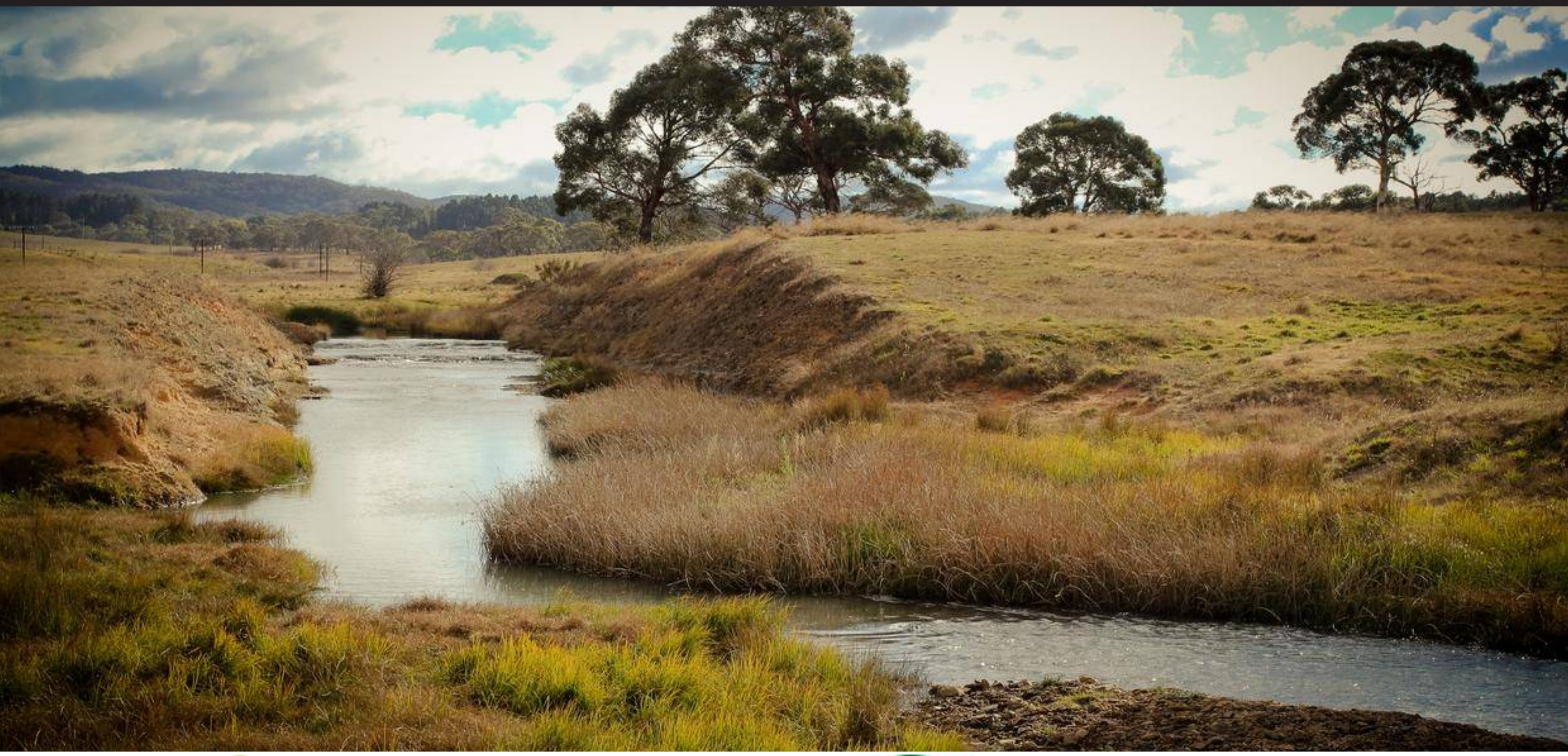
Springvale Water Treatment Project

State Significant Development 7592
Environmental Impact Statement
Volume 2 - Appendix B3

September 2016



EnergyAustralia Centennial Coal

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

GHD

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Springvale Water Treatment Project
Water Resources Impact Assessment

Job Number	21-25109
Revision	0
Date	10 Aug 2016

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

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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

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:

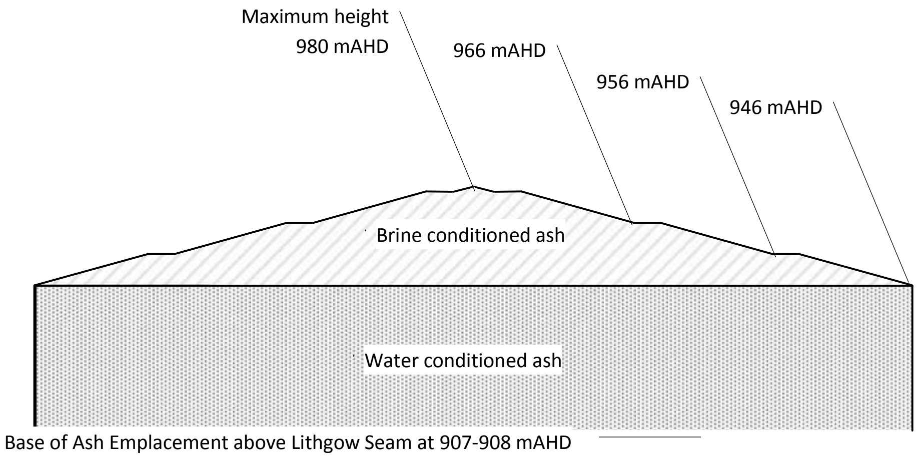
- Treated process wastewater stored on site.
- Coxs River via Lake Lyell and Thompsons Creek Reservoir.
- Fish River water supply scheme.

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.

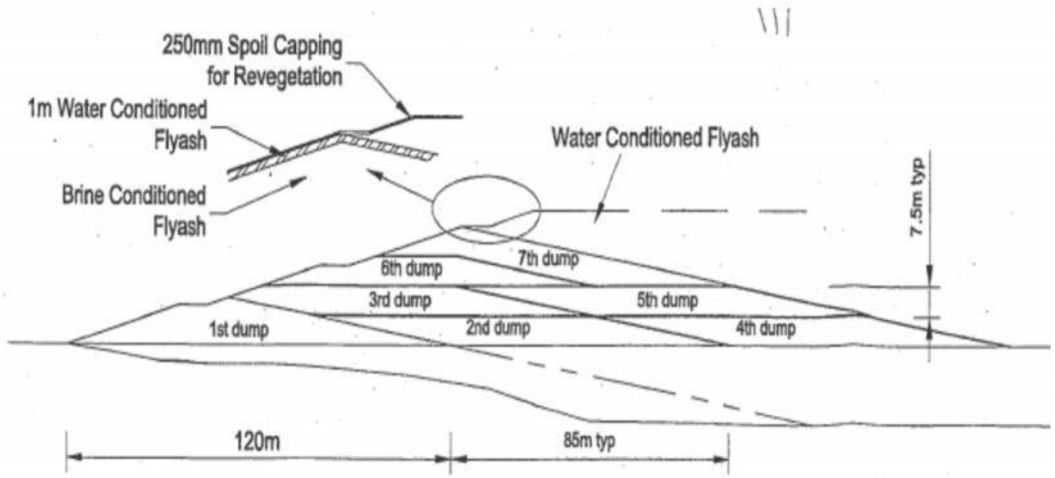
The majority of the make-up water used at MPPS has historically been sourced from the Coxs River. A system of storage dams, interconnecting pipelines and pumping stations exist to supply water to MPPS. Make-up water is pumped from Lake Lyell directly to the cooling water system or to Thompsons Creek 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

