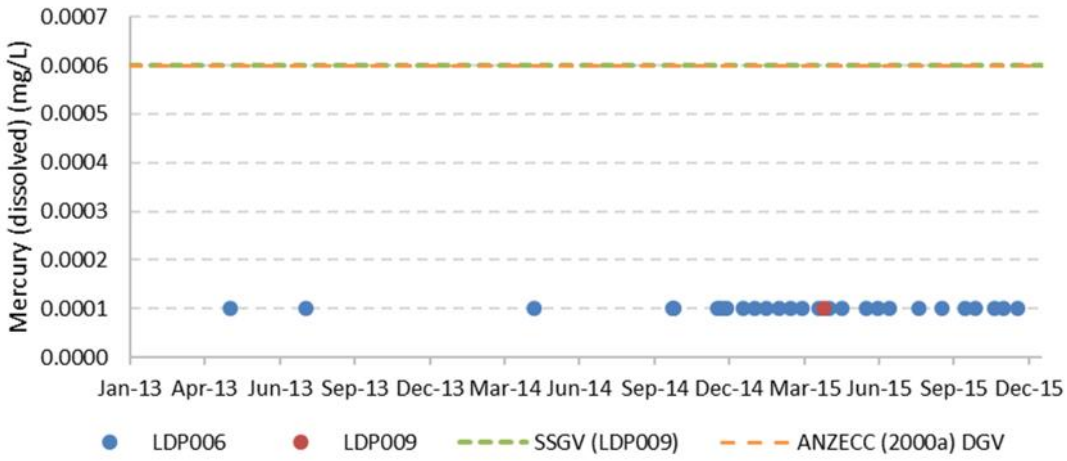


Figure D-76 Mercury (dissolved) recorded at LDP006 and LDP009

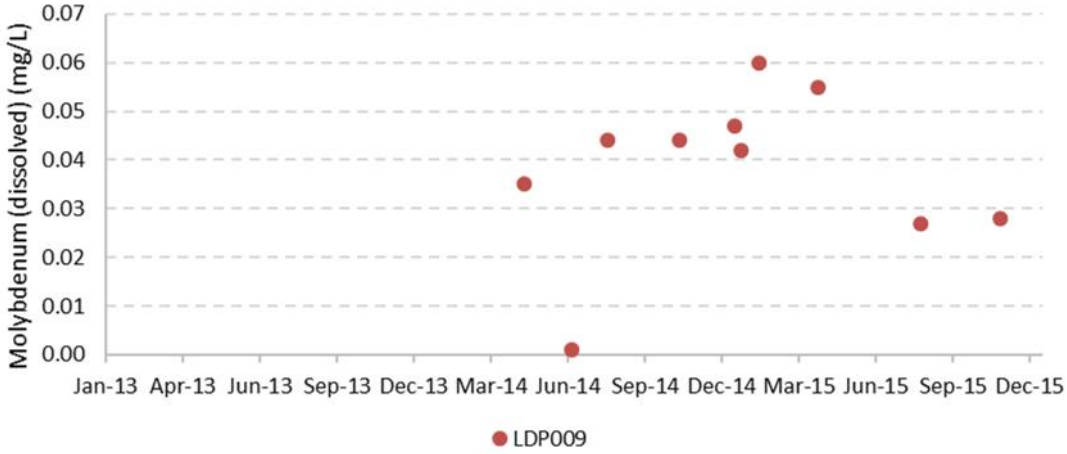


Figure D-77 Molybdenum (dissolved) recorded at LDP009

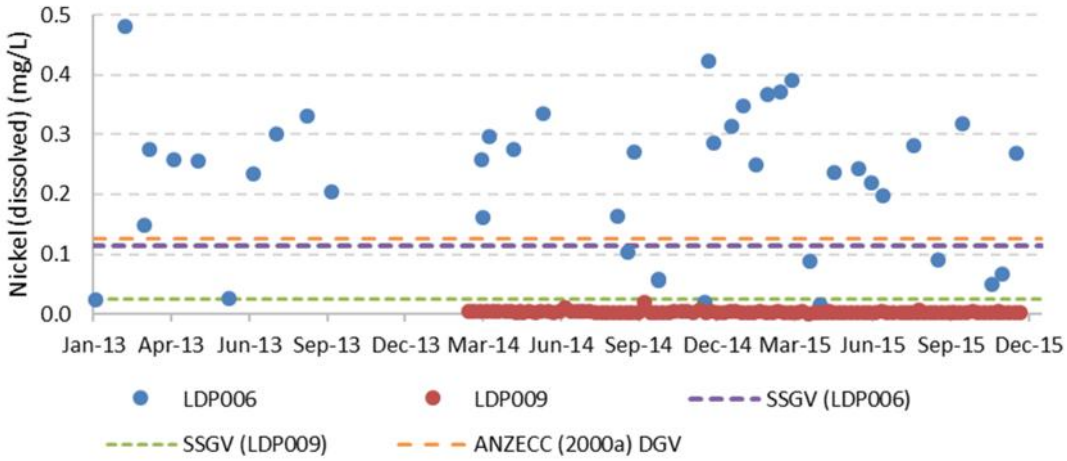


Figure D-78 Nickel (dissolved) recorded at LDP006 and LDP009

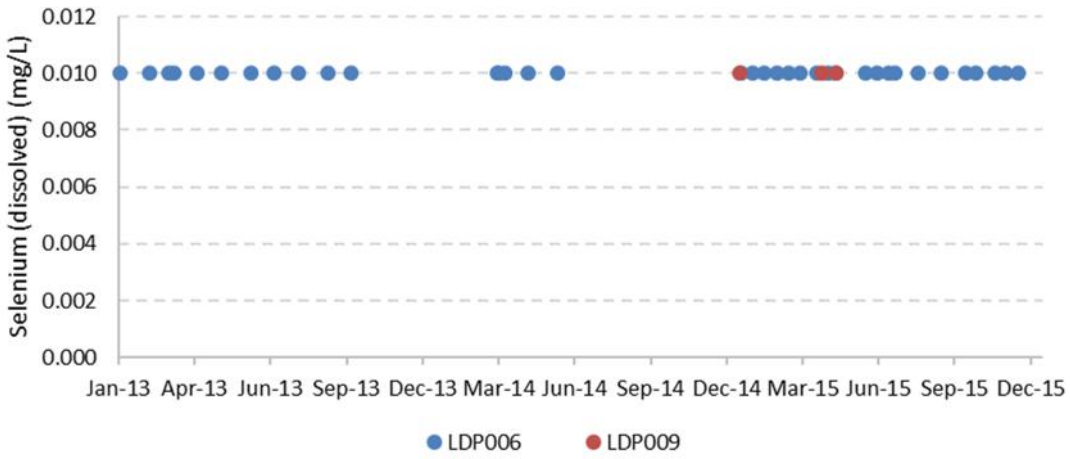


Figure D-79 Selenium (dissolved) recorded at LDP006 and LDP009

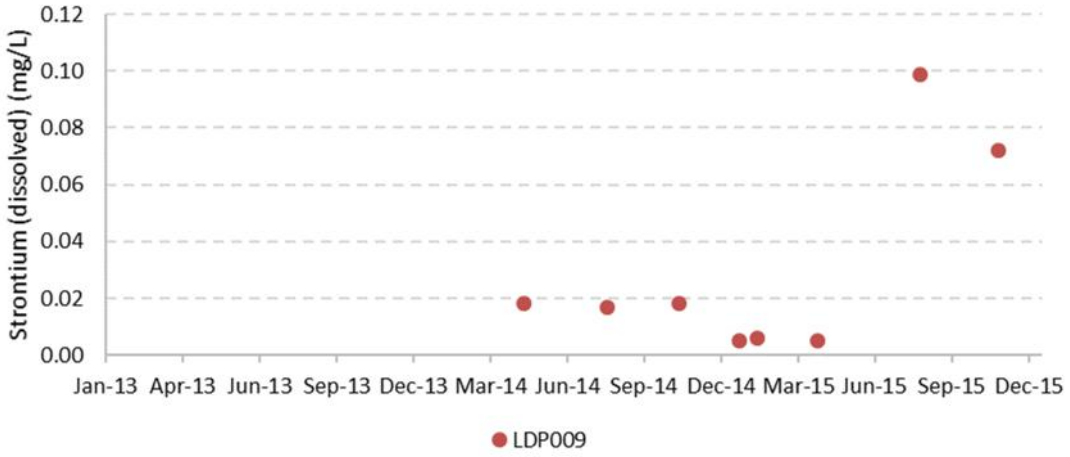


Figure D-80 Strontium (dissolved) recorded at LDP009

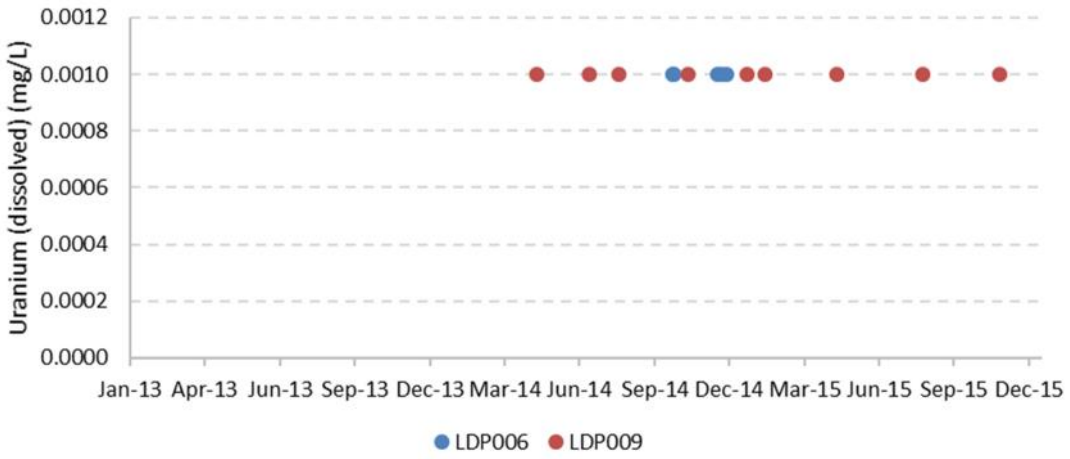


Figure D-81 Uranium (dissolved) recorded at LDP006 and LDP009

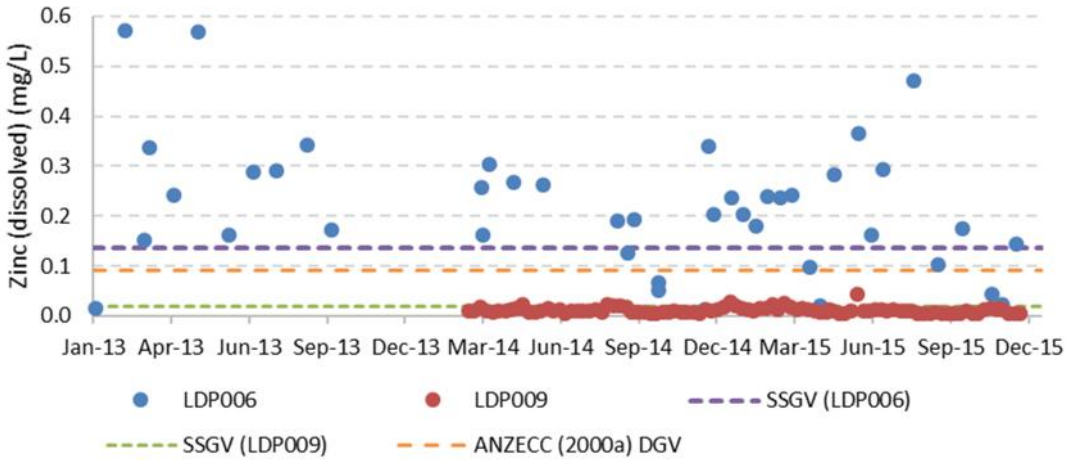


Figure D-82 Zinc (dissolved) recorded at LDP006 and LDP009

D.2.6 Other parameters

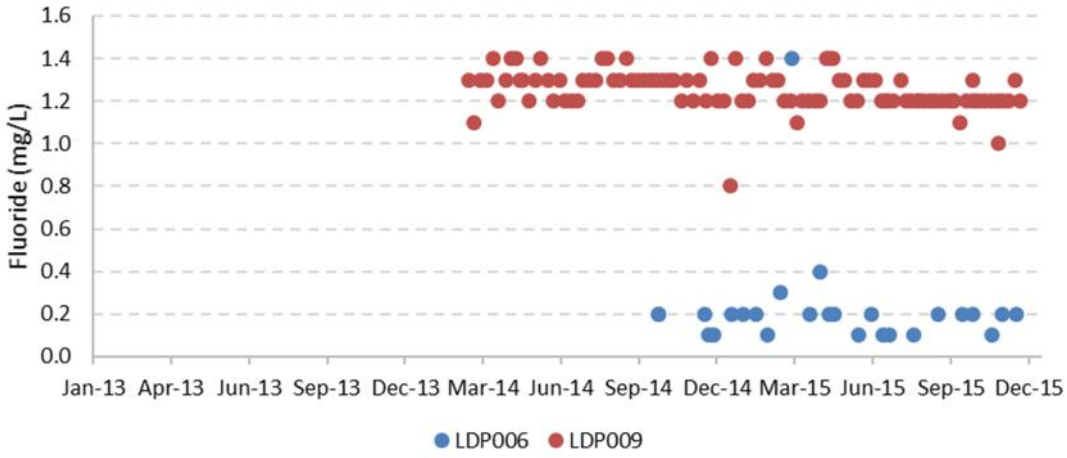


Figure D-83 Fluoride recorded at LDP006 and LDP009

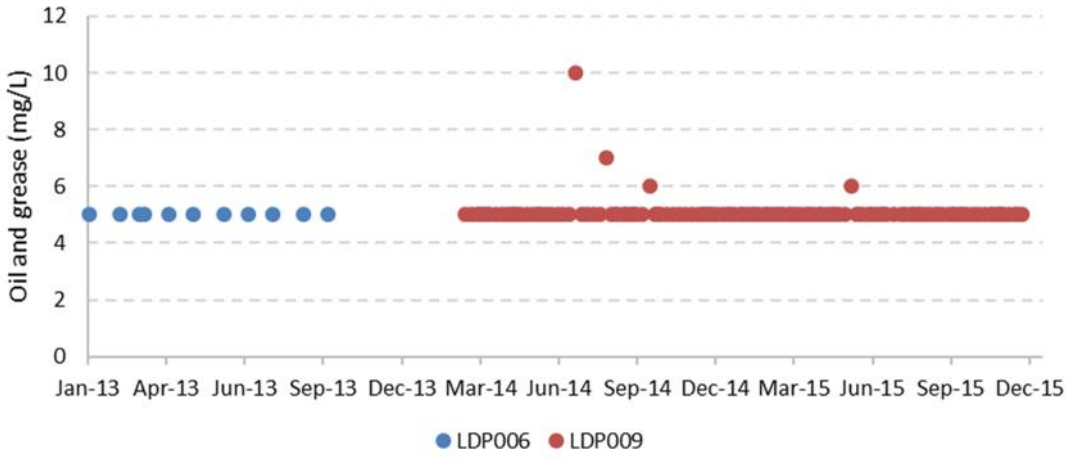


Figure D-84 Oil and grease recorded at LDP006 and LDP009

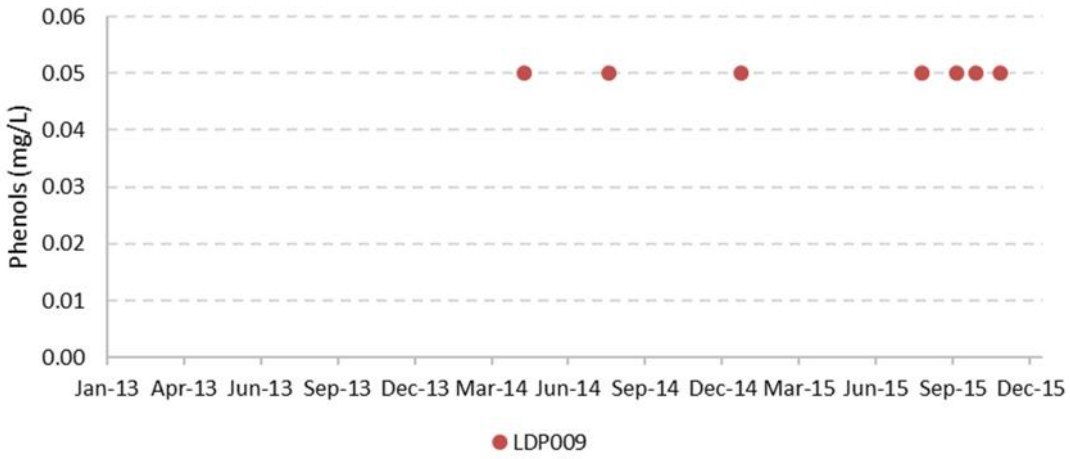


Figure D-85 Phenols recorded at LDP009

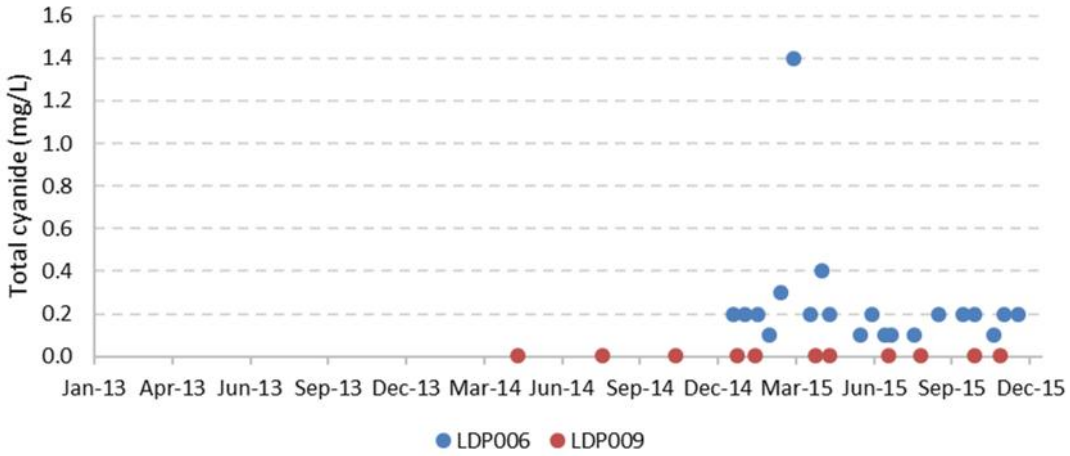


Figure D-86 Total cyanide recorded at LDP006 and LDP009

D.3 Downstream locations

D.3.1 Statistical summary

Parameter	Units	ANZECC (2000a) DGV	Wangcol Creek D/S		Wangcol Creek far D/S		Coxs River D/S	
			Count	Median	Count	Median	Count	Median
Physicochemical parameters								
EC	µS/cm	350	34	1,640	33	1,930	161	1,030
pH	pH units	6.5–9.0	34	7.06	33	7.24	161	8.53
TSS	mg/L	25	34	5	33	5	37	5
Turbidity	NTU	25	34	2	33	3	14	4
Nutrients								
Ammonia	mg/L	0.9	–	–	–	–	12	0.04
Nitrate	mg/L	–	34	0.03	33	0.04	12	0.03
Nitrite	mg/L	–	31	0.01	30	0.01	12	0.01
Nitrite + nitrate	mg/L	–	28	0.04	27	0.04	12	0.05
TKN	mg/L	–	–	–	–	–	12	0.45
Total nitrogen	mg/L	0.25	–	–	–	–	12	0.5
