Springvale Water Treatment Project

State Signi icant Development 7592
Environmental Impact Statement
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EnergyAustralia

Centennial Coal

6. Existing environment – aquatic ecology

6.1 Literature review

6.1.1 Monitoring Programs

Aquatic ecology surveys were not undertaken for the purpose of this Project given the availability of long-term aquatic ecology monitoring programs of sites relevant to the proposed action. As part of the Centennial West aquatic ecology monitoring program, MPR have undertaken biannual baseline monitoring of the waterways in the Impact Assessment Area between 2010 and 2016. Data and observations collected at relevant sites in Sawyers Swamp Creek, Wangcol Creek and Coxs River between 2013 and 2015 through this program have been used as the primary source for the establishment of existing aquatic ecology (MPR, 2013; 2014a; 2014b; 2015a; 2015b; 2016a,b,c). This information has been supplemented with data collected by GHD in a survey of macroinvertebrates and fish as part of the Neubeck Project (GHD, 2014b). Baseline data for Neubecks Creek has been sourced from MPR surveys conducted in 2011 (MPR, 2012a) because upstream sites were dry during 2013 and 2014 surveys conducted by GHD.

No threatened or protected invertebrate or vertebrate aquatic species were caught or observed during the surveys undertaken by MPR and GHD (MPR, 2012a; 2013; 2014a,b; 2015a,b,c; 2016a,b; GHD, 2014b).

Macroinvertebrate data was available from the WaterNSW for two sites on the Coxs River downstream of the PAA that has been monitored on an annual basis between 2001 and 2015. Data collected from relevant sites between 2012 and 2015 have been included in this assessment as representative of regional aquatic ecology health.

A summary of instream monitoring sites used as part of this assessment are provided in Table 6-1. The location of instream monitoring sites in relation to the PAA is shown in Figure 4-1 and Figure 4-2.

Table 6-1 Summary of instream monitoring sites used for this assessment

Waterway	Site code	MGA Zone 56		Site classification	Site description and rationale for classification	Current influences from licensed discharge points**	Data range
		Easting	Northing				
Neubecks Creek	NCup	226192	6306720	Background	Located in the upper reaches of Neubecks Creek.	No discharges to creek.	spring 2011, spring 2013, autumn and spring 2014*
	NC1	225982	6307221	Background	Located in the mid reaches of Neubecks Creek.	No discharges to creek.	spring 2011, spring 2013, autumn and spring 2014*
	NCdn	225480	6305993	Background	Located in the lower reaches of Neubecks Creek, approximately 200 m upstream of the confluence with Wangcol Creek. Provides background data for site that will not be impacted by the Project.	No discharges to creek.	2012-2014 (biannually - autumn and spring)
Wangcol Creek	WCup	224733	6305941	Baseline	Located upstream of the confluence of Neubecks Creek. Provides baseline data for site that will not be impacted by the Project.	LDP1 (MPPS) infrequent discharges to Wangcol Creek 0.4 km upstream.	2013-2015 (biannually - autumn and spring)
	WC1	226076	6305175	Baseline	Located approximately 700 m upstream of LDP006 (Springvale Coal Services site). Provides baseline data for site that will not be impacted by the Project.	LDP1 (MPPS) infrequent discharges to Wangcol Creek 2.6 km upstream.	2013-2015 (biannually - autumn and spring)
	WC2	226732	6304547	Baseline	Located approximately 350 m downstream of LDP006 (Springvale Coal Services site). Provides baseline data for site that may be impacted by the Project.	LDP1 (MPPS) infrequent discharges to Wangcol Creek 3.9 km upstream. LDP006 (SCSS) continual discharges to Wangcol Creek 0.5 km upstream.	2013-2015 (biannually - autumn and spring)