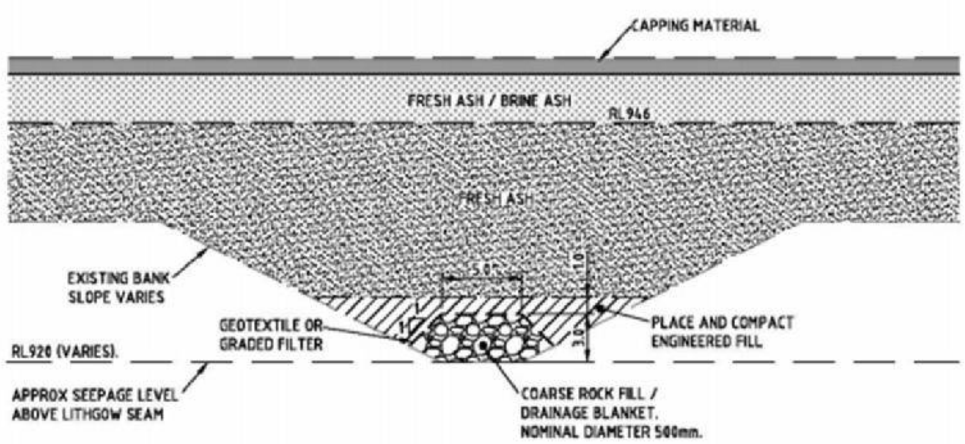
Ash emplacement developed at

- 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)

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

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Ash Emplacement Details

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EnergyAustralia

DATE June 2016

Figure 5-2

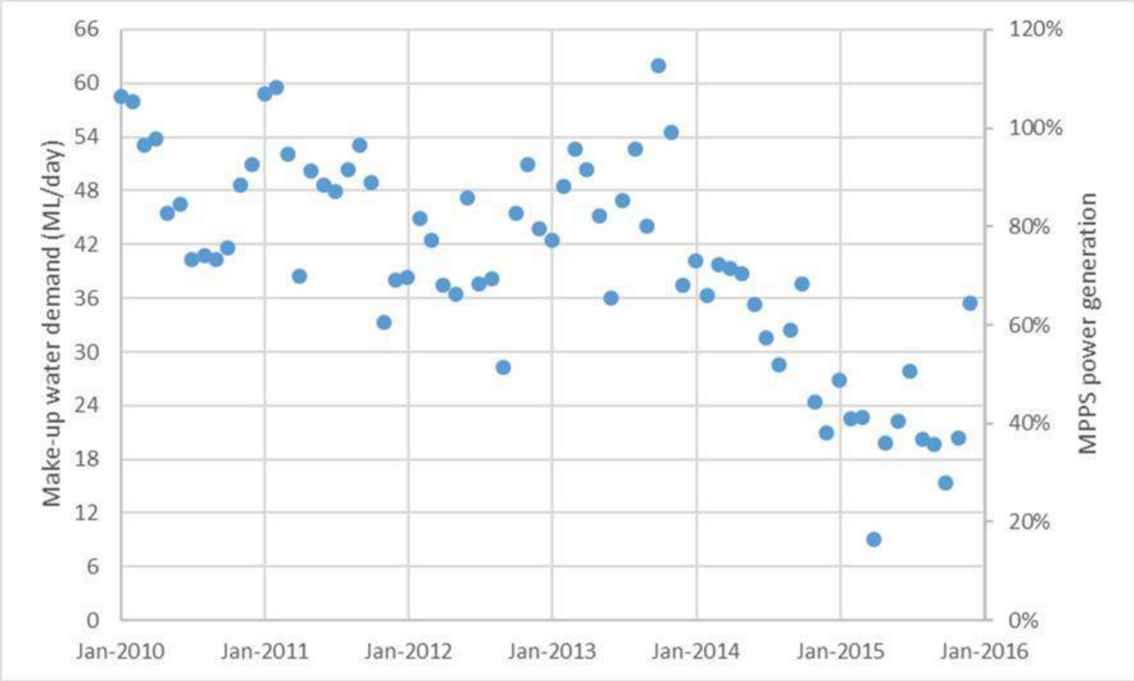

Figure 5-3 Average daily make-up water demand at MPPS

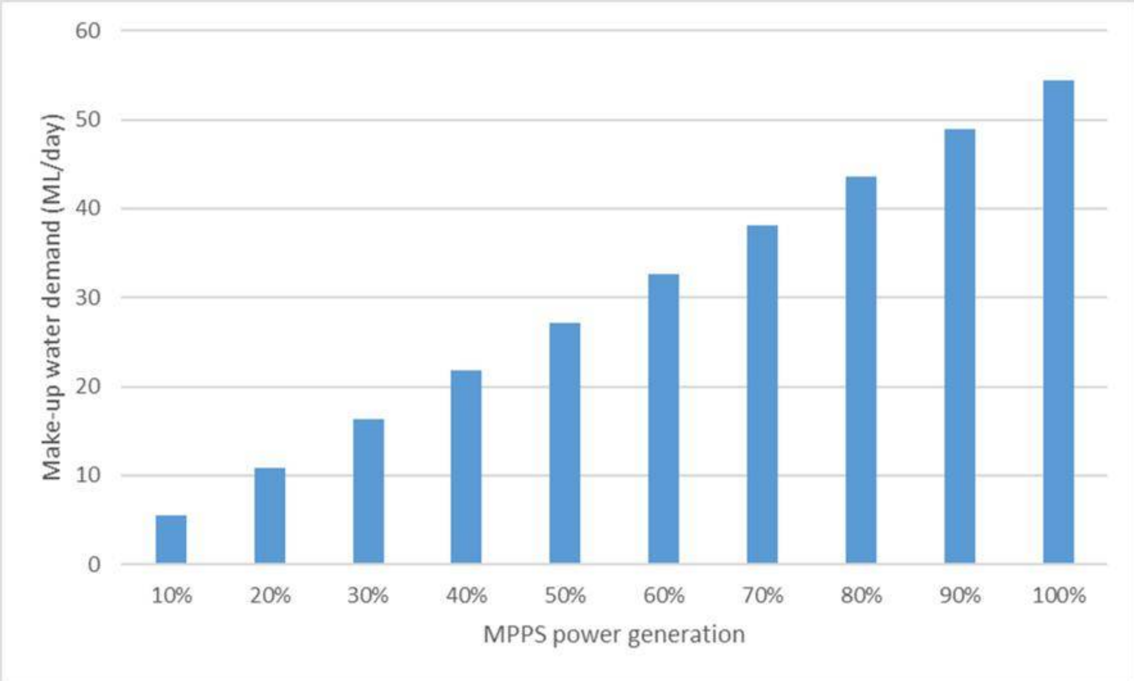

Figure 5-4 Power generation at MPPS and make-up water demand

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.