Total organic carbon	mg/L	–	–	–	–	–	16	5
Total phosphorus	mg/L	0.02	34	0.01	33	0.01	12	0.03
Anions								
Alkalinity	mg/L	–	31	41	30	34	12	208
Chloride	mg/L	–	34	99	33	113	12	23

Parameter	Units	ANZECC (2000a) DGV	Wangcol Creek D/S		Wangcol Creek far D/S		Coxs River D/S	
			Count	Median	Count	Median	Count	Median
Sulfate	mg/L	–	34	800	33	878	12	165
Cations								
Calcium	mg/L	–	34	103	33	114	12	22
Magnesium	mg/L	–	23	84	23	74	12	14
Potassium	mg/L	–	34	16	33	14	12	13
Sodium	mg/L	–	34	161	33	194	12	138
Dissolved metals								
Aluminium	mg/L	0.055	34	0.01	33	0.04	130	0.04
Antimony	mg/L	–	–	–	–	–	15	0.001
Arsenic	mg/L	0.024	–	–	–	–	105	0.01
Barium	mg/L	–	–	–	–	–	12	0.027
Boron	mg/L	0.37	34	0.49	32	0.50	99	0.09
Cadmium	mg/L	0.0026*	34	0.0001	33	0.0001	12	0.0001
Copper	mg/L	0.0014	–	–	–	–	126	0.001
Iron	mg/L	0.3	34	0.115	33	0.07	127	0.05
Lead	mg/L	0.129*	–	–	–	–	12	0.001
Manganese	mg/L	1.9	34	0.745	33	1.13	105	0.049
Molybdenum	mg/L	–	–	–	–	–	12	0.007
Nickel	mg/L	0.125*	34	0.054	33	0.054	105	0.005
Selenium	mg/L	–	34	0.01	33	0.01	–	–

Parameter	Units	ANZECC (2000a) DGV	Wangcol Creek D/S		Wangcol Creek far D/S		Coxs River D/S	
			Count	Median	Count	Median	Count	Median
Strontium	mg/L	–	–	–	–	–	13	0.127
Zinc	mg/L	0.091*	34	0.035	33	0.063	125	0.01
Total metals								
Aluminium	mg/L	–	–	–	–	–	11	0.03
Arsenic	mg/L	–	–	–	–	–	11	0.002
Barium	mg/L	–	–	–	–	–	10	0.03
Iron	mg/L	–	–	–	–	–	10	0.05
Lead	mg/L	–	–	–	–	–	10	0.001
Manganese	mg/L	–	–	–	–	–	11	0.088
Nickel	mg/L	–	34	0.057	33	0.058	11	0.006
Zinc	mg/L	–	34	0.037	33	0.071	15	0.015
Other								
Fluoride	mg/L	–	–	–	–	–	18	1.0
Oil and grease	mg/L	–	34	5	33	5	12	5
Phenols	mg/L	–	–	–	–	–	11	0.05
Total cyanide	mg/L	–	–	–	–	–	11	0.004

* ANZECC (2000a) DGV modified for hardness.