Waterway	Site code	MGA Zone 56		Site classification	Site description and rationale for classification	Current influences from licensed discharge points**	Data range
		Easting	Northing				
Wangcol Creek	WC3	228414	6304303	Baseline	Located approximately 250 m upstream of Coxs River. Provides baseline data for site that may be impacted by the Project.	LDP1 (MPPS) infrequent discharges to Wangcol Creek 4.6 km upstream. LDP006 (SCSS) daily discharges to Wangcol Creek 2.6 km upstream.	2013-2015 (biannually - autumn and spring)
Coxs River	CR1	229809	6307337	Background	Located upstream of confluence with Wangcol Creek and LDP001 (Angus Place Colliery). Provides background data for site that will not be impacted by the Project.	Currently no discharges to creek.	2013-2015 (biannually - autumn and spring)
	CR2	228691	6305324	Baseline	Located approximately 1 km downstream of LDP002 (Angus Place Colliery) but upstream of confluence with Wangcol Creek. Provides background data for site that will not be impacted by the Project.	LDP001 (Angus Place Colliery) daily discharges to Kangaroo Creek 2.6 km upstream. LDP002 (Angus Place Colliery) infrequent discharges to Coxs River 1.5 km upstream	2013-2015 (biannually - autumn and spring)
	CR3	228542	6303509	Baseline	Located approximately 1 km downstream of Wangcol Creek confluence. Provides background data for the Coxs River prior to the Project	LDP001 (Angus Place Colliery) daily discharges to Kangaroo Creek 4.7 km upstream. LDP002 (Angus Place Colliery) infrequent discharges to Coxs River 3.6 km upstream LDP006 (SCSS) daily discharges to Wangcol Creek	2013-2015 (biannually – autumn and spring)

Waterway	Site code	MGA Zone 56		Site classification	Site description and rationale for classification	Current influences from licensed discharge points**	Data range
		Easting	Northing				
						3.1 km upstream. LDP001 (MPPS) infrequent discharges to Wangcol Creek 5.6 km upstream	
	CR4	228348	6302775	Baseline	Located approximately 200 m downstream from Sawyers Swamp Creek confluence and approximately 2 km downstream from Wangcol Creek. Provides background data for site that may be impacted by the Project.	LDP009 (Springvale Mine) daily discharges to Sawyers Swamp Creek 3.1 km upstream) LDP001 (Angus Place Colliery) daily discharges to Kangaroo Creek 5.6 km upstream. LDP002 (Angus Place Colliery) infrequent discharges to Coxs River 4.5 km upstream LDP006 (SCSS) daily discharges to Wangcol Creek 4.0 km upstream. LDP1 (MPPS) infrequent discharges to Wangcol Creek 6.5 km upstream	2013-2015 (biannually - autumn and spring)

Waterway	Site code	MGA Zone 56		Site classification	Site description and rationale for classification	Current influences from licensed discharge points**	Data range
		Easting	Northing				
Coxs River	CR5	228529	6300752	Baseline	Located approximately 400 m downstream from Pipers Flat Creek confluence. Provides background data for site that may be impacted by the Project.	LDP009 (Springvale Mine) daily discharges to Sawyers Swamp Creek 5.7 km upstream) LDP001 (Angus Place Colliery) daily discharges to Kangaroo Creek 8.2 km upstream. LDP002 (Angus Place Colliery) infrequent discharges to Coxs River 7.1 km upstream LDP006 (SCSS) daily discharges to Wangcol Creek 6.6 km upstream. LDP007 (SCSS) infrequent discharges to Pipers Flat Creek 1.0 km downstream LDP1 (MPPS) infrequent discharges to Wangcol Creek 9.1 km upstream LDP004 (Lidsdale Siding) infrequent discharges to Pipers Flat Creek 0.6 km upstream	2013-2015 (biannually - autumn and spring)

Waterway	Site code	MGA Zone 56		Site classification	Site description and rationale for classification	Current influences from licensed discharge points**	Data range
		Easting	Northing				
Coxs River	CR6	228533	6297741	Baseline	Located downstream from Lake Wallace	LDP009 (Springvale Mine) daily discharges to Sawyers Swamp Creek 9.7 km upstream) LDP001 (Angus Place Colliery) daily discharges to Kangaroo Creek 12.2 km upstream. LDP002 (Angus Place Colliery) infrequent discharges to Coxs River 11.1 km upstream LDP006 (SCSS) daily discharges to Wangcol Creek 10.6 km upstream. LDP007 (SCSS) infrequent discharges to Pipers Flat Creek 5.0 km downstream LDP1 (MPPS) infrequent discharges to Wangcol Creek 13.1 km upstream LDP004 (Lidsdale Siding) infrequent discharges to Pipers Flat Creek 4.6 km upstream	2013-2015 (biannually - autumn and spring)
Sawyers Swamp Creek	SSWdn	232266	6301445	Background	Located upstream from known discharges into Sawyers Swamp Creek.	Currently no discharges to creek.	Autumn 2013
	SSCup	231939	6301659	Background	Located upstream from known discharges into Sawyers Swamp Creek.	Currently no discharges to creek.	Autumn 2014