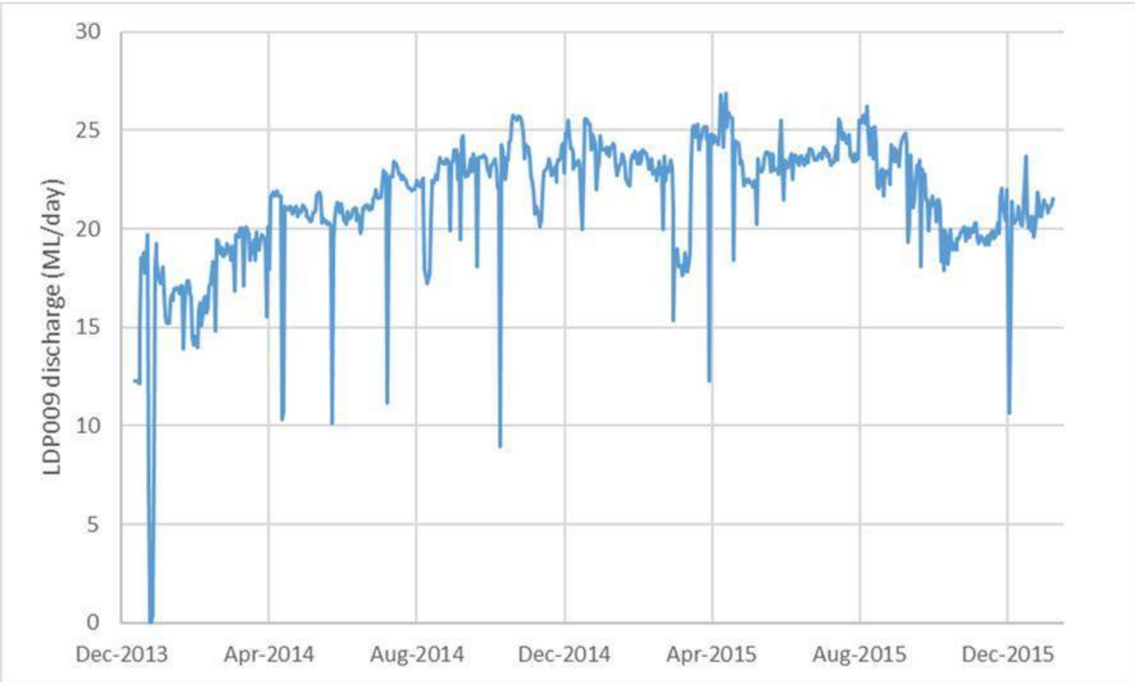

Figure 5-5 Monitored daily LDP009 discharges

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

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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

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.

