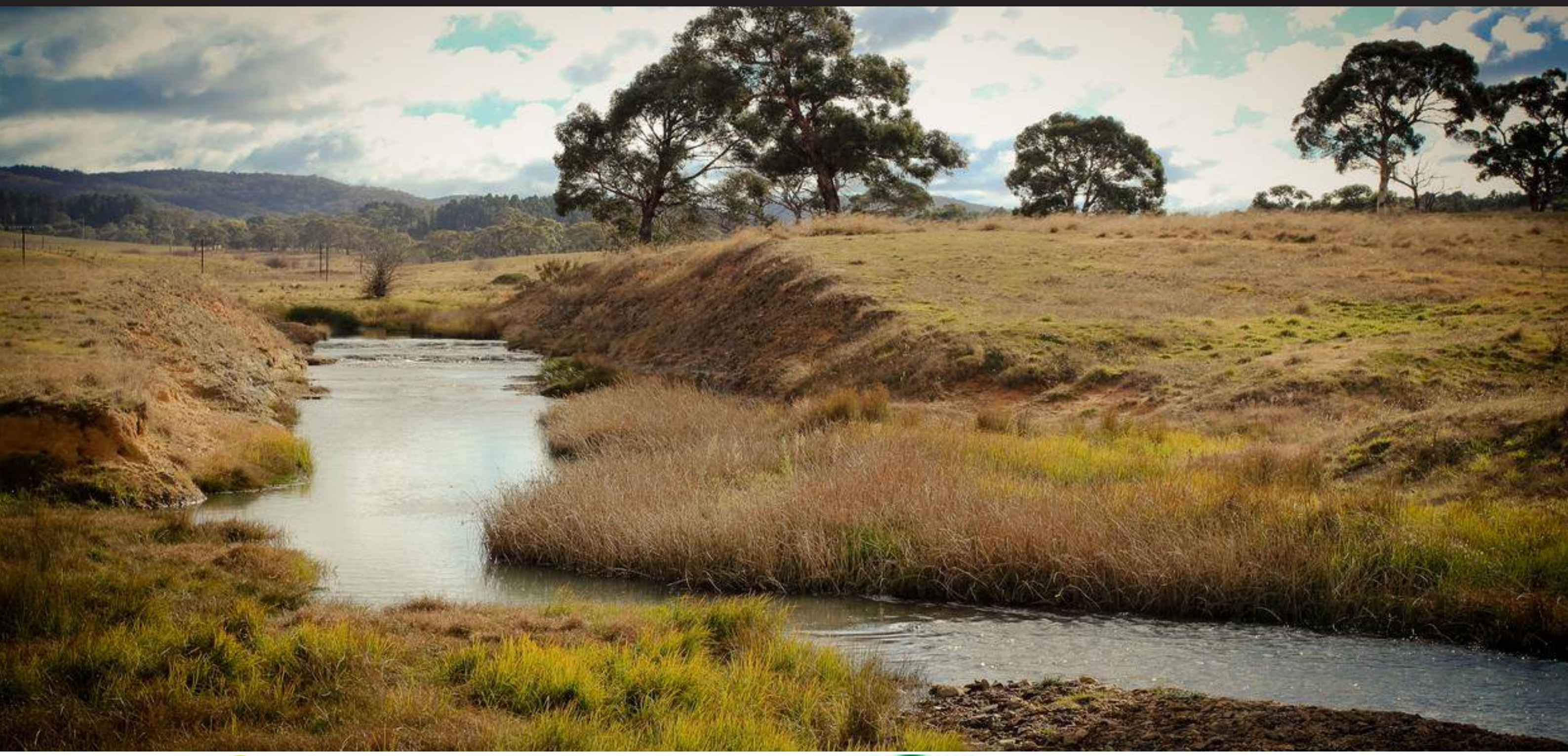
# Springvale Water Treatment Project

## State Significant Development 7592
## Environmental Impact Statement
## Volume 2 - Appendix B2

September 2016