Waterway	Site code	MGA Zone 56		Site classification	Site description and rationale for classification	Current influences from licensed discharge points**	Data range
		Easting	Northing				
	DP9dn	229606	6302260	Baseline	Located downstream from LDP009. Currently receives discharge which will cease as part of this Project.	LDP009 (Springvale Mine) daily discharges to Sawyers Swamp Creek directly upstream.	2013-2015 (biannually - autumn and spring)
Regional – Coxs River	MMP37	233006	6284088	Baseline - regional	Located downstream of Lake Lyell which regulates water release. Downstream of all regional projects (see Section 3.6)	LDP009 (Springvale Mine) daily discharges to Sawyers Swamp Creek 34.5 km upstream) LDP001 (Angus Place Colliery) daily discharges to Kangaroo Creek 37 km upstream. LDP002 (Angus Place Colliery) infrequent discharges to Coxs River 35.9 km upstream LDP006 (SCSS) daily discharges to Wangcol Creek 35.4 km upstream. LDP007 (SCSS) infrequent discharges to Pipers Flat Creek 29.8 km downstream LDP1 (MPPS) infrequent discharges to Wangcol Creek 37.9 km upstream LDP004 (Lidsdale Siding) infrequent discharges to Pipers Flat Creek 29.4 km upstream	Spring 2012, Spring 2013, Spring 2014, Spring 2015

Waterway	Site code	MGA Zone 56		Site classification	Site description and rationale for classification	Current influences from licensed discharge points**	Data range
		Easting	Northing				
	E086	245976	6248675	Baseline - regional	Located just upstream of Warragamba Dam. Downstream of all regional projects (see Section 3.6)	LDP009 (Springvale Mine) daily discharges to Sawyers Swamp Creek 116.5 km upstream) LDP001 (Angus Place Colliery) daily discharges to Kangaroo Creek 119 km upstream. LDP002 (Angus Place Colliery) infrequent discharges to Coxs River 117.9 km upstream LDP006 (SCSS) daily discharges to Wangcol Creek 117.4 km upstream. LDP007 (SCSS) infrequent discharges to Pipers Flat Creek 111.8 km downstream LDP1 (MPPS) infrequent discharges to Wangcol Creek 119.9 km upstream LDP004 (Lidsdale Siding) infrequent discharges to Pipers Flat Creek ~111.4 km upstream	Spring 2012, Spring 2013, Spring 2014, Spring 2015

* indicates habitat assessment only as site was dry during survey event.

** does not include Pine Dale Coal Mine LDPs as these points are no longer operational.

6.1.2 Catchment condition

Hawkesbury-Nepean health strategy - 2010

A Hawkesbury-Nepean health strategy on the catchment was delivered in 2010. The strategy acknowledged that the rivers and riparian lands of the Hawkesbury-Nepean are experiencing significant pressure from:

- urban and rural residential development.
- extraction of water for metropolitan water supply and agriculture.
- nutrient input from sewage treatment plants.
- on-site sewage systems and run-off from agricultural and urban areas.
- clearing of riparian lands.

These pressures result in altered aquatic habitat that generally supports less diversity.

The strategy acknowledged that the quality of the water flowing from these catchments is critical to Sydney's drinking water and the health of the Hawkesbury-Nepean catchment. As part of the strategy, a broad range of programs were developed to maintain water quality throughout the catchments. These include licensing polluting premises such as Sewage Treatment Plants, Sustaining the Catchments Regional Plan, establishment of the Sydney Catchment Authority (now WaterNSW), National Parks and world heritage areas in the catchment, and setting water quality objectives.

Consistent water quality objectives have been considered as part of the Water Resources Impact Assessment (GHD, 2016) and this Project, for proposed discharge points.