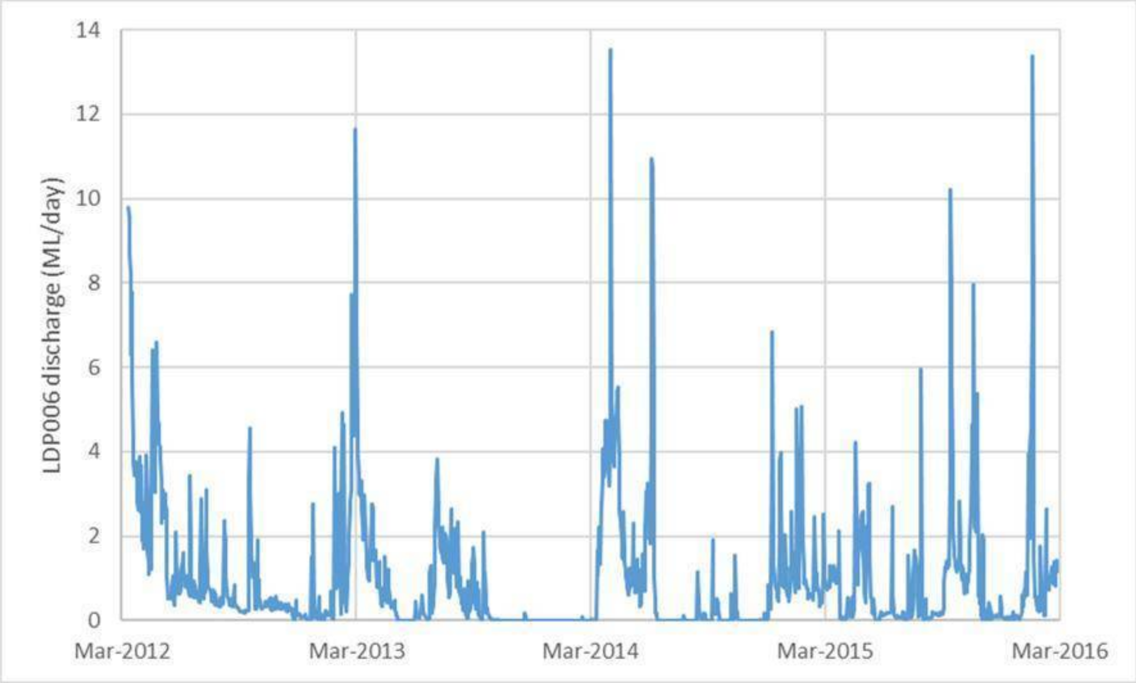


Figure 5-7 Monitored daily LDP006 discharges

5.2 Water and salt balance assessment

5.2.1 Model validation

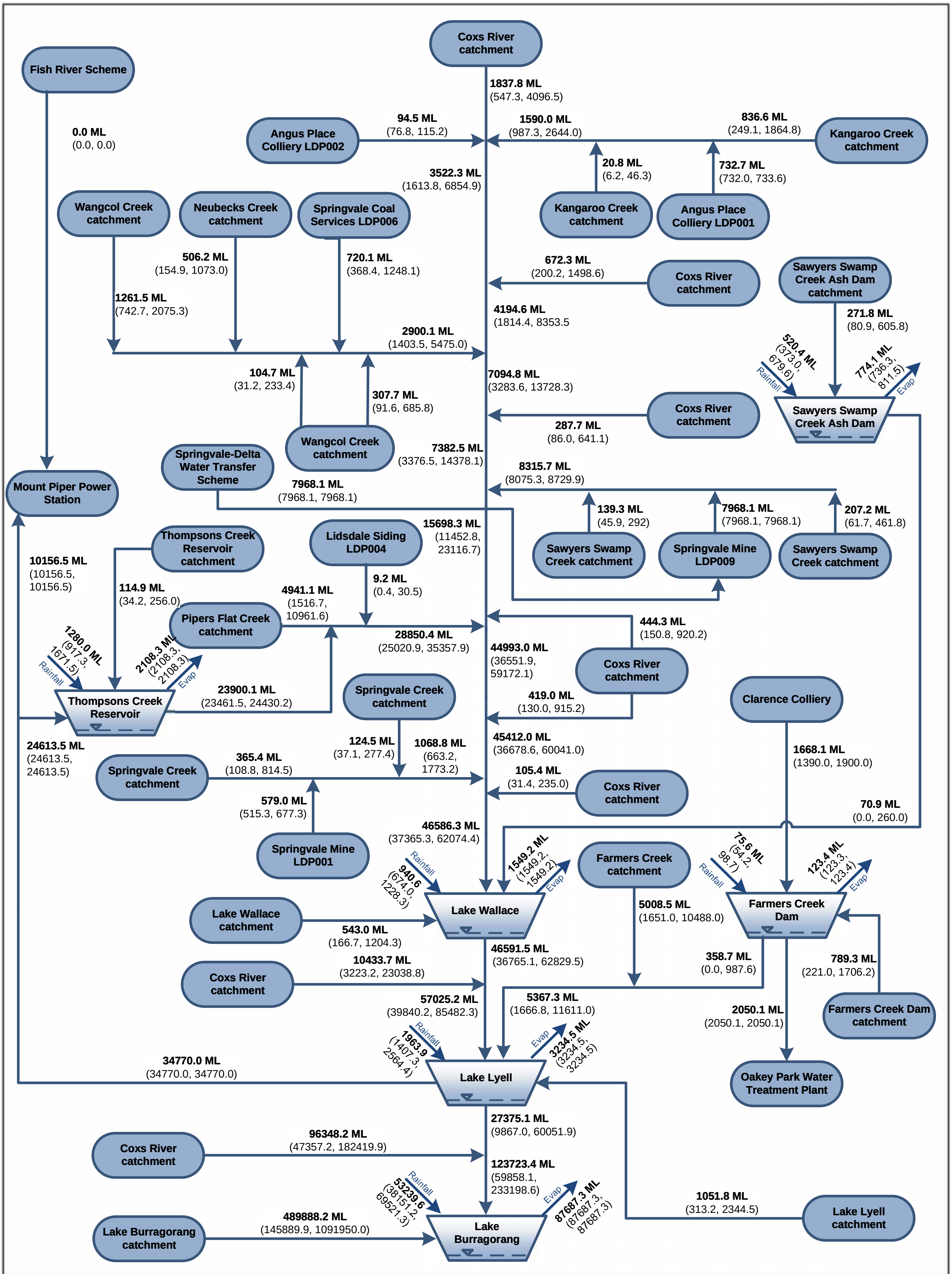
Outputs of the water and salt balance model were compared to available stream flow and EC data to provide an indication of the validity of the representation of existing conditions in the model. Data from two monitoring locations on the Coxs River over a period of ten years was used to verify the modelling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



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

GHD

Springvale Water Treatment Project
Water Resources Impact Assessment

Annual water transfers
Existing conditions (2016)

Centennial Coal
EnergyAustralia

DATE Jul 2016

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.

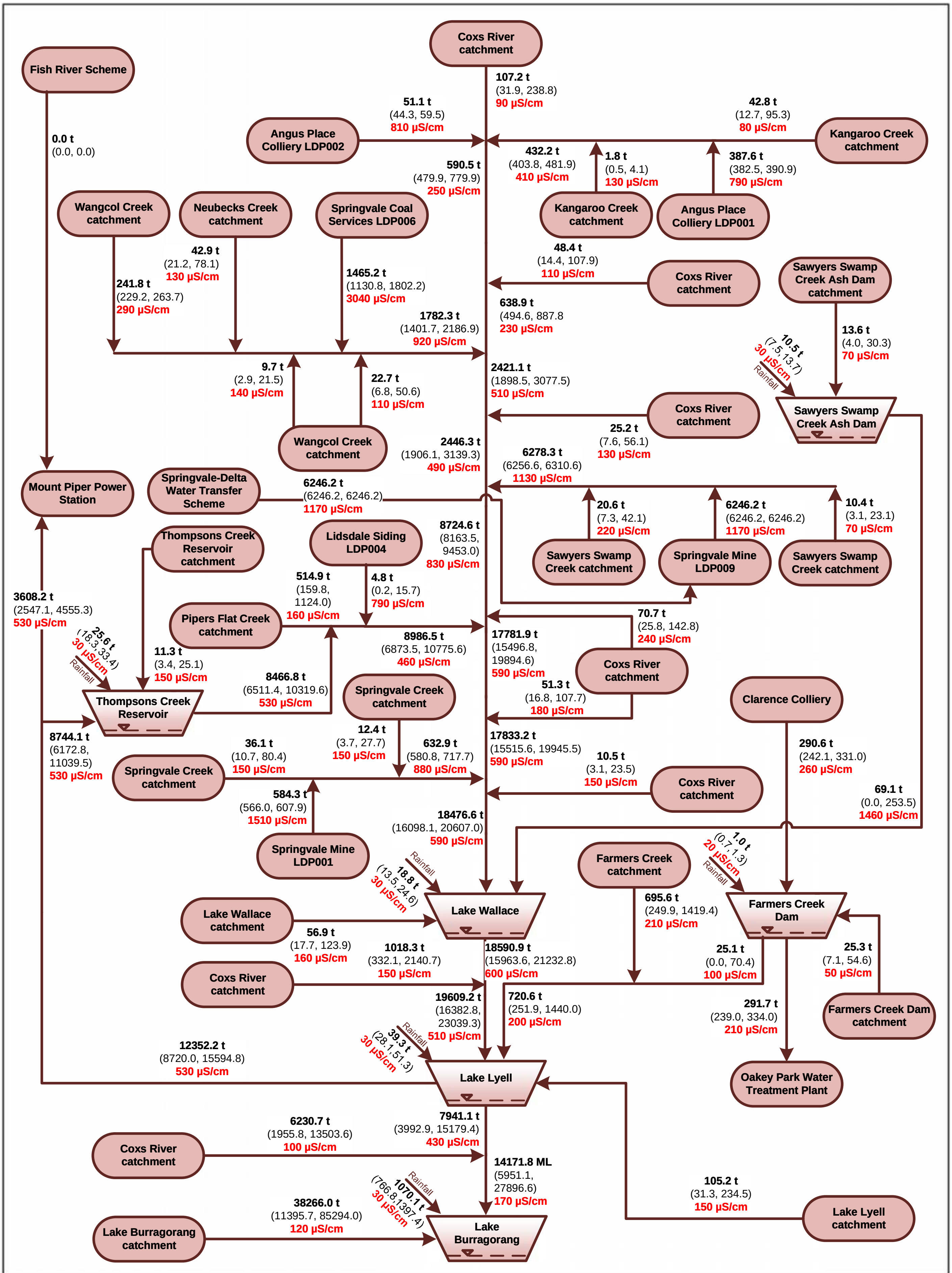
Wangcol Creek catchment

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.