EnergyAustralia Centennial Coal

# 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.

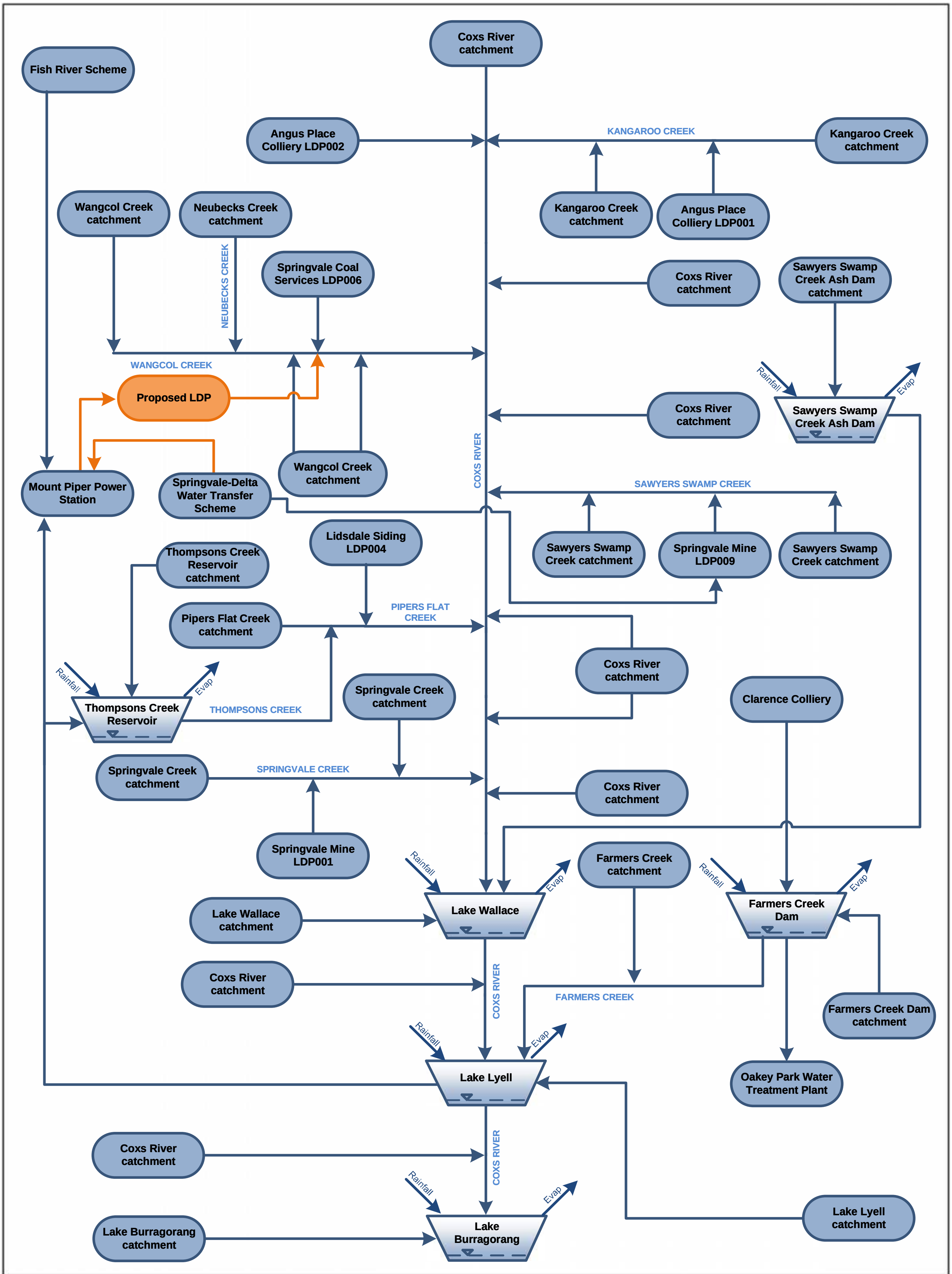
A timeline of each modelled operation has been presented in Appendix B.