D.3.2 Time series graphs

Physicochemical parameters

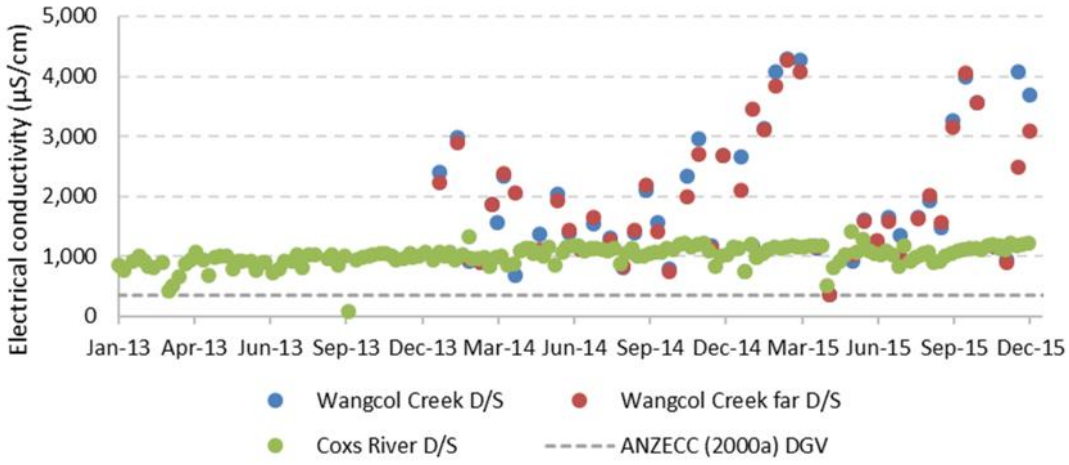


Figure D-87 Electrical conductivity recorded at downstream monitoring locations

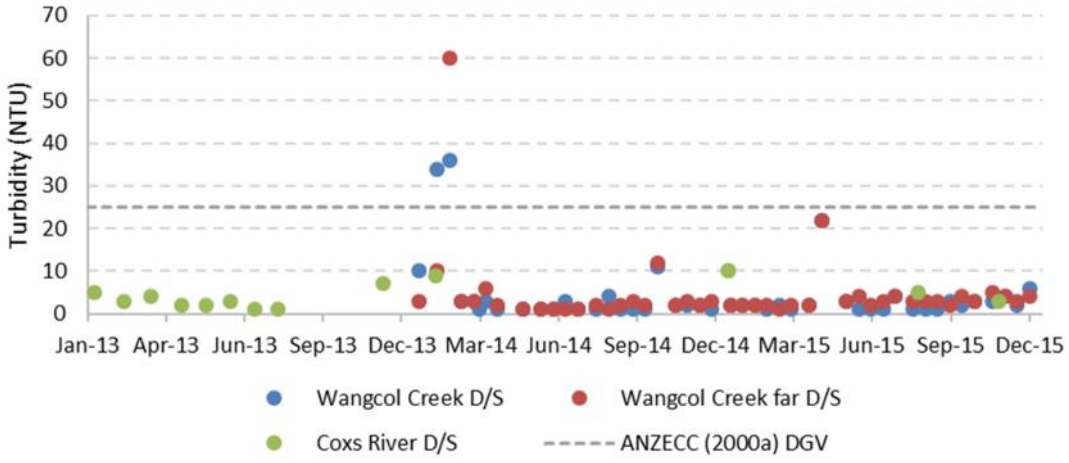


Figure D-88 pH recorded at downstream monitoring locations

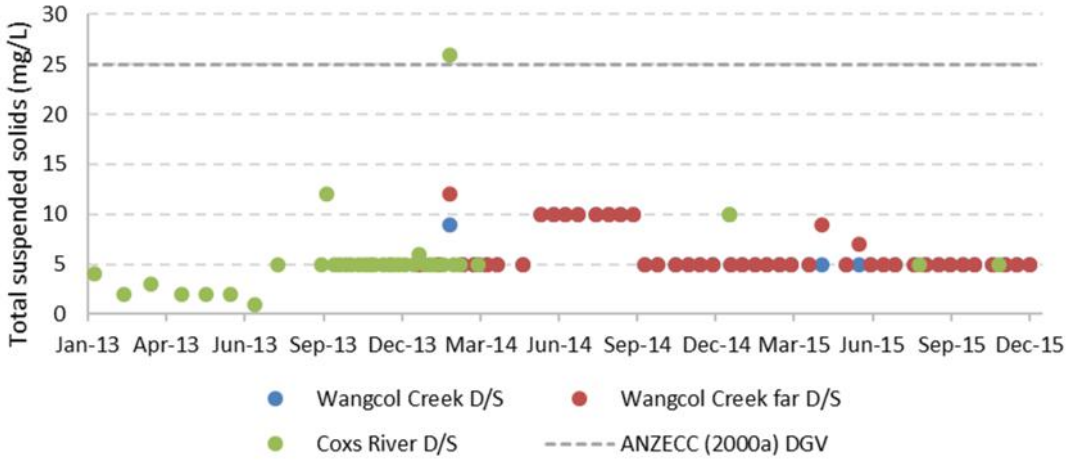


Figure D-89 Total suspended solids recorded at downstream monitoring locations

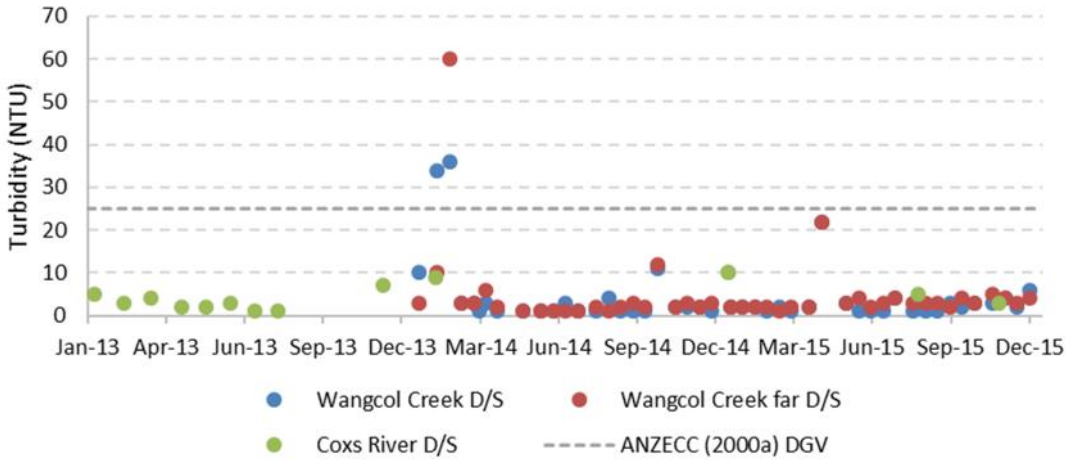


Figure D-90 Turbidity recorded at downstream monitoring locations

Nutrients

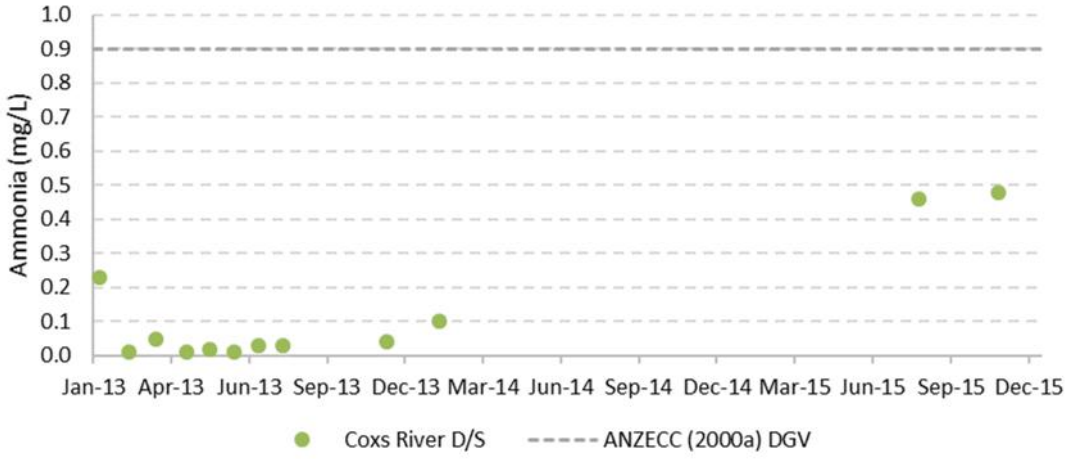


Figure D-91 Ammonia recorded at downstream monitoring locations

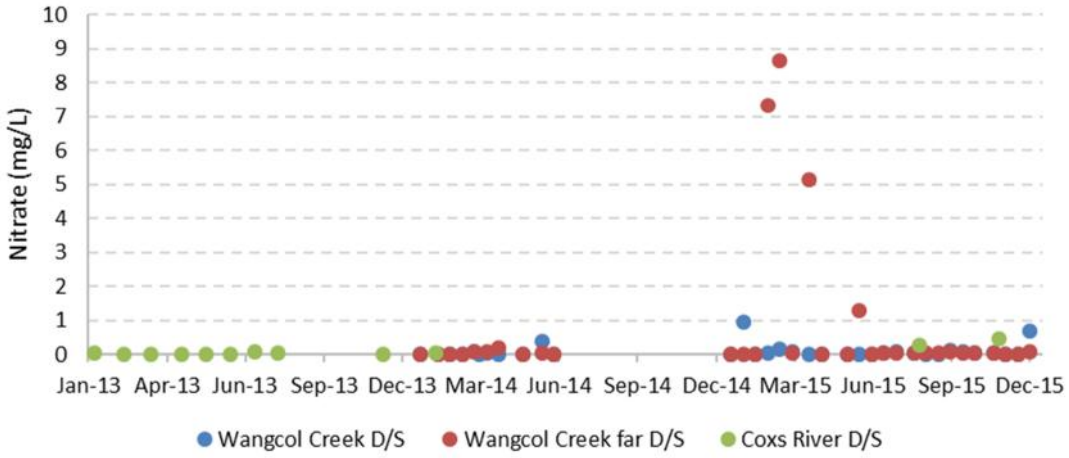


Figure D-92 Nitrate recorded at downstream monitoring locations

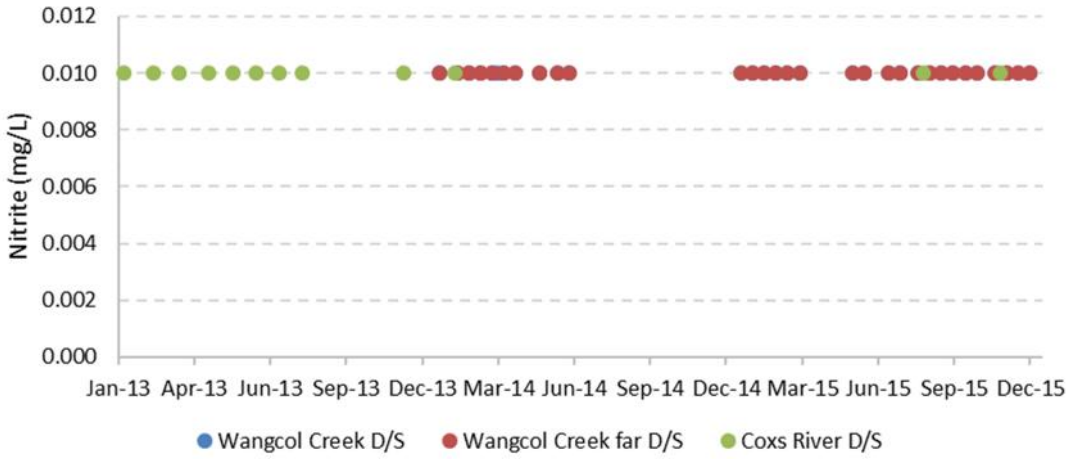


Figure D-93 Nitrite recorded at downstream monitoring locations

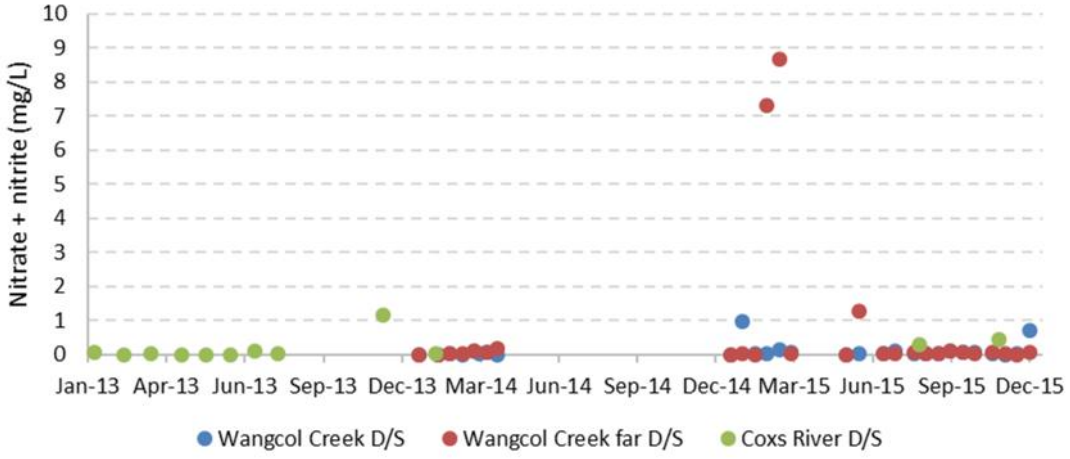


Figure D-94 Nitrite + nitrate recorded at downstream monitoring locations

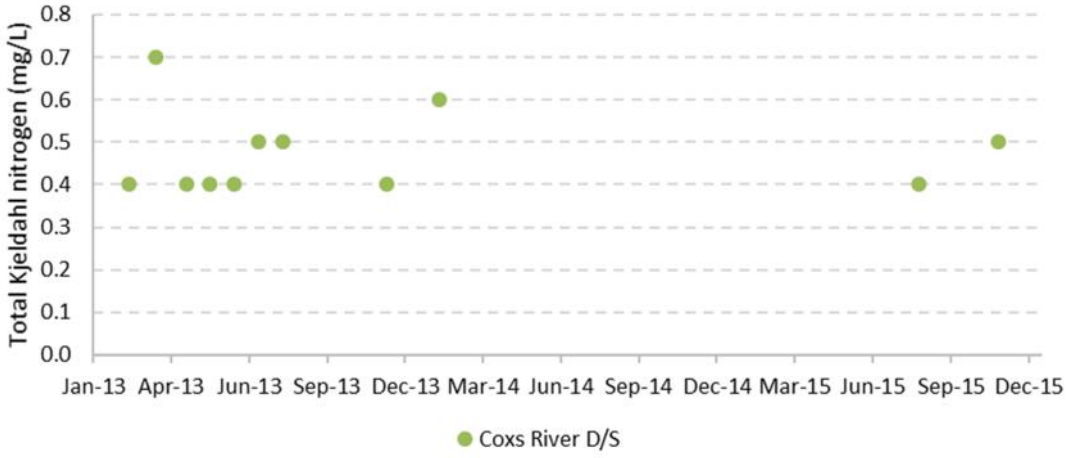


Figure D-95 Total Kjeldahl nitrogen recorded at downstream monitoring locations

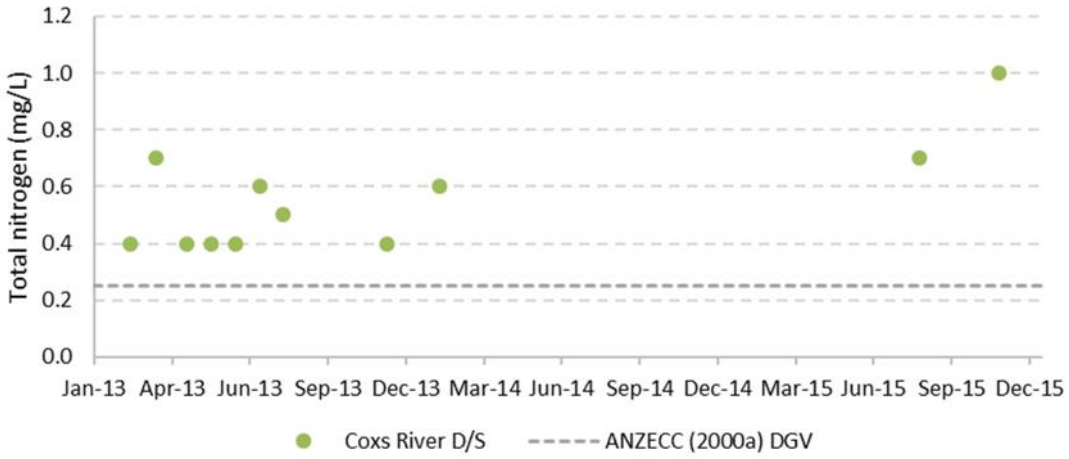


Figure D-96 Total nitrogen recorded at downstream monitoring locations

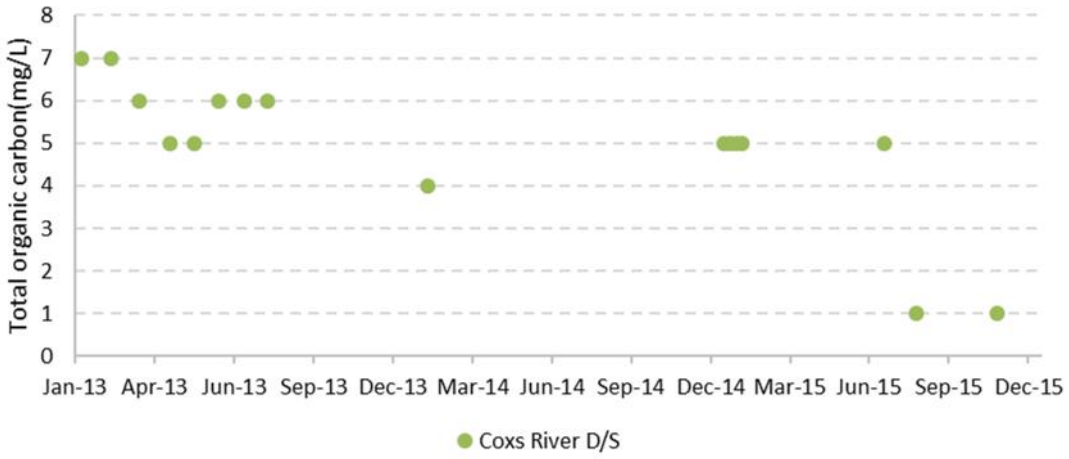


Figure D-97 Total organic carbon recorded at downstream monitoring locations