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

Springvale Water Treatment Project
Water Resources Impact Assessment

Annual salt transfers
Existing conditions (2016)

Centennial Coal
EnergyAustralia

DATE Jul 2016

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.

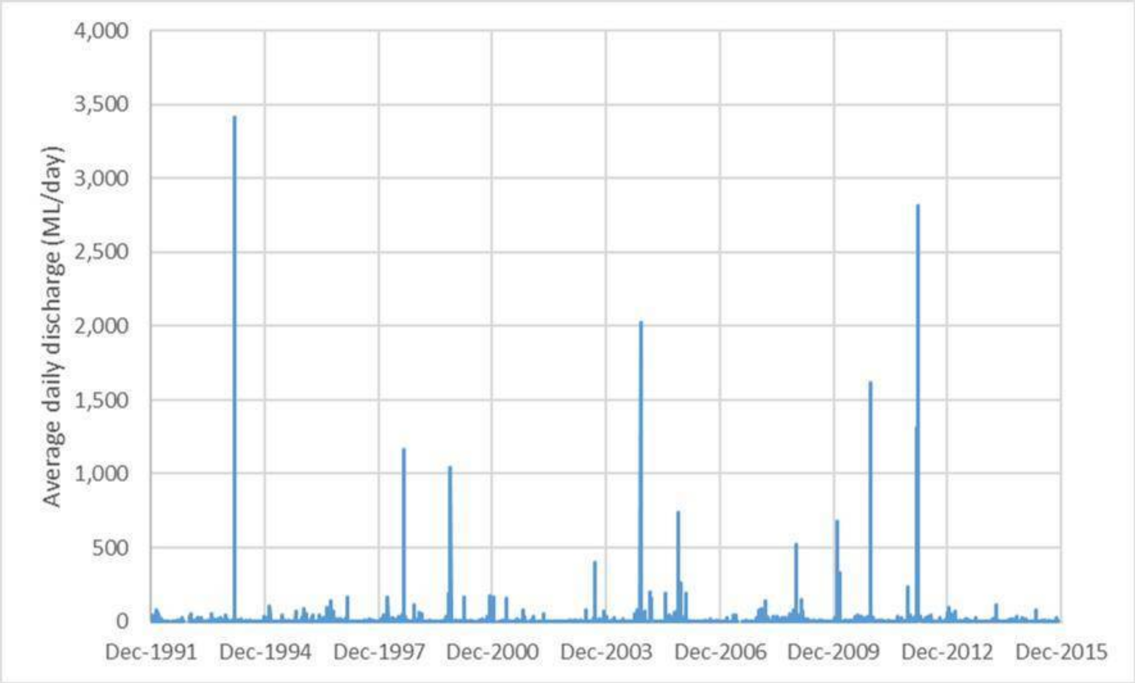


Figure 5-10 Average daily discharge recorded at Wangcol Creek gauge

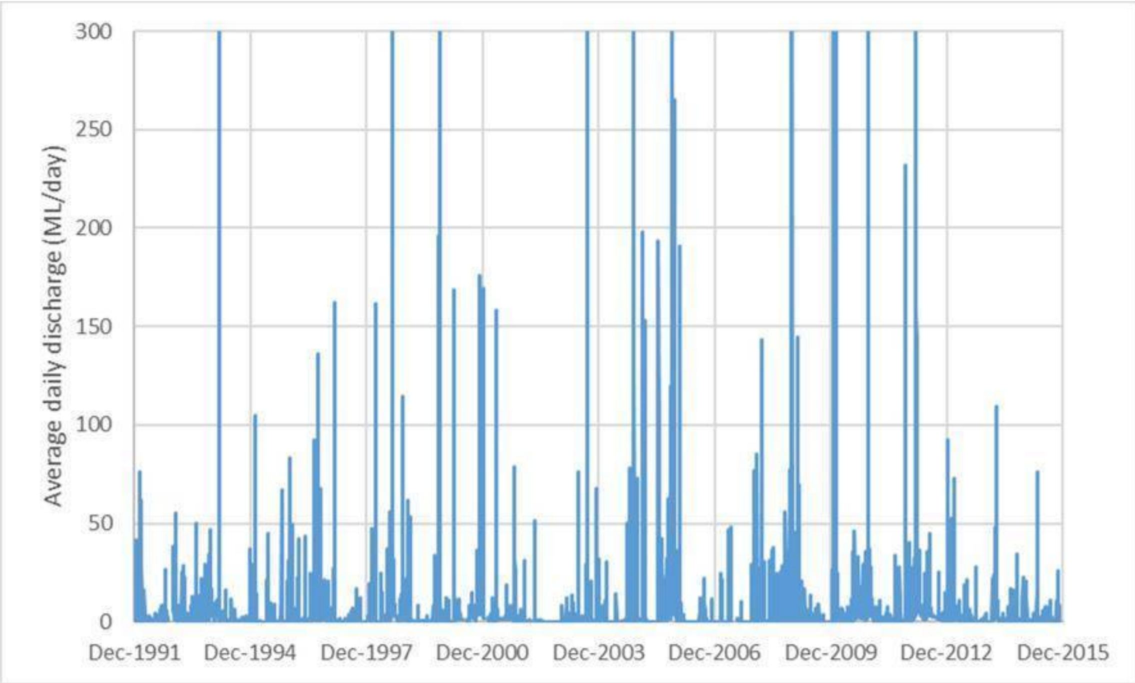


Figure 5-11 Average daily discharge recorded at Wangcol Creek gauge (between 0 ML/day and 300 ML/day)

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).