Sydney Catchment Authority audit - 2013

The audit undertaken by then Sydney Catchment Authority (now WaterNSW) in 2013 identified the Coxs River as a priority sub-catchment. The audit identified that Mining comprises 0.2% of the surface of the catchment with the largest mining area (938 ha) in the Upper Coxs River sub-catchment concentrated around the power generation land uses. The audit reviewed EPL conditions and existing pollution reduction programs which indicated compliance of the period. The audit found that existing LDPs are a source of elevated concentrations of metals into the catchment.

In terms of groundwater environment within the Coxs river catchment, the audit considered that a moderate risk to GDEs was applicable to the Coxs River, Fractured Rock and Sydney Basin groundwater source with higher risks associated in areas of mining land use.

The audit generally concluded that the water quality during the audit period, and the long-term trends in water quality parameters, either in catchment streams or in storages did not indicate unusual changes or trends. The evidence available indicated that the raw water arising in Catchment is generally of good quality, which was regarded as a reflection of the effectiveness of relatively recent catchment management practices.

The audit predicted loads of total nitrogen and phosphorus at 57 tonnes/year and 8.3 tonnes/year, respectively, based on 2010 predictions. A decreasing trend of electrical conductivity from Upper Coxs River was determined during the audit period of approximately 27 µS/cm/year. These trends were also shown in total nitrogen and phosphorus concentrations per year.

The lower portion of Coxs River continues to have one of the highest percentage of native vegetation cover compared with other waterways within the catchment at greater than 90%.

However, the mid portion of Coxs River was identified as a high priority for riparian vegetation improvement.

Fish habitat within the mid and upper portions of the Coxs River were defined as low due to significant barriers to fish migration (online reservoirs). Works to improve fish passage are ongoing.

The audit assessed AUSRIVAS banding as a measure of macroinvertebrate community health. Based on data from 2001 to 2009, the Upper Coxs River sub-catchment had the highest percentage of sites (52.7%) in the severely impaired (Band C) or extremely impaired (Band D) condition (DECCW, 2010).

6.2 Aquatic habitat assessments

Descriptions of aquatic habitats in the IAA and reference waterways are provided below based on observations collected by GHD and MPR during aquatic ecology surveys undertaken in the vicinity of the Project (MPR, 2012; MPR, 2013; 2014a; 2014b; 2015a; 2015b; 2016a,b; GHD, 2014b).

6.2.1 Neubecks Creek

Neubecks Creek is approximately 4.5 km long, with its headwaters originating north of Blackmans Flat. The creek is located north-west of the PAA and joins Wangcol Creek, upstream of the proposed discharge point.

The headwaters of the creek are located within relatively undisturbed bushland. Neubecks Creek is likely to be ephemeral and dependent on rainfall to flow and some sites were dry during the survey periods. The lower reaches of Neubecks Creek have very limited riparian vegetation and included patches of blackberry and terrestrial grasses and sedges. Several unnamed drainage lines flow to Neubecks Creek.

Site NCup

Table 6-2 provides a summary of photographs showing upstream and downstream conditions at site NCup.

The site is a third order stream and has been classified as a Class 4 fish habitat. Site NCup is located in the headwaters of Neubecks Creek.

During the 2013 and the 2014 surveys (GHD, 2014b), the site was dry. The channel is small and undefined and it is likely this site only holds water during periods of rain. Large amounts of leaf litter were observed in the channel. Native open forest, including large snow gum (*Eucalyptus pauciflora*) surround the site.

Table 6-2 Representative photographs of site NCup

Site	September 2013	May 2014	October 2014
NCup facing upstream showing the dry undefined channel			

NCup facing downstream showing the dry undefined channel			

Site NC1

Table 6-3 provides a summary of photographs showing upstream and downstream conditions at site NC1.

The site is a fourth order stream and has been classified as a Class 4 fish habitat. Site NC1 is located 0.5 km downstream of site NCup. The channel is more defined compared to NCup. During the GHD (2014b) surveys this site was dry. A large amount of leaf litter was observed in the channel. Surrounding the site was native open forest, including snow gums.