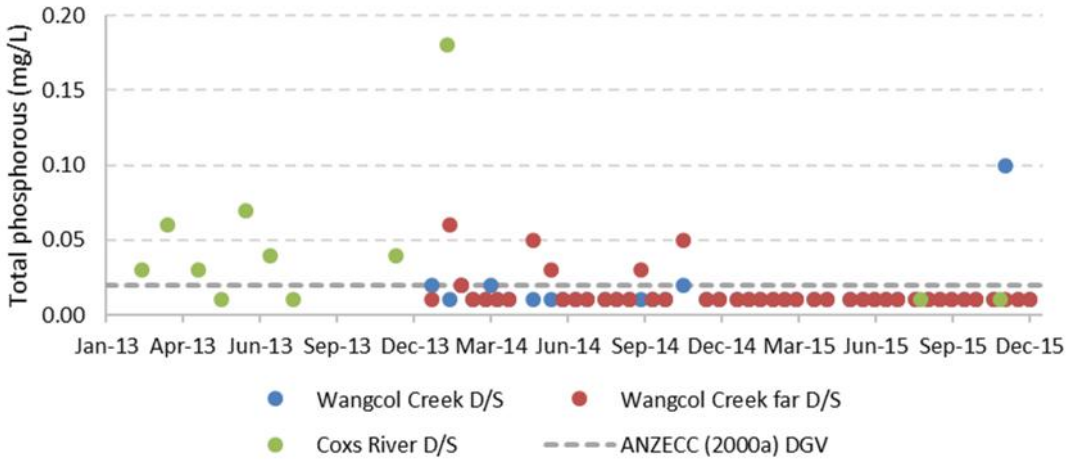


Figure D-98 Total phosphorus recorded at downstream monitoring locations

Anions

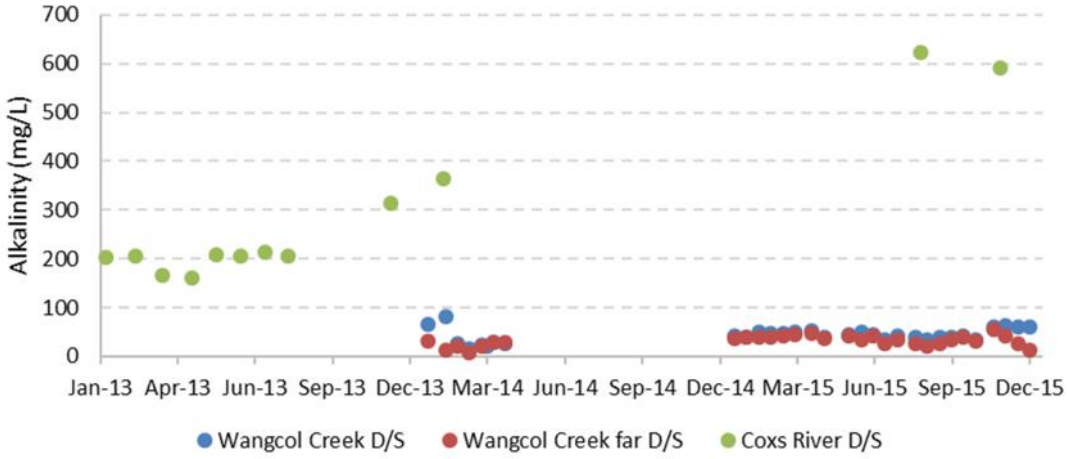


Figure D-99 Alkalinity recorded at downstream monitoring locations

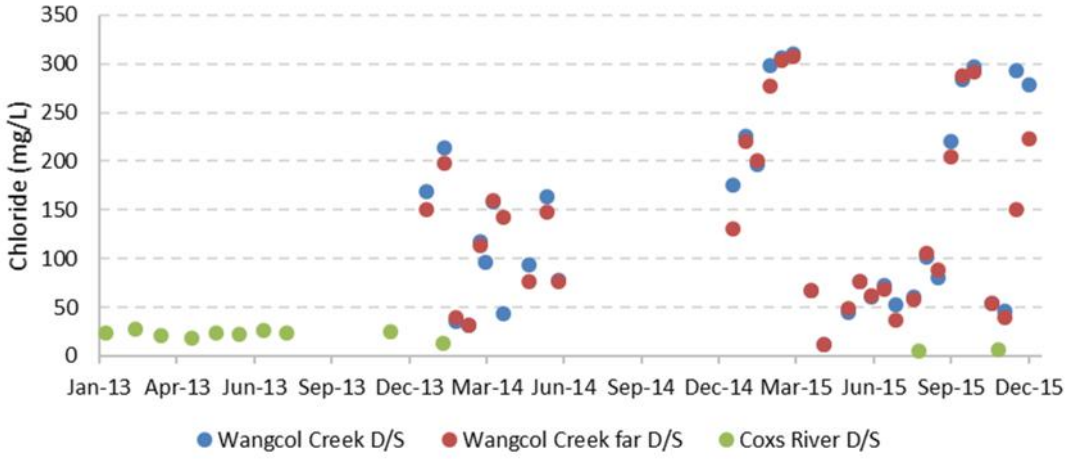


Figure D-100 Chloride recorded at downstream monitoring locations

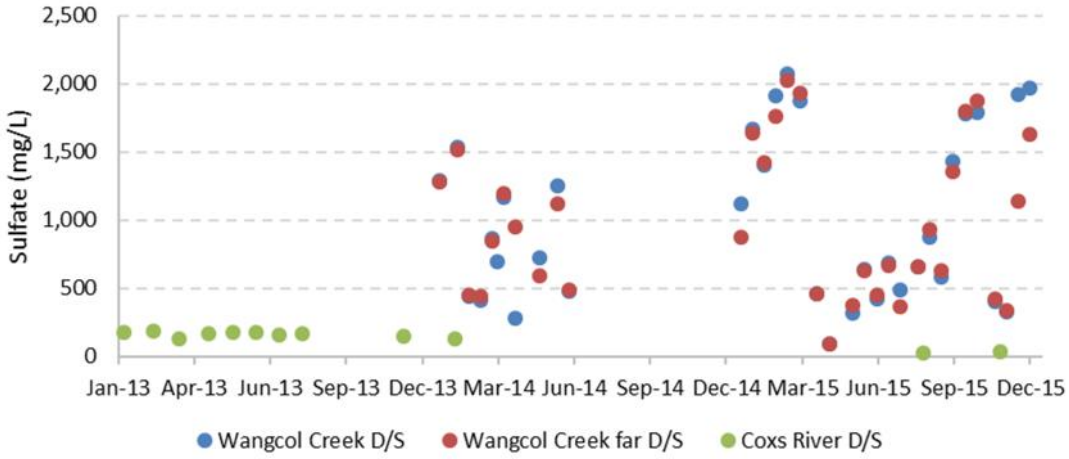


Figure D-101 Sulfate recorded at downstream monitoring locations

Cations

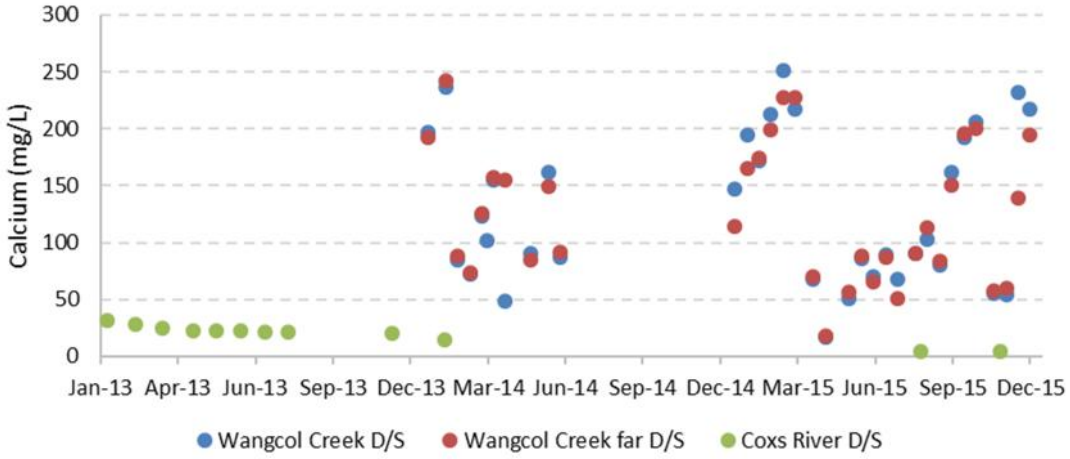


Figure D-102 Calcium recorded at downstream monitoring locations

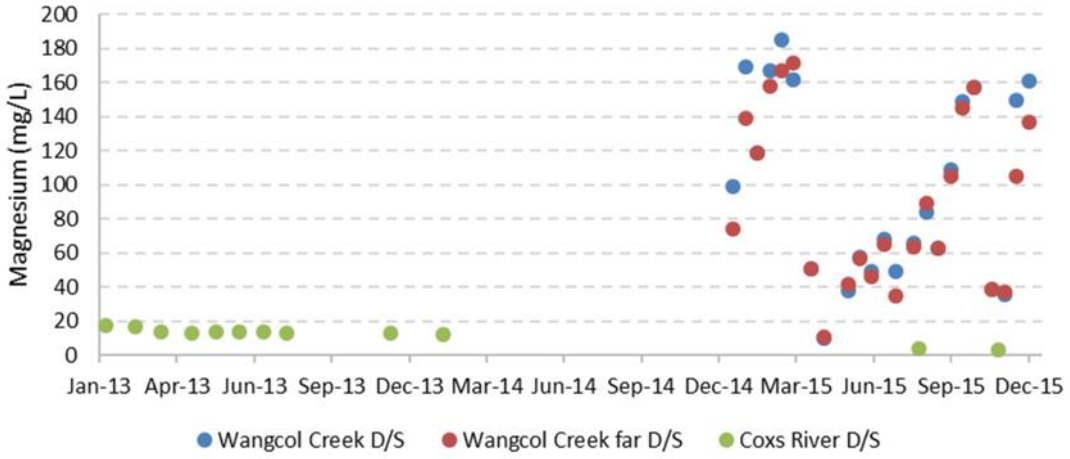


Figure D-103 Magnesium recorded at downstream monitoring locations

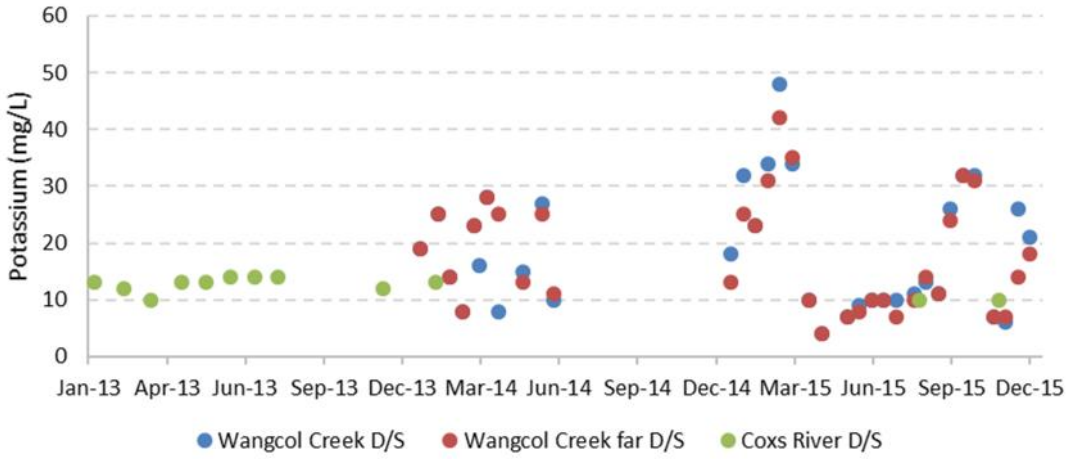


Figure D-104 Potassium recorded at downstream monitoring locations

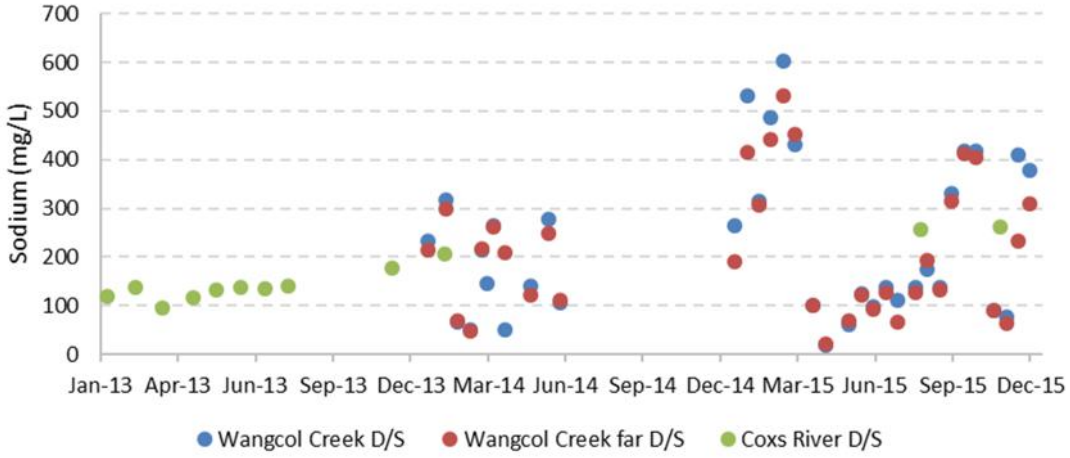


Figure D-105 Sodium recorded at downstream monitoring locations

Metals

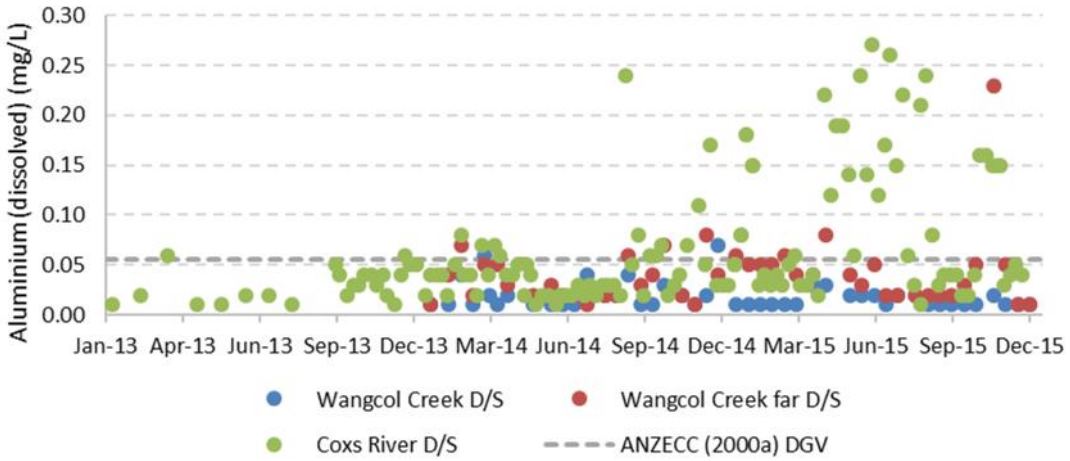


Figure D-106 Aluminium (dissolved) recorded at downstream monitoring locations

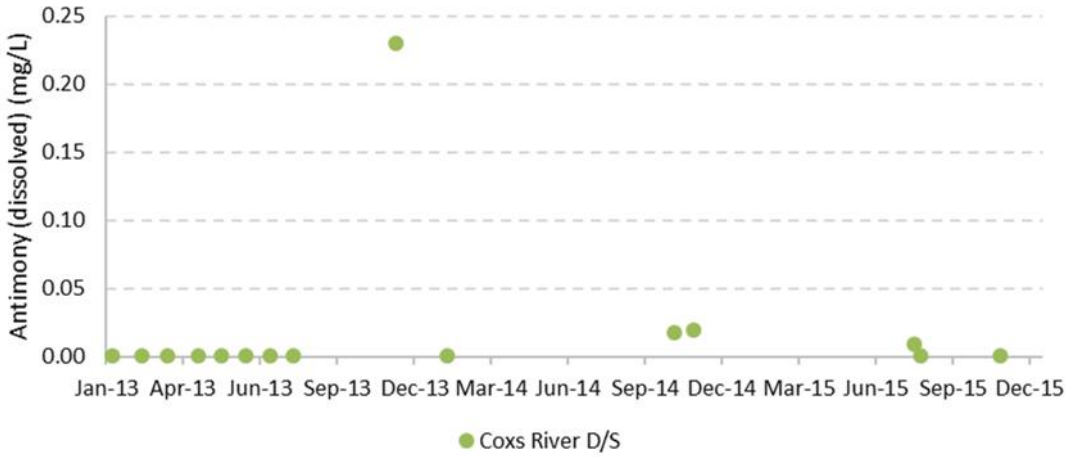


Figure D-107 Antimony (dissolved) recorded at downstream monitoring locations

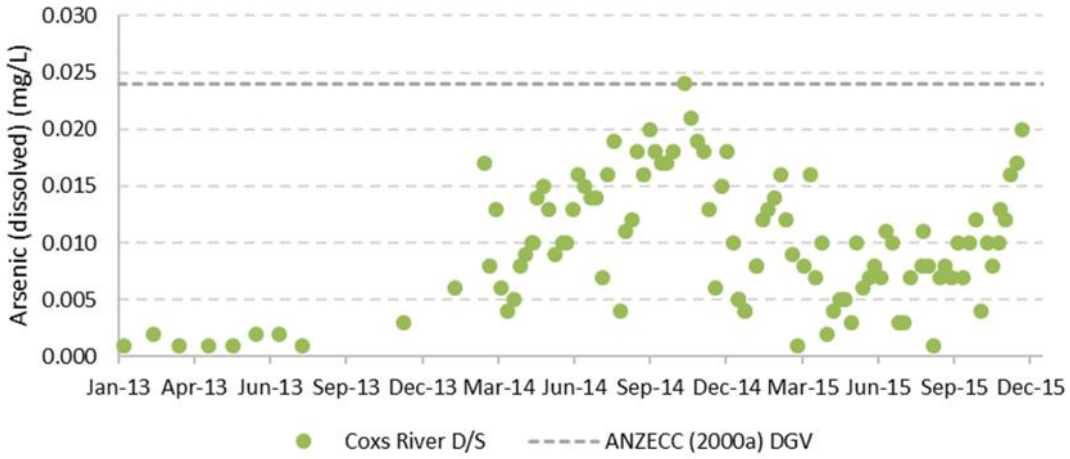


Figure D-108 Arsenic (dissolved) recorded at downstream monitoring locations