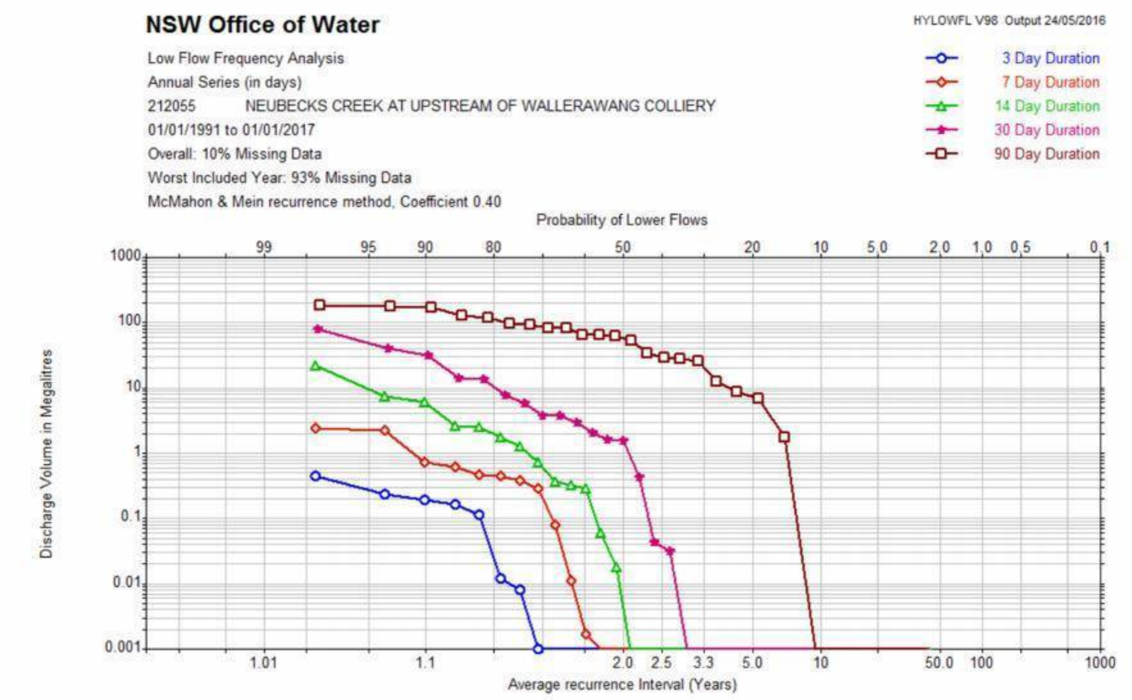


Figure 5-12 Low flow frequency analysis for Wangcol Creek gauge (DPI-Water, 2016c)

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).

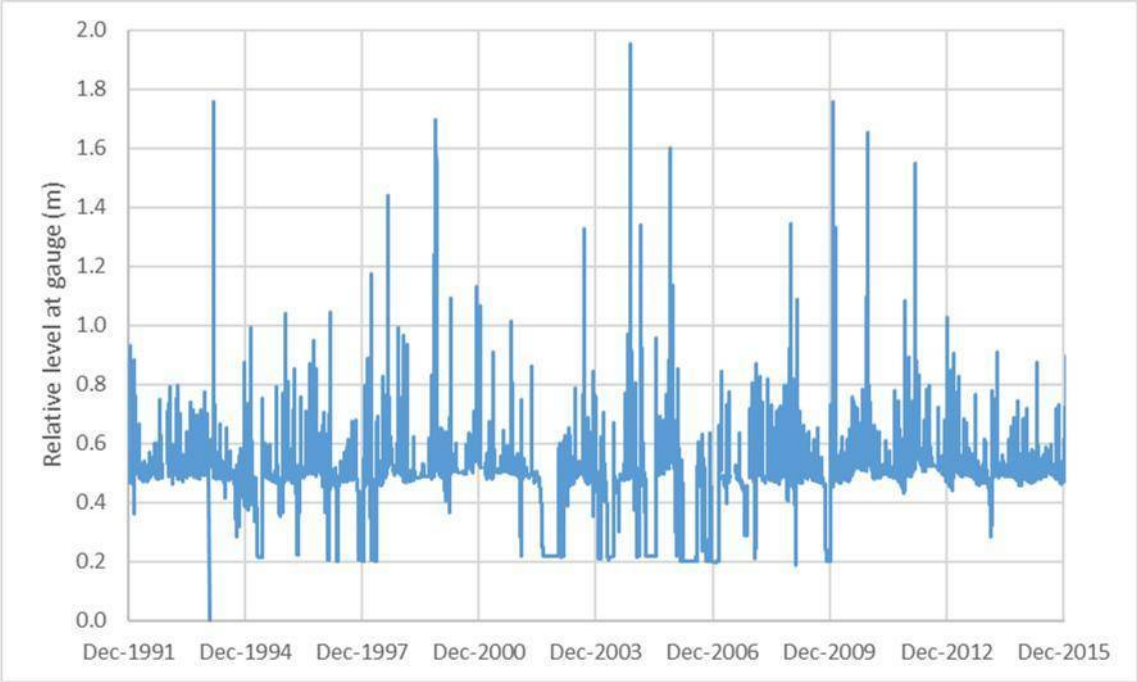


Figure 5-13 Flow level recorded at Wangcol Creek gauge

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.

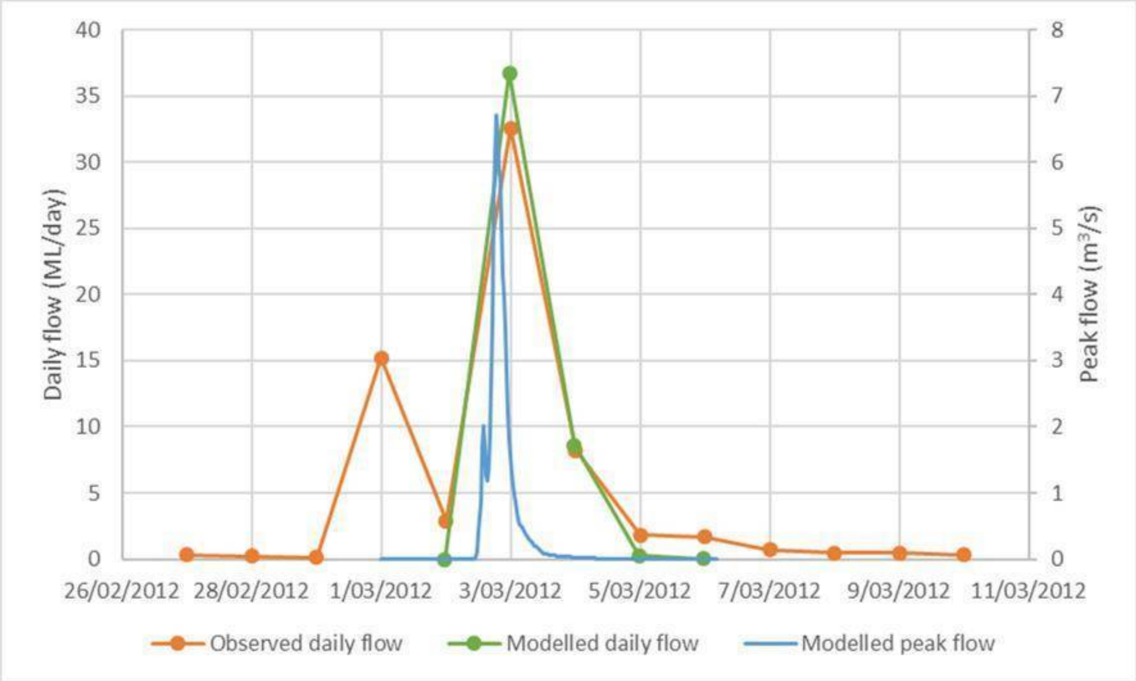


Figure 5-14 Hydrological model calibration results

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

<u>XPRAFTS modelling</u>

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.