Table 6-3 Representative photographs of site NC1

Site	October 2013	May 2014	October 2014
NC1 facing upstream showing the dry channel			
NC1 facing downstream showing the dry channel			

Site NCdn

Table 6-4 provides a summary of photographs showing upstream and downstream conditions at site NCdn during 2013 and 2014.

The site is a fourth order stream and has been classified as a Class 3 fish habitat due to the semi-permanent pools observed and the presence of hydrophilic plants including sedges. This site is located immediately upstream of the haul road and the confluence of Neubecks Creek and Wangcol Creek. NCdn is not currently influenced by any discharges. The surrounding land has been cleared and likely used historically for grazing. There is a culvert which allows flow under the haul road. It is likely that part of the channel through the culvert remains dry except following rainfall.

During the 2013 and 2014 GHD (2014b) surveys the site was dominated by pool habitat and slight surface flow was observed in the earlier surveys. There was no flow observed during the spring 2014 survey. This site has low banks (0.2 m high) and a narrow channel, ranging between 0.5 m and 2 m wide. Instream habitat was dominated by overhanging bank vegetation, detritus, small woody debris and macrophytes. The creek substrate was comprised entirely of silt/clay. The riparian vegetation was limited to pasture grasses, sedges (*Juncus usitatus* and *Eleocharis* sp.), exotic blackberry and scattered willow trees.

Table 6-4 Representative photographs of site NCdn

Site	October 2013	May 2014	October 2014
NCdn facing upstream			
NCdn facing downstream toward the haul road			

6.2.1 Wangcol Creek

Wangcol Creek is approximately 6 km long. Its headwaters are in the far south-west extent of Ben Bullen State Forest, approximately 2 km west of the PAA. Flow rate in Wangcol Creek above this confluence contains a daily volumetric contribution from LDP006 at SCSS and large rainfall event based discharges from LDP1 at MPPS. The Wangcol Creek valley below the confluence with Neubecks Creek has been subject to extensive disturbance related to the mining industry. The creek has been realigned several times to facilitate historical and nearby mining activities and the present channel from LDP006 at SCSS to the confluence with Coxs River is a realignment of the original creek (Cardno, 2013a).

Aquatic habitat in Wangcol Creek is limited and dominated by pools. Substrate comprises fine silt sediments. Riparian vegetation is sparse and mainly consists of terrestrial grasses and sedges along with exotic pines and willows. Bank stability is generally low, due to the limited riparian zone in some parts, and in-situ bank materials.

Site WCup

Table 6-5 provides a summary of photographs showing upstream and downstream conditions at WCup.

The site is a third order stream and has been classified as a Class 3 fish habitat. This site is located upstream of the confluence with Neubecks Creek at the Castlereagh Highway. MPPS is located approximately 300 m upstream of the site, along with LDP1 which is located 0.4 km upstream. A triple cell box culvert allows water to flow under the highway, but is typical drowned by still water within the creek.

During the GHD (2014b) surveys the site was dominated by pool habitat. The banks were relatively low (0.3 m high) and unstable, with artificial substrate and grasses providing limited stabilisation. The width of Wangcol Creek at this site varied between 1.5 m and 3.5 m, with depths of up to 1 m. The substrate comprised fine sediment (silt/clay) with some sand, gravel and pebble. Instream habitat was limited, and consisted of stands of *Typha* sp. and other trailing bank vegetation.

The riparian vegetation was limited to pasture grasses, with no shrubs or trees in the reach of the site. However, some large trees were observed immediately upstream of the site. Emergent macrophytes were present, including *Typha* sp. and *Juncus usitatus.*

Table 6-5 Representative photographs of site WCup

Site	October 2013	May 2014	October 2014
WCup facing upstream towards the highway bridge			
WCup facing downstream beyond the highway bridge			

Site WC1

Table 6-6 provides a summary of photographs showing upstream and downstream conditions at WC1.

The site is a fourth order stream and has been classified as a Class 3 fish habitat. This site is located approximately 50 m upstream of a small causeway which may restrict fish passage during periods of low flow. This site can be influenced by discharges from LDP1 at MPPS (when they occur), which is located 2.6 km upstream. It is also influenced by flows from Neubecks Creek and which flows to Wangcol Creek approximately 1 km upstream of WC1.