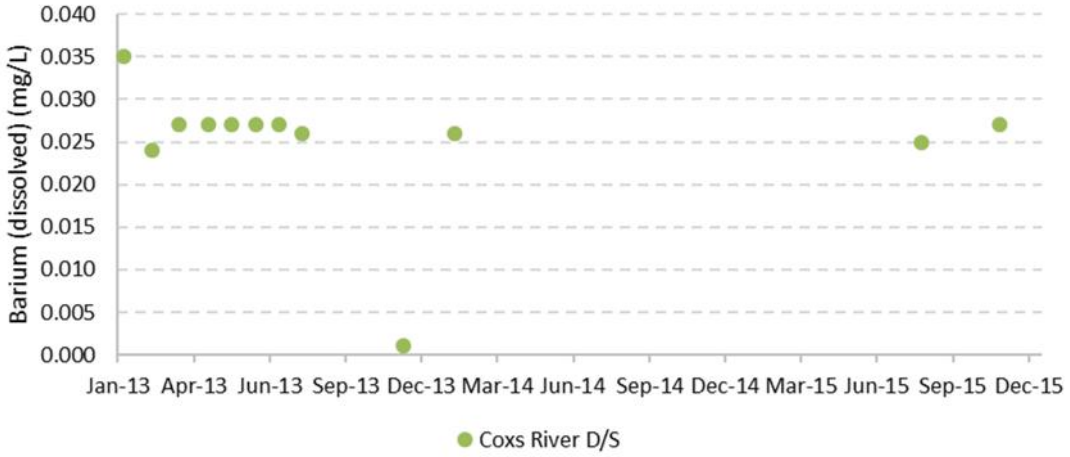


Figure D-109 Barium (dissolved) recorded at downstream monitoring locations

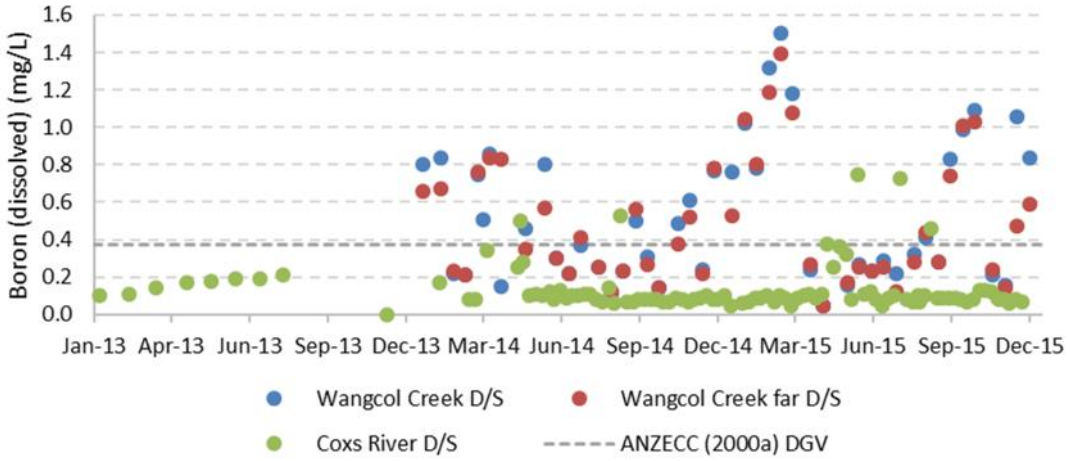


Figure D-110 Boron (dissolved) recorded at downstream monitoring locations

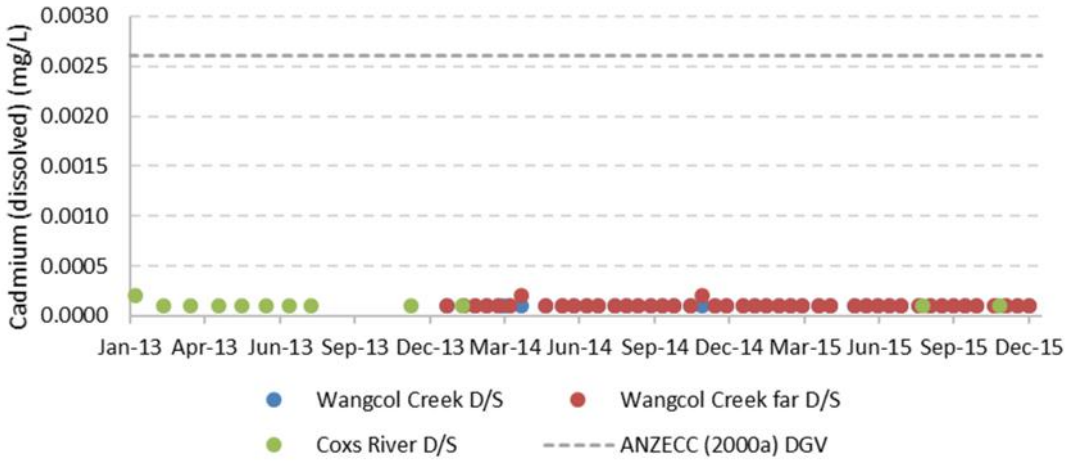


Figure D-111 Cadmium (dissolved) recorded at downstream monitoring locations

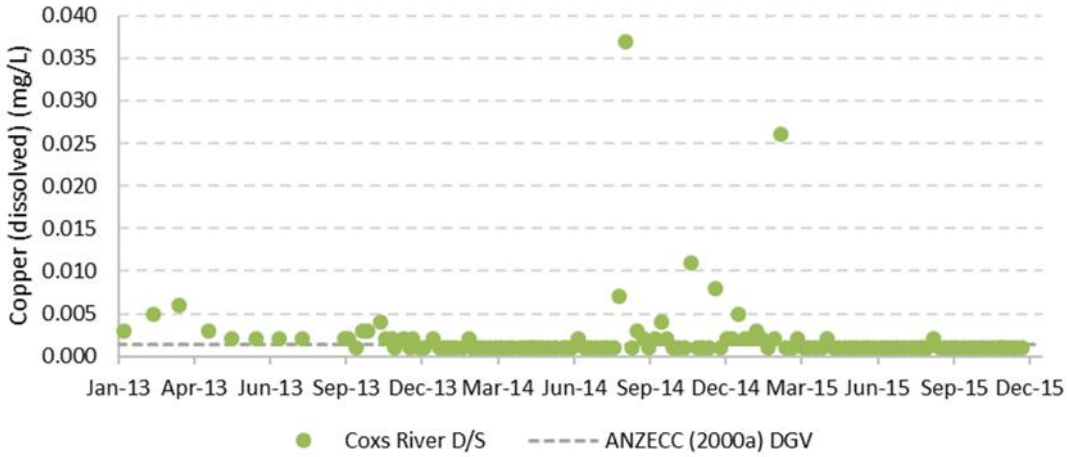


Figure D-112 Copper (dissolved) recorded at downstream monitoring locations

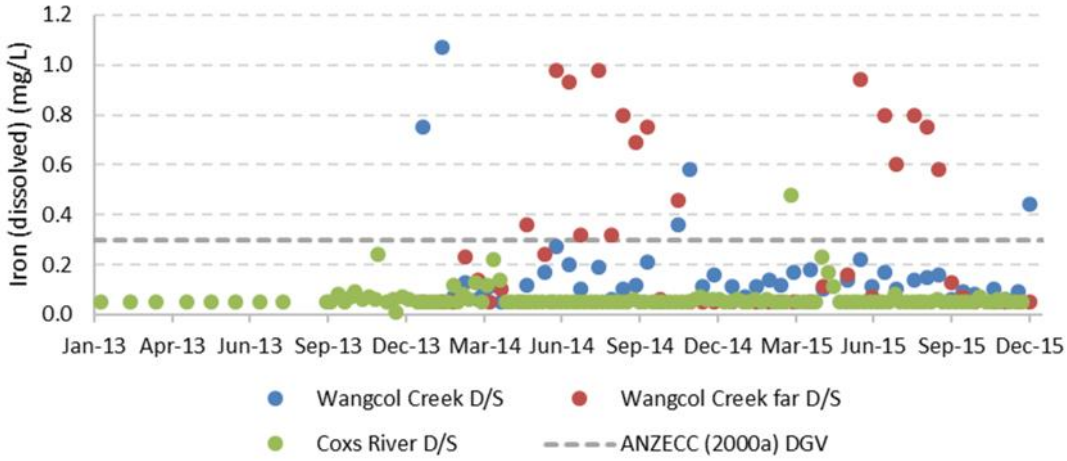


Figure D-113 Iron (dissolved) recorded at downstream monitoring locations

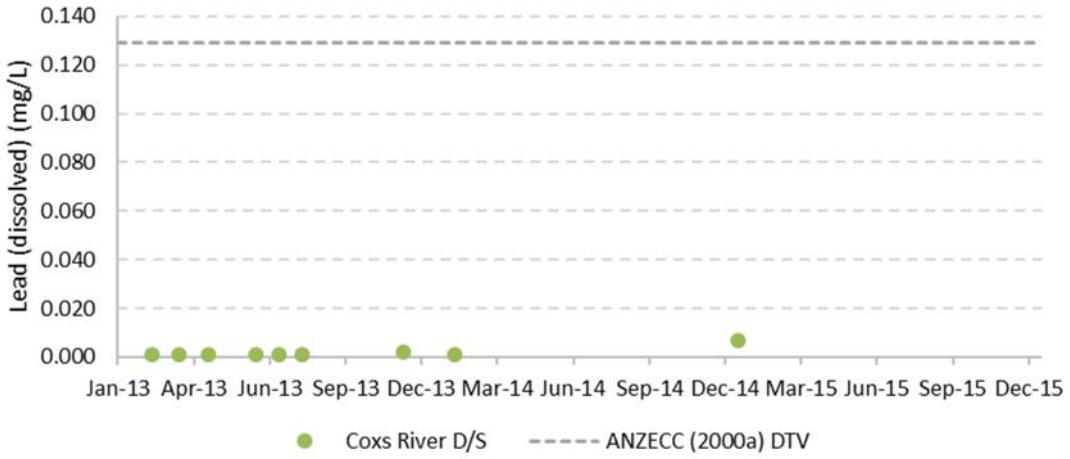


Figure D-114 Lead (dissolved) recorded at downstream monitoring locations

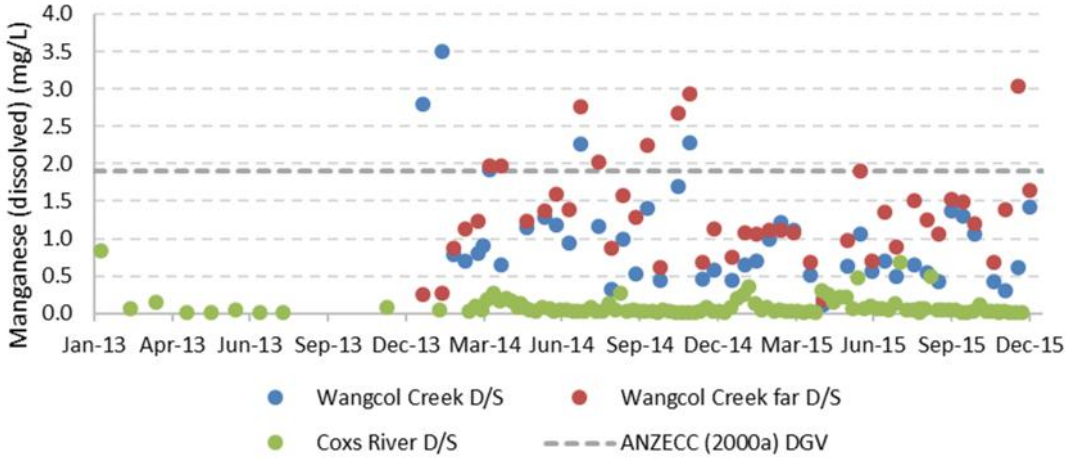


Figure D-115 Manganese (dissolved) recorded at downstream monitoring locations

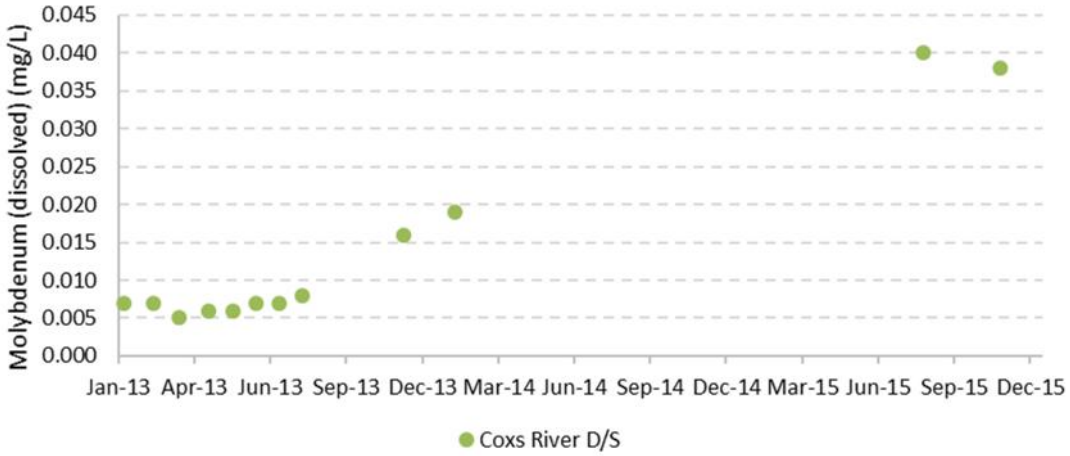


Figure D-116 Molybdenum (dissolved) recorded at downstream monitoring locations

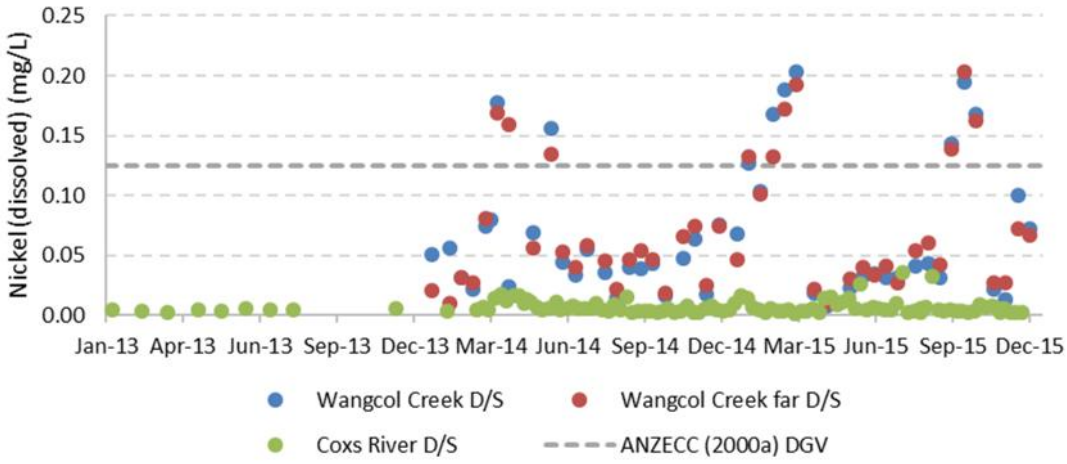


Figure D-117 Nickel (dissolved) recorded at downstream monitoring locations



Figure D-118 Selenium (dissolved) recorded at downstream monitoring locations

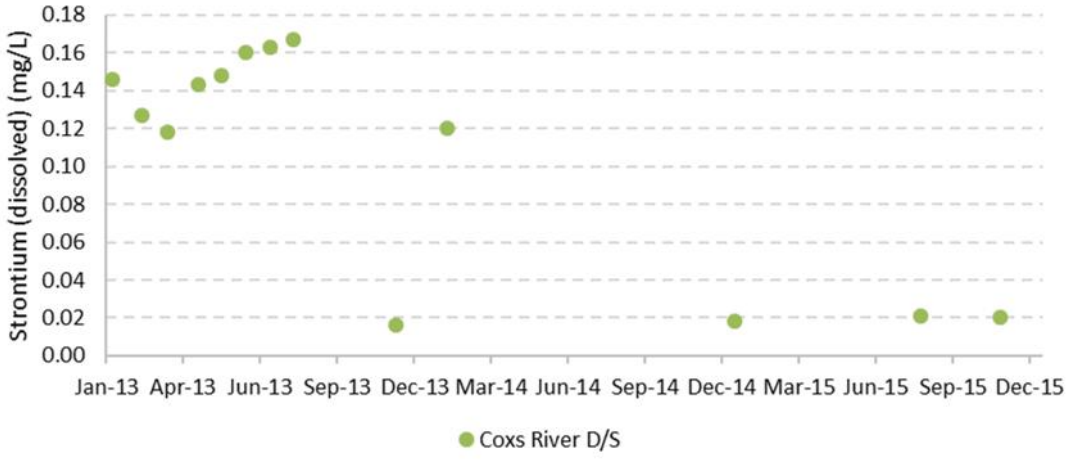


Figure D-119 Strontium (dissolved) recorded at downstream monitoring locations

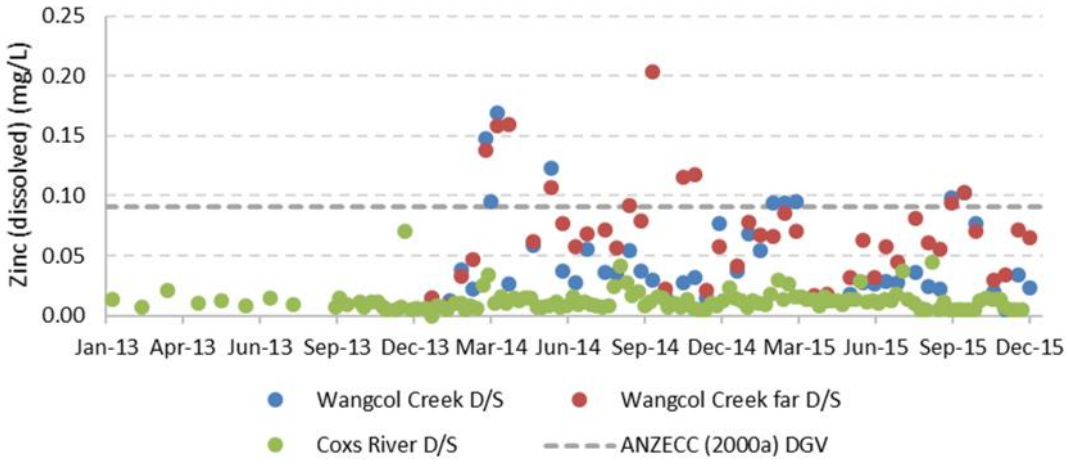