### 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 |

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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. |

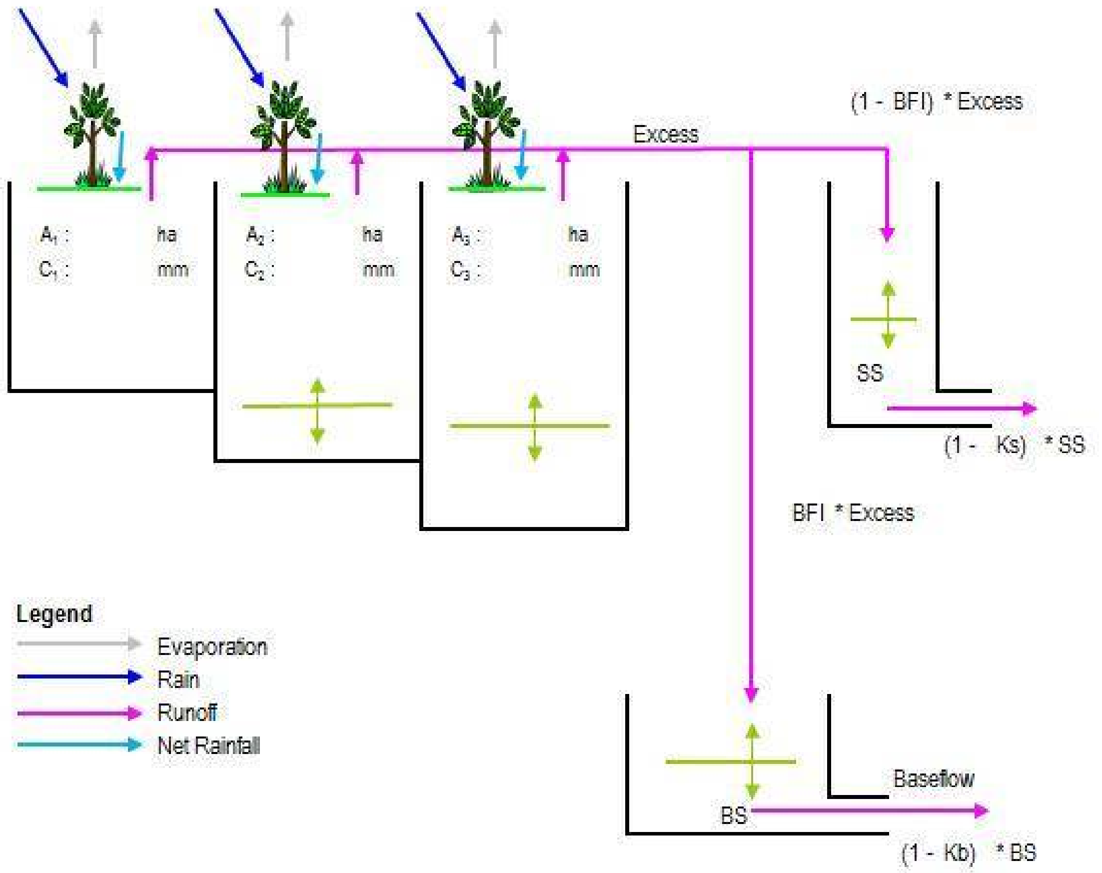



Figure 4-2 Australian Water Balance Model representation

### 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.

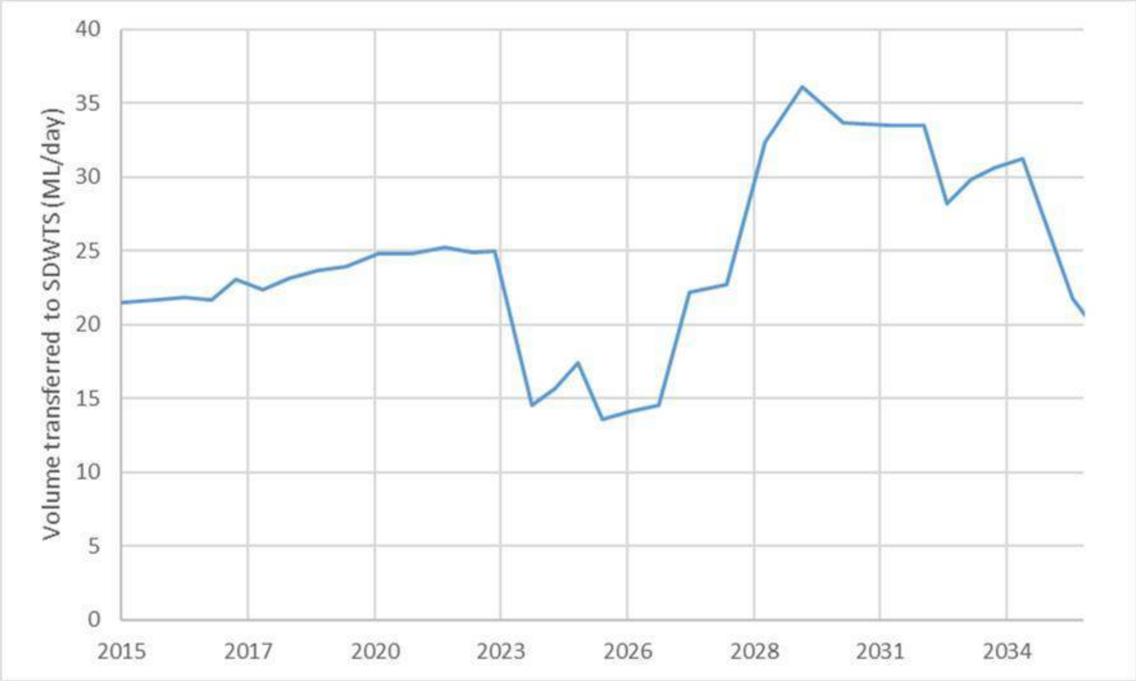



Figure 4-3 Predicted groundwater inflows into Angus Place Colliery and Springvale Mine (CSIRO, 2015)

### *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.

<u>Water supply storages</u>

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.

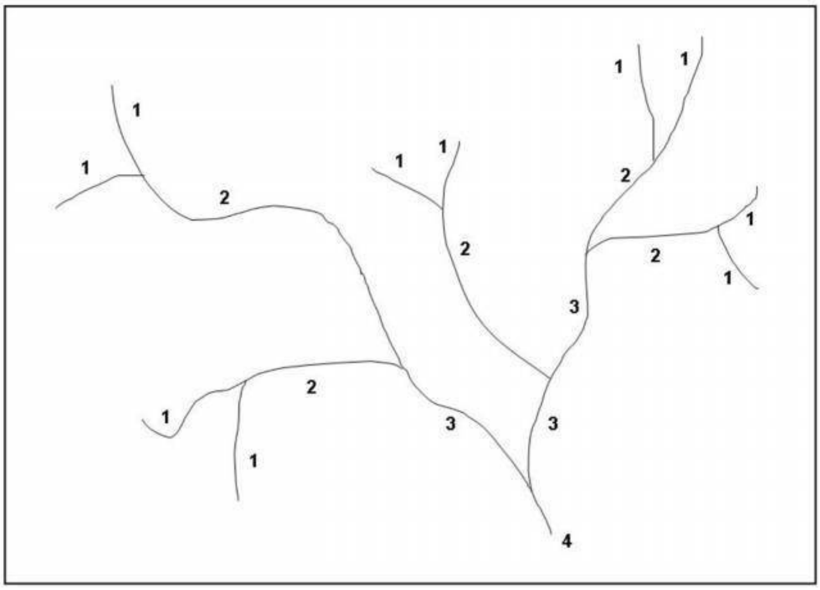



Figure 4-4 Stream order for a generic catchment using Strahler (1952) method

### 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

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

## 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."*

<u>Water quality objectives</u>

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.

<u>Ecosystem condition</u>

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.

<u>Reference site</u>

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.

<u>Default guideline values</u>

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.

<u>Australian Drinking Water Guidelines</u>

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.<br><6.5 may be corrosive.<br>>8 progressively decreases efficiency of chlorination.<br>>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.<br><0.2 NTU is the target for effective filtration of Cryptosporidium and Giardia.<br><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.<br>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.<br>Taste threshold 3 mg/L.<br>High concentrations colour water blue/green.<br>>1 mg/L may stain fittings.<br>>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.<br>Taste threshold 0.3 mg/L.<br>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).<br>>0.1 mg/L causes taste, staining.<br><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.<br>Natural concentrations generally <0.01 mg/L.<br>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 |