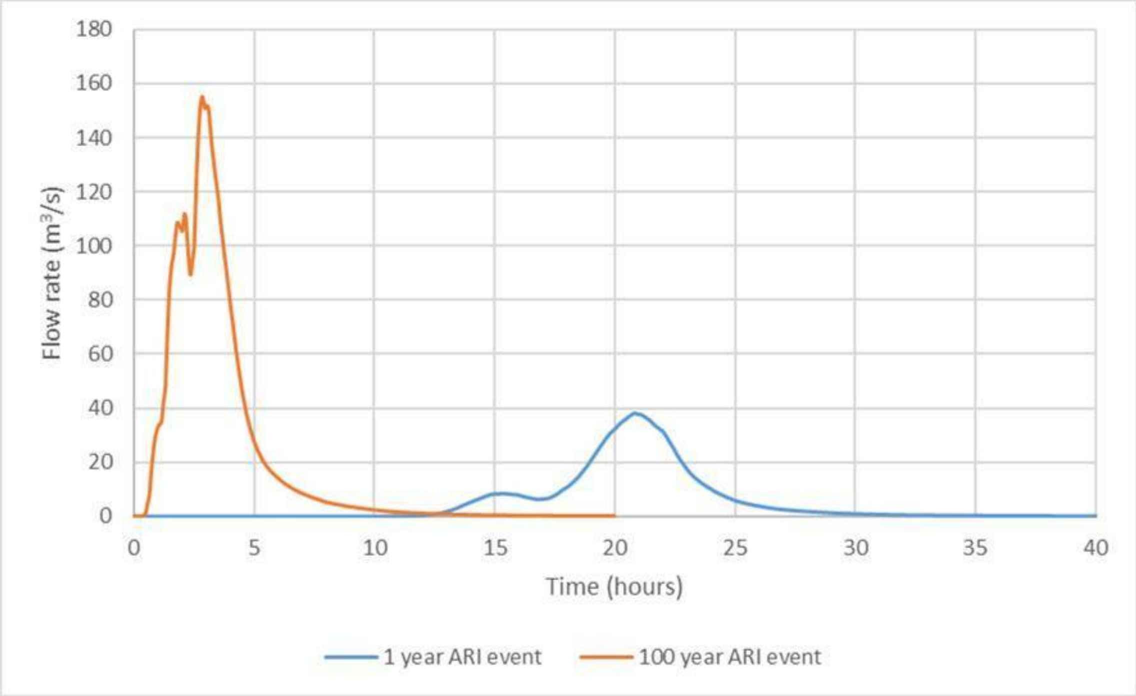


Figure 5-15 Hydrographs for peak 1 year and 100 year ARI events for Wangcol Creek under existing conditions

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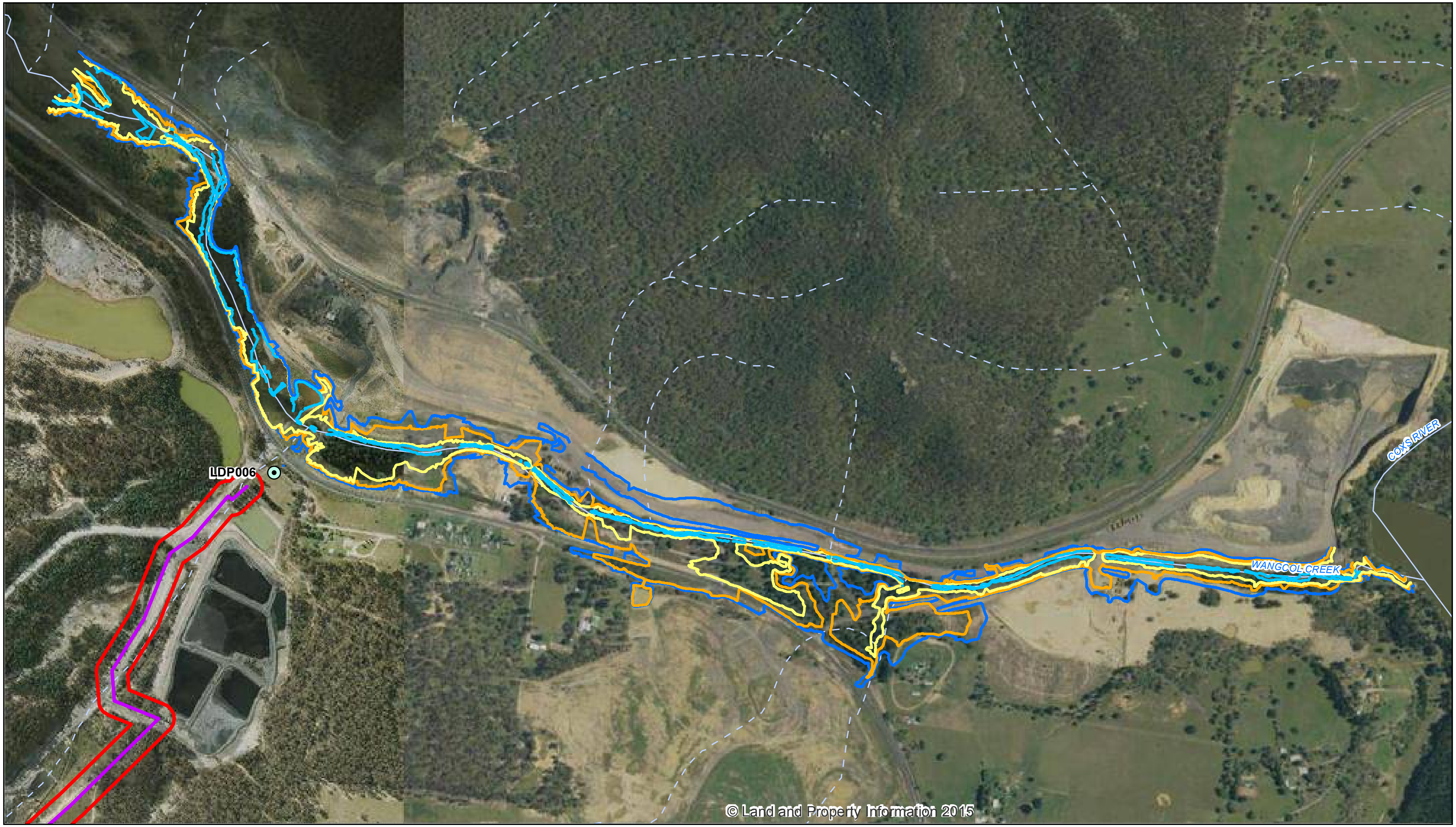
Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

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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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

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.