Figure D-120 Zinc (dissolved) recorded at downstream monitoring locations

Other parameters

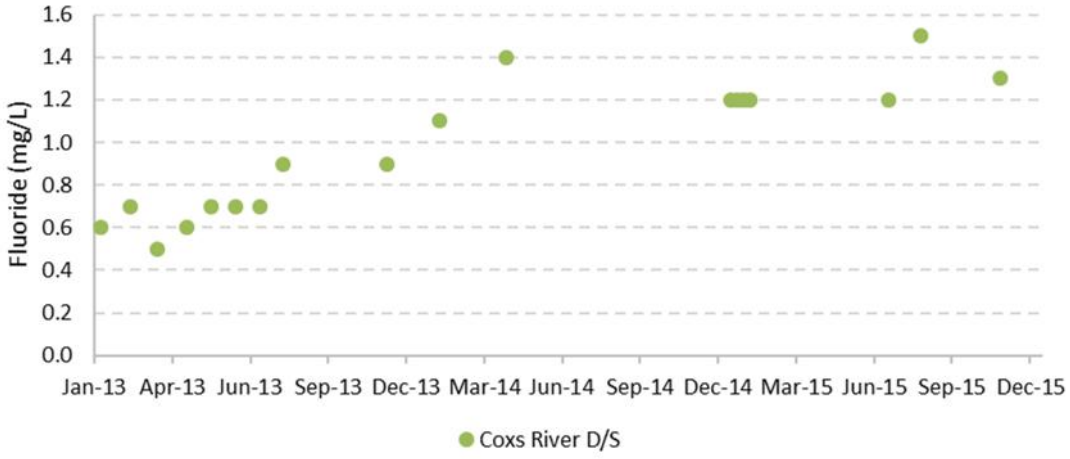


Figure D-121 Fluoride recorded at downstream monitoring locations

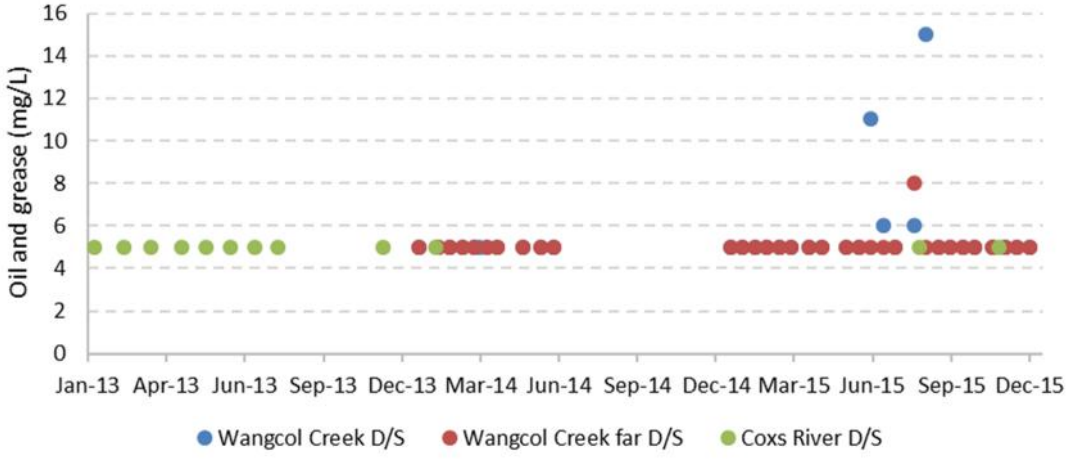


Figure D-122 Oil and grease recorded at downstream monitoring locations

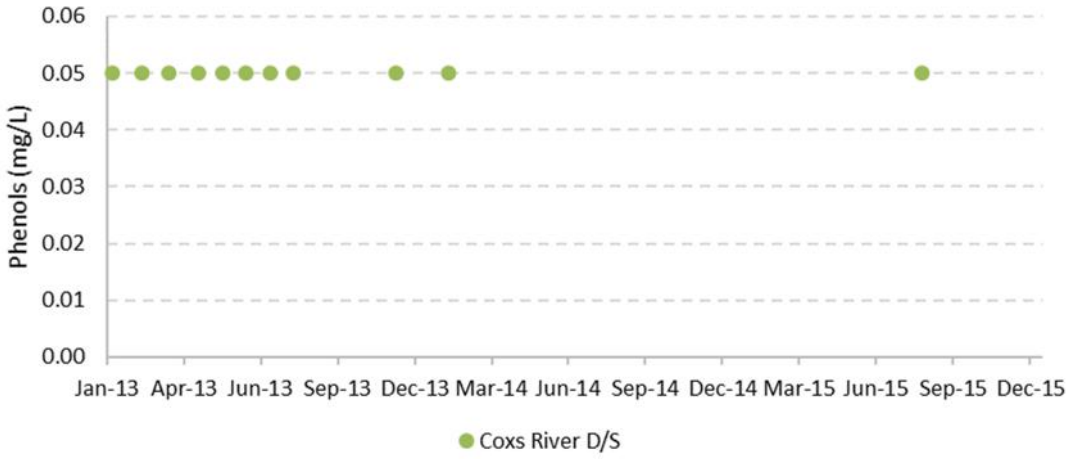


Figure D-123 Phenols recorded at downstream monitoring locations

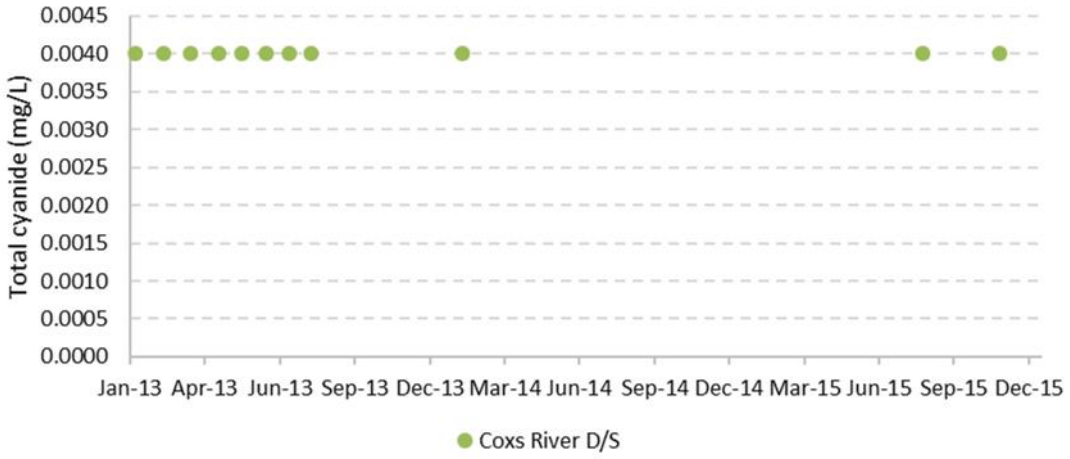


Figure D-124 Total cyanide recorded at downstream monitoring locations

Appendix E – Groundwater information

Table D-1 SCSS Groundwater Bore Information (RPS 2013a)

Bore Id	Approximate Easting (m)	Approximate Northing (m)	Bore Depth Drilled (m)	Approximate Ground Elevation (m AHD)	Screen Interval (m)	Target Aquifer
BH01	225978	6305018	18.3	912.4	N/A	Lithgow Seam (unmined)
BH02	225948	6303880	30	916.0	N/A	Marrangaroo Formation
BH03	226175	6304416	18.57	905.2	N/A	Saturated overburden
BH04	225611	6304579	27.51	923.0	N/A	Lithgow Seam workings (void)
BH05	225757	6304656	30.19	928.8	N/A	Lithgow Seam (unmined pillar)
BH06	226183	6304758	9.3	905.4	N/A	Lithgow Seam
BH07	225485.7	6303099	33	924.2	18.0–33.0	Up-gradient saturated overburden
BH08	225978.6	6304608	24.4	927.4	21.4–24.4	Lithgow Seam workings (void)