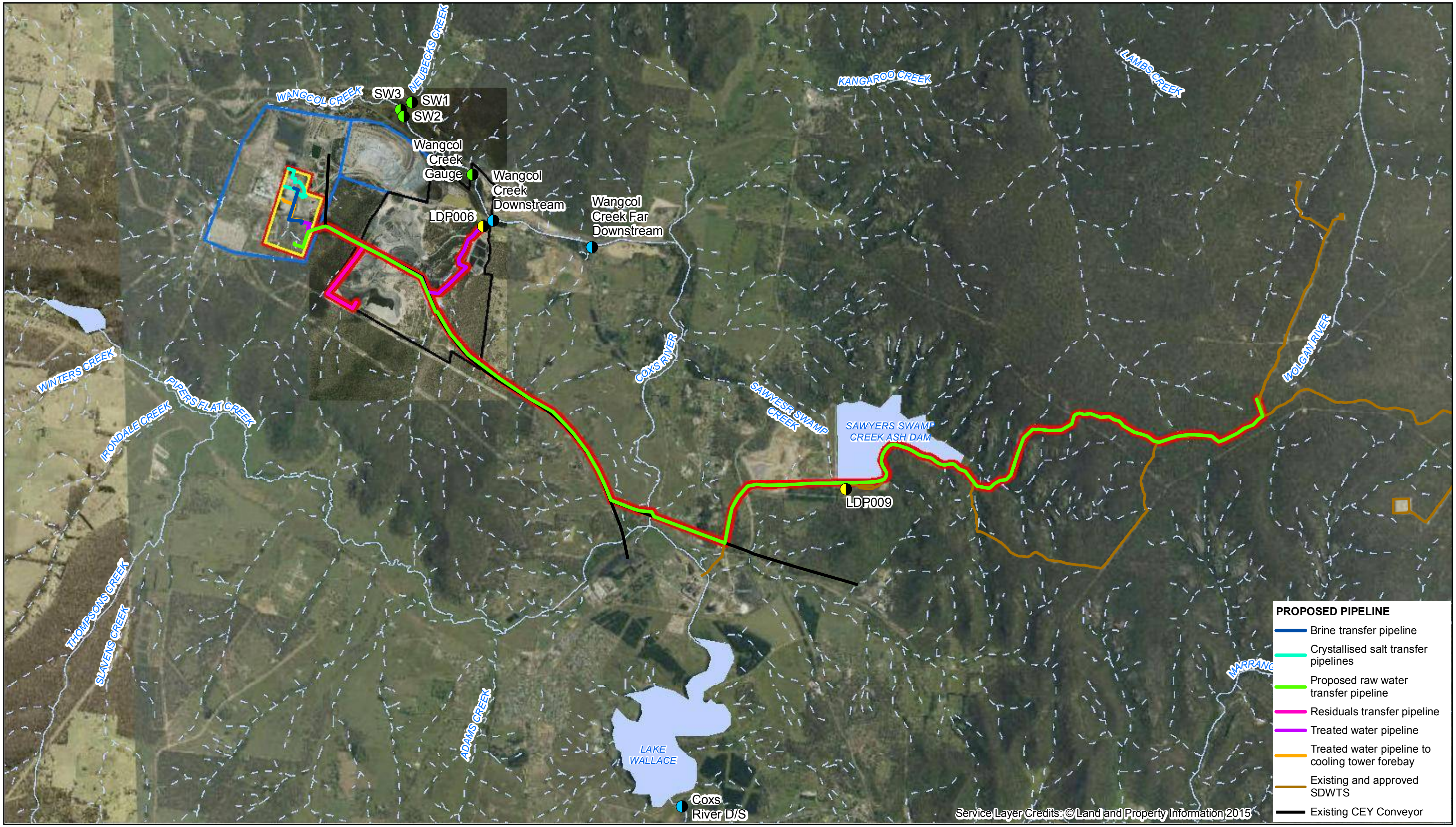
| Parameter | Units | Discharge limits | |
|---|---|---|---|
| | | LDP006 | LDP009 |
| Zinc (dissolved) | mg/L | – | 0.05 |
| **Other** | | | |
| Fluoride | mg/L | – | 1.8 |
| Oil and grease | mg/L | 10 | 10 |