During the GHD (2014b) surveys the site was dominated by pool habitat, with slight surface flow observed. The banks were relatively low (0.3 m) and were vegetated with grass and sedge species. The width of the creek at this site was between 1 m and 4 m. The substrate comprised mainly fine sediment (silt/clay) with some sand and gravel. Instream habitat comprised overhanging grasses, macrophytes and some sticks and detritus. A small stand of *Typha* sp. was observed.

The riparian vegetation was limited to pasture grasses and sedges, with limited shrubs or trees in the reach of the site. Emergent macrophytes were present, including *Typha* sp. and *Juncus usitatus.* Green algae belonging to Charophyta were also observed instream.

Table 6-6 Representative photographs of site WC1

Site	September 2013	May 2014	October 2014
WC1 facing upstream			
WC1 facing downstream			

Site WC2

Table 6-7 provides a summary of photographs showing upstream and downstream conditions at WC2.

The site is a fourth order stream and has been classified as a Class 3 fish habitat. Site WC2 is located adjacent to the Pine Dale Coal Mine. This site can be influenced by event based discharges from LDP1 at MPPS, located 3.87 km upstream, and is influenced by daily contributions from LDP006 at SCSS, located immediately upstream (0.5 km).

During the GHD (2014b) surveys the site was dominated by pool habitat, with slight surface flow observed during the surveys. The banks appeared to be artificially stabilised with concrete, which was also present in the stream bed. The banks were approximately 2 m high and the width of the site at this point varied between 0.5 m and 3 m. There was dominant iron precipitate at this site as shown in Table 6-7, likely caused by the discharge of mine affected water upstream of the site. Instream habitat was limited and comprised mainly overhanging bank vegetation. The substrate was comprised mainly silt/clay with some sand, gravel, pebble, cobble and artificial concrete.

The riparian vegetation was considered poor, and consisted of a few tall trees (exotic pine), some shrubs and mostly grasses. There was some *Juncus usitatus* present on both banks. Large cleared gravel areas associated with Pine Dale Coal Mine operations existed beyond the riparian zone.

Table 6-7 Representative photographs of site WC2

Site	October 2013	May 2014	October 2014
WC2 facing upstream showing artificial substrate			
WC2 facing downstream			
WC2 showing abundant iron precipitate			

Site WC3

Table 6-8 provides a summary of photographs showing upstream and downstream conditions at WC3.

The site is a fourth order stream and has been classified as a Class 3 fish habitat. Site WC3 is located immediately upstream of the confluence with Coxs River. At this point the river consists of a large pool (200 m by 400 m). This site is influenced by all operational based discharges within the catchment.

During the GHD (2014b) surveys the site was dominated by pool habitat, with slight surface flow observed during the spring 2013 and autumn 2014 surveys. No flow was observed during the spring 2014 survey with large isolated pools and rocky bars upstream observed to be dry. Immediately downstream of the site banks had been stabilised with concrete. At the site the banks were approximately 2 m high and the channel was relatively straight and varied between 1.5 m and 3.5 m wide. The instream habitat comprised detritus and small woody debris, as well as some overhanging bank vegetation. The substrate was dominated by silt/clay, with some sand.

The riparian vegetation was limited to pasture grasses on the left bank and some exotic pine trees on the right bank and the sedge *Juncus usitatus* was present both.

Table 6-8 Representative photographs of site WC3

Site	September 2013	May 2014	October 2014
WC3 facing upstream			
WC3 facing downstream			

6.2.2 Coxs River

The Coxs River is a major tributary of the Hawkesbury-Nepean River system and is part of the Sydney drinking water catchment. The river extends for approximately 155 km. Land use in the upper part of the catchment is primarily grazing, forestry, power generation and coal mining. The river receives input from a number of LDPs in the upper reaches, including Angus Place Colliery, Springvale Coal Services site, Springvale Mine and Mt Piper Power Station.

Aquatic habitat in the upper catchment is dominated by pool habitat and bed and banks comprised smaller particle sized substrate. Generally, there is little riparian vegetation, likely leading to high erosion potential of stream banks. Further down in the catchment the Coxs River widens and deepens with increased flow including some riffle sections.