BH09	225875.7	6304526	25.5	929.8	22.5–25.0	Lithgow Seam workings (void)
BH10	225652.9	6304342	25.2	936.5	22.0–25.0	Lithgow Seam workings (void)
BH11	225088	6304251	N/A	921.0	N/A	General
BH12	225667	6304819	N/A	916.5	N/A	General (paired site)
BH13	225667	6304819	N/A	916.5	N/A	General (paired site)
BH14	224866	6304259	33.2	940.0	Open hole	Lithgow Seam
BH15	225042	6304667	25.5	940.0	18.6–24.6	Up-gradient Overburden (dry)

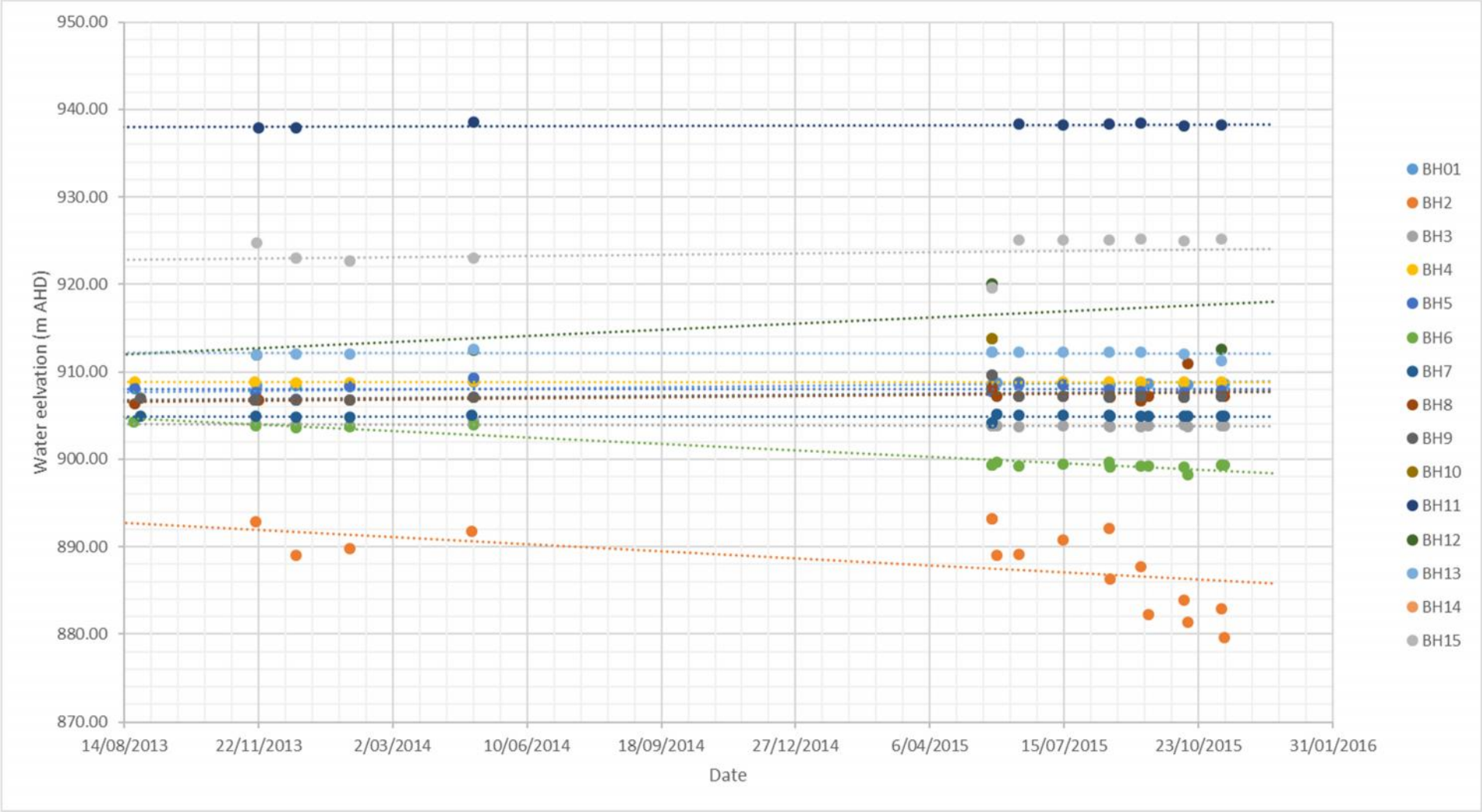


Figure D-1 Groundwater Level Monitoring Data at SCSS (2013-2015)

Table D-2 MPPS Groundwater Bore Information (CDM Smith 2012)

Bore Id	Approximate Easting (m)	Approximate Northing (m)	Bore Depth Drilled (m)	Approximate Ground Elevation (m AHD)	Target Aquifer
MPGM4_D1	225604	6305355	11.2	911.97	Coal / Sandstone (unknown screen)
MPGM4_D8	226000.5	6305242	7.6	919.38	Alluvium
MPGM4_D9	225686.7	6305314	UNK	905.9	Not known
MPGM4_D10	225241.5	6304898	UNK	909.611	Fill / sandstone @ 16.2 m bgl
MPGM4_D11	225312.6	6305090	22.2	925.93	Fill / sandstone @ 21 m bgl
MPGM4_D15	225029.6	6304670	27	937.34	Blackmans Flat Conglomerate and Marrangaroo Conglomerate
MPGM4_D16	225092.4	6304253	27.13	940.9	
MPGM4_D17	225456.9	6304438	28.71	921.88	
MPGM4_D18	225280	6304711	31.25	936.55	
MPGM4_D19	225029.6	6304670	38.1	932.86	
MPGM4_D4 (BG)	224626	6305937	8.67	917.62	Fill (unknown screen)