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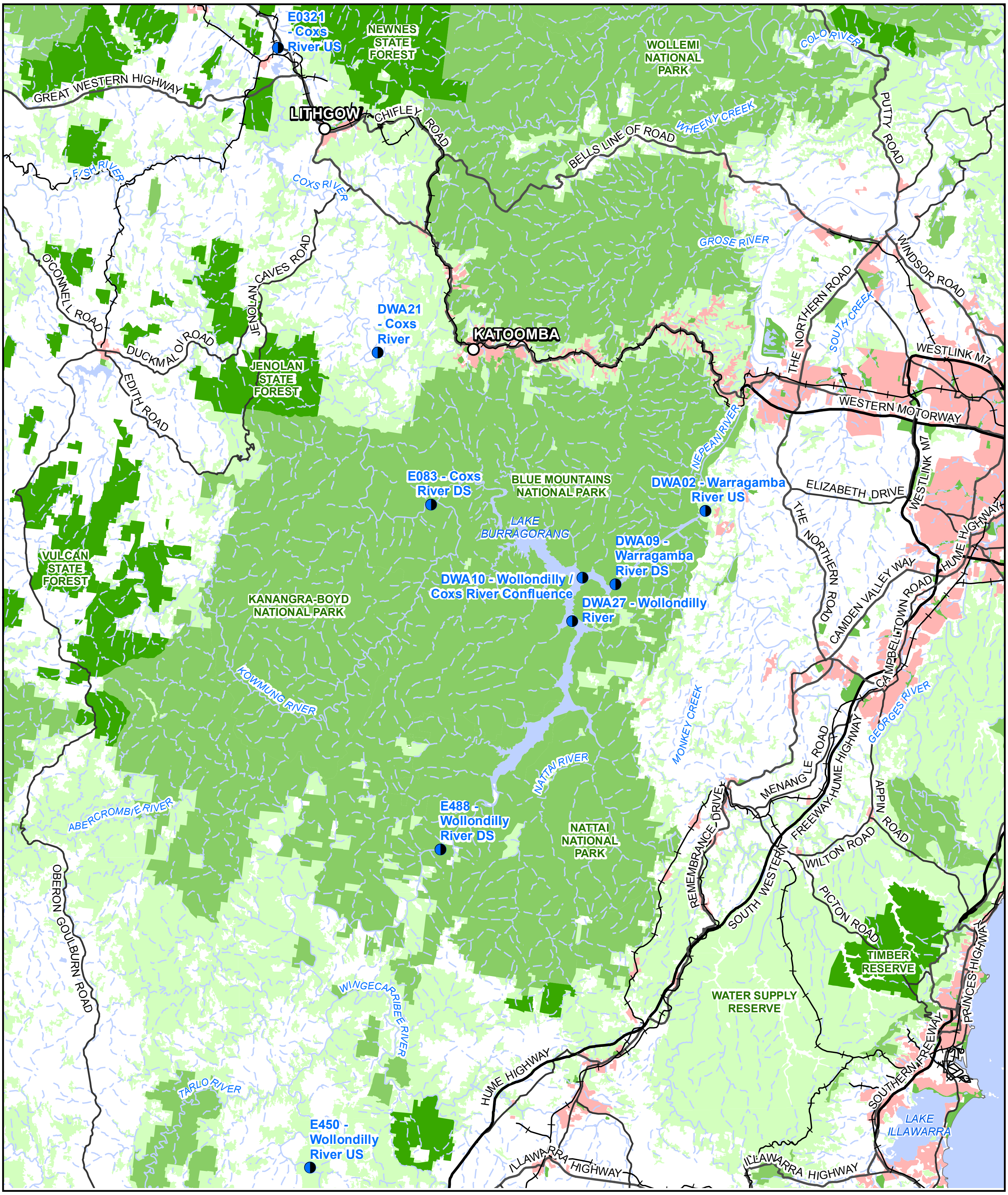
Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial: Site location, boundaries, pipeline; imagery, 2016. Created by: tmorton




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

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GHD

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

## Regional locations

**Figure 4-6**

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G:\22\0105001\GIS\Maps\Deliverables\Western\Springvale\2125109\WRIA\10_3\2125109_WRIA010_Regional_SurfaceMonitoringLocations_0.mxd

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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*

<u>August 2014</u>

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.