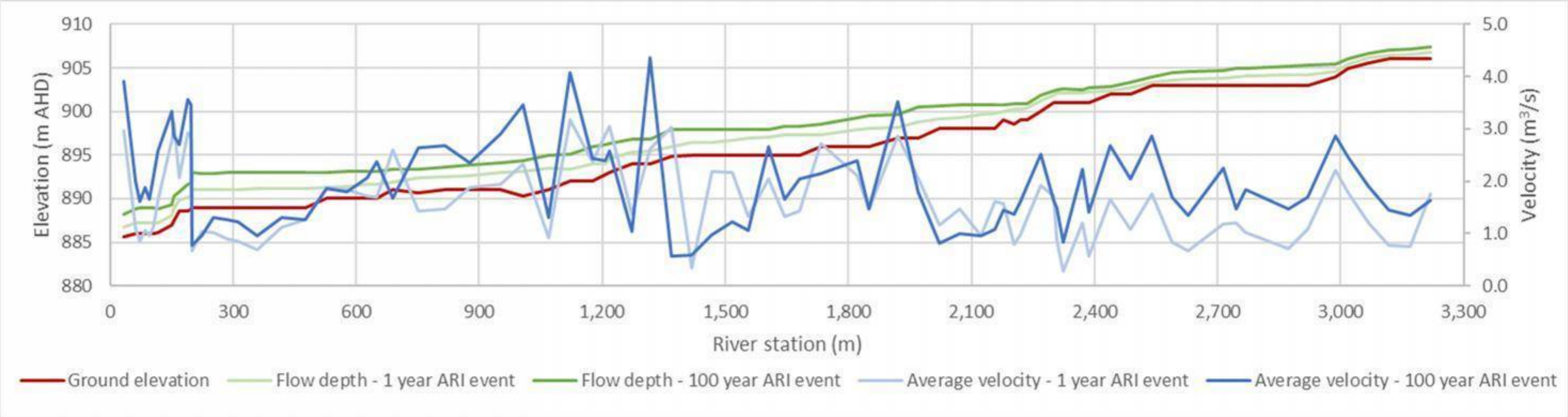


Figure 5-18 Water level and velocity results for existing Wangcol Creek for 1 year and 100 year ARI events

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.

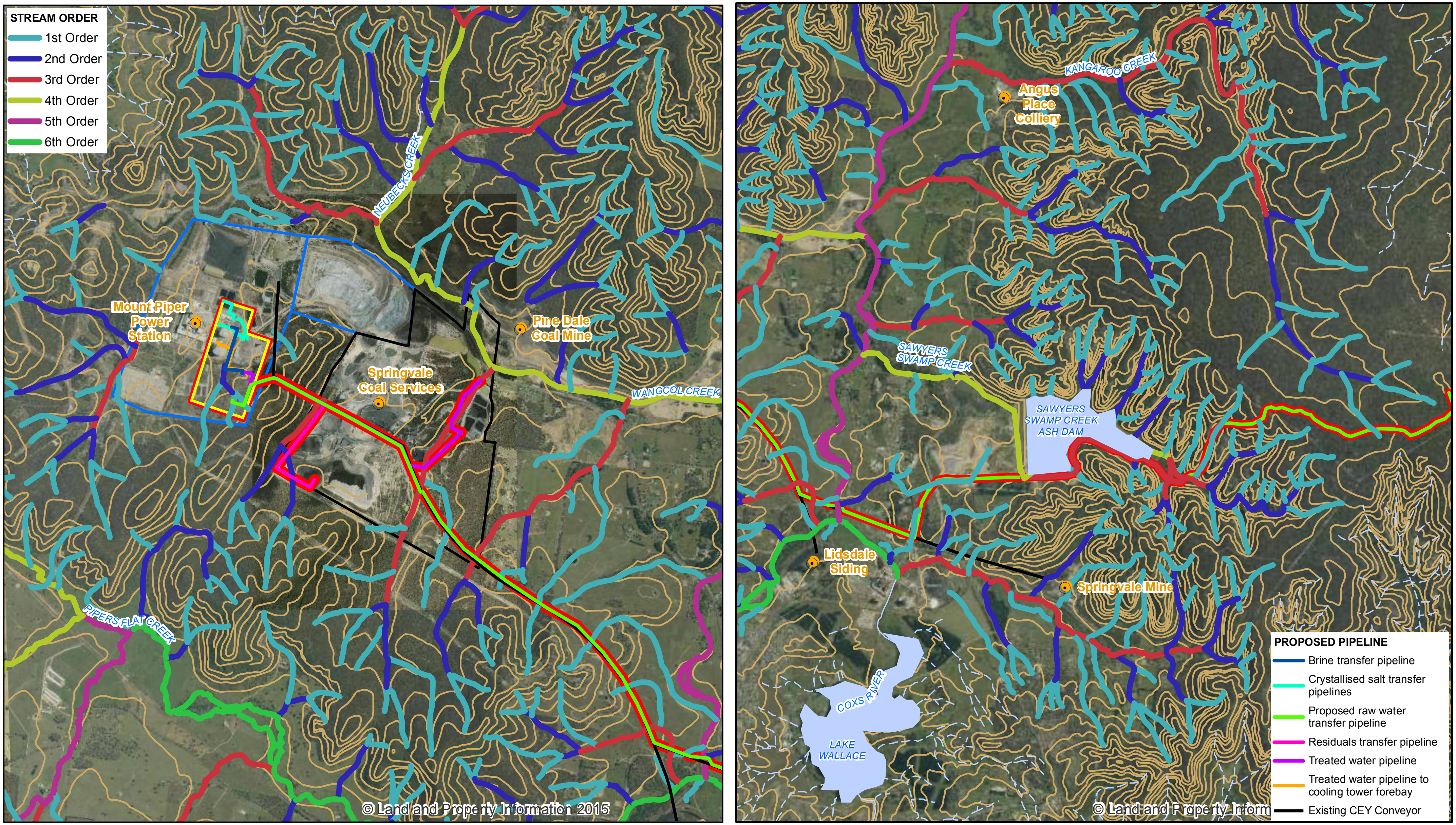
The crossing structure located directly downstream of LDP006 on Lamberts Gully and Castlereagh Highway (structure 1) has the largest determined capacity of all structures considered. This is typical of the significance of the Lamberts Gully catchment contributing to the highway at this location and the 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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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

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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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

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