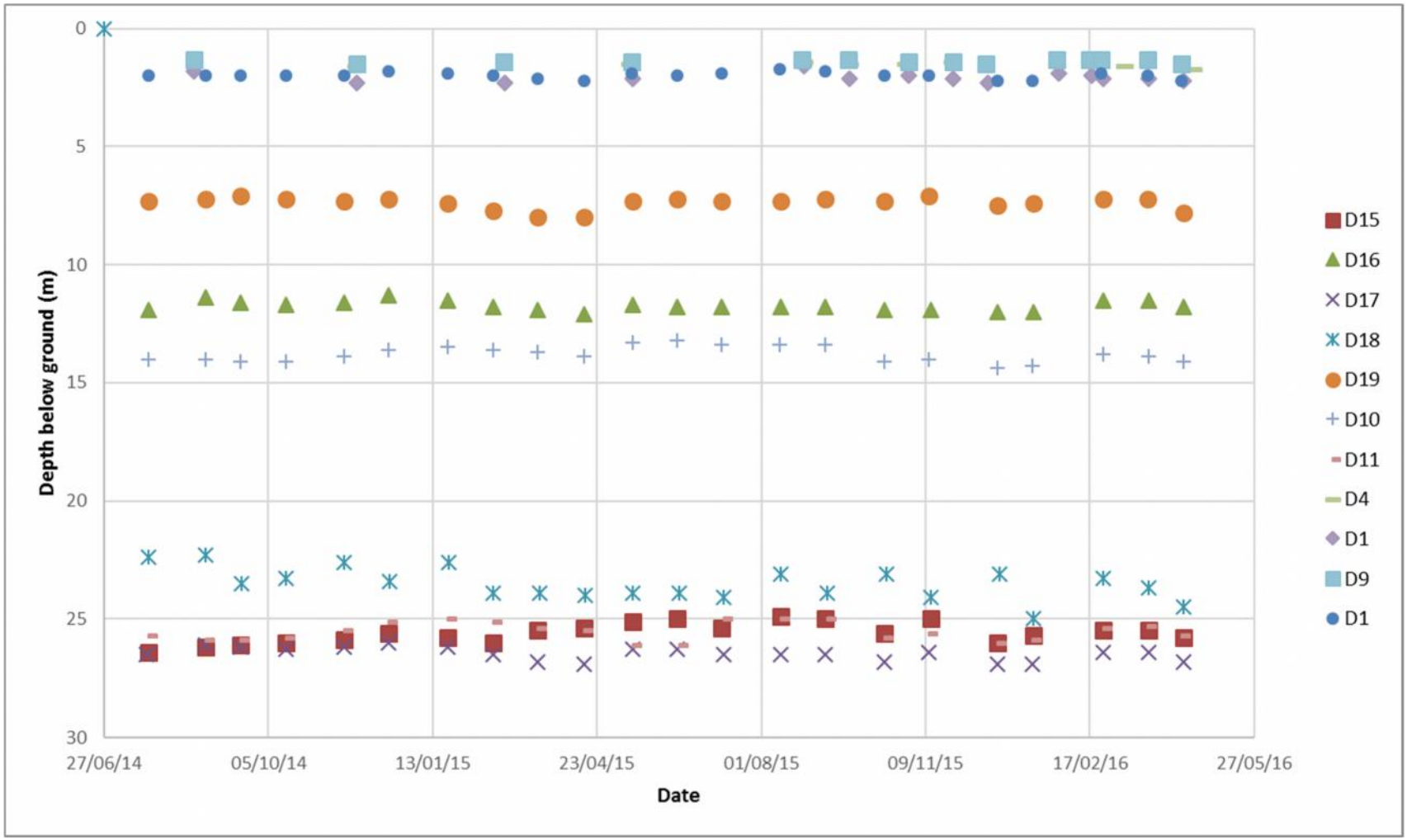


Figure D-2 Groundwater Level Monitoring Data at MPPS (2014-2016)

Table D-3 Licensed groundwater bores within 7.5 km radius of SCSS and MPPS

Work no.	License no.	Type	Final depth	Drilled Date	Function	Salinity	Yield	SWL	Latitude	Longitude
212008			0		UNK				228634	6297591
212023			0		UNK				228556	6297619
212054			0		UNK				228806	6300679
212055			0		UNK				226170	6305169
21210036			0		UNK				227465	6298729
GW030862			146	1/07/1981	INDS				232011	6305425
GW030898			232	1/09/1981	INDS				227255	6310750
GW039443			70	1/02/1990	IRAG				231952	6297313
GW045638			61		HUSE				221353	6311600
GW047572	10BL141431	Bore open thru rock	29	1/03/1980	IRAG	(Unknown)	0	0	778887	6301601
GW047706			23	1/11/1980	IRAG				777764	6301233
GW050247			31	1/02/1980	HUSE				777853	6301631
GW050996			46	1/02/1980	HUSE				230232	6299640
GW053046		Bore	59		INDS	0-500 ppm	0	0	229846	6306999
GW053071	10BL134354	Bore open thru rock	15	1/12/1980	IRAG	(Unknown)	0	0	227433	6300764
GW053401		Bore open thru rock	26	1/11/1980	IRAG	1001-3000 ppm	0	0	778055	6302365
GW053598			60	1/06/1981	INDS, MINE				777016	6305818
GW053719		Other	60		INDS	V.Salty	0	0	228233	6306368
GW053868			28	1/05/1982	IRAG				777781	6300924
GW054873		Bore	0	1/05/1981	HUSE	(Unknown)	0	0	220800	6306526
GW054874	80BL118273	Bore open thru rock	30	1/05/1981	HUSE	(Unknown)	0	0	220863	6307053
GW056349			37	1/09/1981	HUSE				777146	6304951
GW057380	10BL125180	Bore open thru rock	43	1/03/1983	HUSE	(Unknown)	0	0	225236	6298882
GW057649	10BL126321	Bore	24	1/02/1983	HUSE	Fair	0	0	225902	6299117

Work no.	License no.	Type	Final depth	Drilled Date	Function	Salinity	Yield	SWL	Latitude	Longitude
GW057658			31	1/02/1983	HUSE				778116	6299958
GW058320	80BL124389	Bore	33	1/01/1980	UNK	(Unknown)	0	0	779149	6307114
GW058576	10BL128116	Bore	0	1/02/1983	HUSE	(Unknown)	0	0	225778	6298928
GW059086			75	1/08/1980	WSUP				221041	6299965
GW059358			24	1/02/1983	MINE, MNAS				227236	6313278
GW060428			15	1/01/1983	IRAG				231162	6296890
GW062815	10BL134742	Bore	57	1/11/1983	HUSE	Fair	0	0	228910	6302103
GW067586			49	24/01/1989	HUSE				778248	6299386
GW067999		Bore open thru rock	53	26/03/1990	HUSE		0	0	221253	6300518
GW068458		Bore	53	26/03/1990	UNK		0.75	3.05	221242	6300530
GW072713	10BL154771	Bore	16	26/05/1994	HUSE	Good	0	0	228517	6302706
GW100514	10BL138828	Bore	33	1/01/1982	HUSE		0.75	0	221229	6300410
GW101340	10BL158032	Bore	26	5/09/1996	MON		0	2.55	225045	6305599
GW101341	10BL158032	Bore	31	5/09/1996	MON		0	18.49	224965	6305690
GW101342	10BL158032	Bore	29	5/09/1996	MON		0	27.2	224586	6305370
GW101413	10BL158376	Bore	36	9/01/1998	HUSE		0.63	22	779031	6303157
GW101461	10BL158341	Bore	45	8/01/1998	HUSE		0.63	15	228708	6301416
GW101752			53	11/08/1995	HUSE				776893	6304283
GW101844	10BL157524	Bore	50	17/06/1983	HUSE		0	20	221039	6300127
GW102079	10BL158928	Bore	43	27/01/1999	HUSE	Good	1.51	3	223093	6299654
GW102175			40	10/12/1998	HUSE				223183	6298330
GW102225	10BL142467	Bore	53	1/02/1991	HUSE		0	0	221174	6300328
GW102254	10BL156819	Bore	38	1/09/1994	HUSE		0.06	6.4	221344	6300719
GW102426			70	14/08/1995	HUSE				231546	6299830
GW102427			68	14/08/1995	HUSE				231521	6299799

Work no.	License no.	Type	Final depth	Drilled Date	Function	Salinity	Yield	SWL	Latitude	Longitude
GW103032	10BL156822	Bore	58	1/01/1994	IRAG		3	0	778347	6301555
GW103238			68	14/08/1995	HUSE				231463	6299287
GW105064	10BL164659	Bore	104	11/07/2002	INDS		0.6	6	230354	6307751
GW105235	10BL161212	Bore	72	9/02/2003	HUSE		1.136	23.5	224097	6299210
GW105294	10BL162989	Bore	16	1/02/2003	HUSE		0.126	3	230337	6307812
GW105295	10BL162991	Bore	16	2/08/2004	HUSE		0.126	3	230239	6307855
GW105801			37	1/01/2003	HUSE				227528	6297908
GW105973	10BL163783	Bore	0	24/05/2005	UNK		0	0	230354	6307815
GW106243	10BL163822	Bore	0	18/07/2005	UNK		0	0	229939	6307312
GW106259			72	18/09/2002	HUSE				777440	6301052
GW106737	10BL164509	Bore	90	25/11/2004	HUSE		0.65	33	228017	6303098
GW107329	10BL165224	Bore	48	5/09/2005	HUSE		0.4	26	230020	6307335
GW108613		Bore	53	28/07/2004	HUSE	Good	5.675	27	788327	6307462
GW108881			21	29/05/2008	MON				229567	6311037
GW108932			18	18/06/2008	MON				229743	6312099
GW108939			16	19/06/2008	MON				229924	6312340
GW109018			12	10/07/2008	MON				229888	6311416
GW109260			9	29/10/1985	MON				231949	6301453
GW109261	10WM000002	Piezometer	18	2/11/1985	MON		0	9.8	229804	6301350
GW109262	10WM000002	Piezometer	17	30/10/1985	MON		0	3.6	230234	6301699
GW109263	10WM000002	Piezometer	6	25/08/2008	MON		0	3.5	230188	6302356
GW109264	10WM000002	Piezometer	14	6/11/1985	MON		0	4.5	229631	6302172
GW109265	10WM000002	Piezometer	15	7/11/1985	MON		0	1	229380	6301985
GW110157	10BL165933	Bore	9	14/10/2005	MON		0	0	227341	6304272
GW110158	10BL165933	Bore	9	14/10/2005	MON		0	0	227594	6304231

Work no.	License no.	Type	Final depth	Drilled Date	Function	Salinity	Yield	SWL	Latitude	Longitude
GW110159	10BL165933	Bore	10	13/10/2005	MON		0	0	227830	6304284
GW110160	10BL165933	Bore	43	15/10/2005	MON		0	0	228222	6304736
GW110161	10BL165933	Bore	28	13/10/2005	MON		0	0	228450	6304256
GW110162	10BL165933	Bore	12	13/10/2005	MON		0	0	228445	6304252
GW110329	10BL600114	Bore	8	1/01/2006	HUSE		2.5	2	779076	6302271
GW110437		Bore	90	9/03/2009	MON		0.0631	0	227895	6300507
GW110480	10BL603120	Bore	10	28/07/2009	MON		0	0	229530	6301970
GW110481	10BL603121	Bore	16	28/07/2009	MON		0	0	229166	6301607
GW110482	10BL603122	Bore	33	29/07/2009	MON		0	0	229153	6303047
GW110483	10BL603122	Bore	21	29/07/2009	MON		0	0	229149	6303043
GW110484	10BL603123	Bore	59	29/07/2009	MON		0	0	229722	6302886
GW110485	10BL603123	Bore	65	17/09/2009	MON		0	0	229732	6301996
GW110520	10BL603501	Bore	38	6/03/2009	INDS		0.505	1.2	227995	6300665
GW110847			8	1/01/2007	HUSE				777262	6303431
GW110861	10BL603591	Bore	24	19/02/2010	MON		0	0	227055	6303562
GW110998			55	6/08/2010	HUSE				225718	6296702
GW110999			55	1/05/2007	HUSE				225943	6297777
GW111021			360	19/08/2010	DRNG				230615	6306064
GW111025			380	23/08/2010	DRNG				233981	6300737
GW111026			400	23/08/2010	DRNG				231254	6300484
GW111027			24	23/02/2004	MON				226988	6303549
GW111028			24	23/02/2004	MON				226945	6303551
GW111029			24	21/02/2010	MON				227030	6303584
GW111030			24	20/02/2010	MON				227070	6303571
GW111203			84	3/02/2010	MON				226800	6306346

Work no.	License no.	Type	Final depth	Drilled Date	Function	Salinity	Yield	SWL	Latitude	Longitude
GW111204			16	15/03/2010	MON				228994	6308259
GW111205			87	1/02/2010	MON				226797	6306348
GW111206			39	6/02/2010	MON				227132	6306531
GW111207			50	18/02/2010	MON				224813	6306516
GW111208			105	8/03/2010	MON				228994	6308259
GW111334			12	14/02/2010	MON				227687	6304308
GW111358			6	10/02/2011	MON				227122	6299450
GW111359			6	10/02/2011	MON				227111	6299452
GW111360			6	10/02/2011	MON				227109	6299443
GW111471			24	23/02/2010	MON				227094	6303739
GW111472			24	23/02/2010	MON				227053	6303741
GW111473			81	23/03/2010	MON				227298	6303561
GW111535			15	28/07/2011	MON				777602	6305622
GW111536			15	28/07/2011	MON				777679	6305661
GW111537			15	27/07/2011	MON				777725	6305604
GW111587			80	6/12/2011	HUSE				227926	6297585
GW801271			55	8/06/2000	HUSE				227176	6297536
GW802266	80BL242355	Bore	114	21/06/2004	HUSE	(Unknown)	0.189	5	779038	6305343
GW802816			37	22/03/2004	HUSE				776817	6304350
GW804393			27	16/05/2000	MINE, MNAS				782725	6313040
GW804550			33	15/05/1989	HUSE				776920	6304210
GW804624			0	29/06/1994	HUSE				778710	6305445

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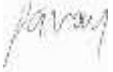
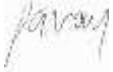
Level 3 GHD Tower 24 Honeysuckle Drive Newcastle NSW 2300
PO Box 5403 Hunter Region Mail Centre NSW 2310
T: (02) 4979 9999 F: (02) 4979 9988 E: ntlmail@ghd.com

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Cover photos: Rock Formations on Newnes Plateau and Coxs River

Springvale Coal Pty Limited
Level 18
BT Tower, 1 Market St
Sydney NSW 2000
www.centennialcoal.com.au