<u>October 2014 and April 2015</u>

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).

<u>May 2016</u>

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).

<u>Concentrations tested</u>

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**

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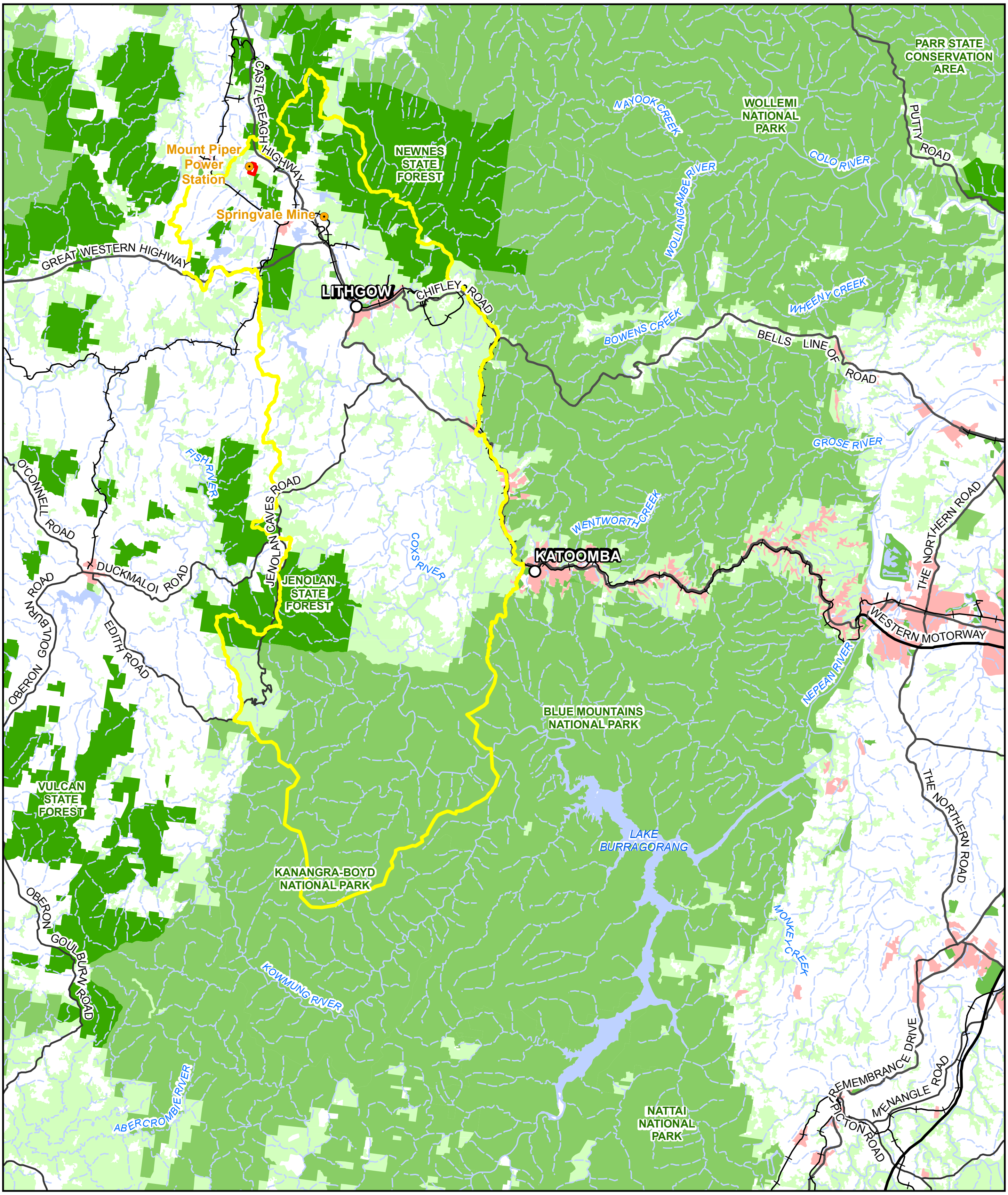
Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial: Site location, boundaries, alignment, monitoring locations, imagery, 2016. Created by: tmorton




LEGEND

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

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