Site CR1

Table 6-9 provides a summary of photographs showing upstream and downstream conditions at site CR1.

The site is a fifth order stream and is located upstream from any local LDPs. The land surrounding the site is used for grazing. Surface flow was observed during 2015 surveys (MPR, 2016). Stream width averaged 1.8 m with maximum depths of 1 m recorded.

During the 2015 surveys (MPR, 2016) the substrate comprised mainly fine sediment with some pebbles, gravel and sand. Detritus, submerged and emergent macrophytes (e.g. Jointed rush (*Juncus articulatus*), trailing bank vegetation and undercut banks provided instream habitat. Filamentous algae were also observed in more recent monitoring rounds.

Table 6-9 Representative photographs of site CR1

Site	May 2015	November 2015
CR1 facing upstream		
CR1 facing downstream		

Site CR2

Table 6-10 provides a summary of photographs showing upstream and downstream conditions at site CR2.

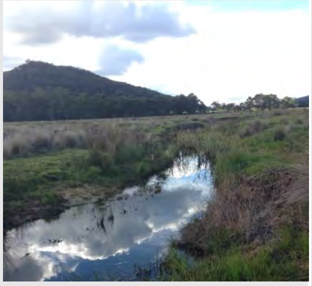
The Coxs River at CR2 is a fifth order stream and has been classified as a Class 2 fish habitat. This site is located immediately upstream of the Mt Piper Haul Road. A twin cell circular culvert allows the creek to flow under the haul road. This site is located upstream of the confluence with Wangcol Creek. Kangaroo Creek discharges to the Coxs River upstream of this site, which also receives discharge from LDP002 at Angus Place Colliery. The land surrounding the site is used for grazing and a small riffle zone immediately upstream of the site serves as a cattle crossing.

The site was dominated by pool habitat, with a small riffle upstream. Some surface flow was observed during the 2013 and 2014 surveys (GHD, 2014b). The banks were low (0.3 m high) and were eroded in sections. The stream width varied between 1 m and 4 m, and was relatively deep for its size (up to 1.5 m deep).

The substrate comprised mainly fine sediment with some gravel and sand. Detritus, submerged and emergent macrophytes, trailing bank vegetation and undercut banks provided instream habitat.

The riparian vegetation of the site was limited to pasture grasses and exotic blackberry with no tree or shrub corridor present. This lack of bank stabilisation has resulted in a high erosional potential for the stream banks of this site. Emergent macrophytes, including Cumbungi (*Typha* sp.), *Eleocharis* sp. and common rush (*Juncus usitatus)* were abundant along the bank. Submerged curly-leaf pondweed (*Potamogeton crispus*) beds were present during all surveys (GHD, 2014b) and filamentous algae was abundant during the 2015 surveys (MPR, 2016).

Table 6-10 Representative photographs of site CR2

Site	September 2013	May 2014	October 2014
CR2 facing upstream			
CR2 facing downstream towards the haul road			

Site CR3

Table 6-11 provides a summary of photographs showing upstream and downstream conditions at site CR3.

The Coxs River at CR3 is a fifth order stream and has been classified as a Class 2 fish habitat. MPR sampled CR3 between 2014 and 2015. The site is located between the inputs of Wangcol Creek and Sawyers Swamp Creek. Instream conditions at this monitoring location are influenced by the former Commonwealth Open Cut mine which includes a large waterbody spanning 320 metres in length and reaches 150 metres wide. Generally, there are no restrictions to fish passage at this site with sections of incised waterway and broad open pools. However, the Lake Wallace and Lake Lyell and other regulated water bodies further downstream provide a barrier to fish passage through the wider catchment.

Surveys undertaken by MPR indicated that the monitoring site has a consistent condition during both autumn and spring monitoring rounds. MPR indicated that water is clear and flowing through site length with a maximum depth to 0.7 m and average depth 0.2 m. The types of edge habitat that observed by MPR during monitoring included trailing bank vegetation, macrophytes (rush (*Baumea rubiginosa*), jointed rush and cumbungi*), charophytes* and detritus*.*

Sediment was comprised of gravel and sand, with some boulders and cobbles and some fine silt accumulated on the surface. Overburden fill makes up the channel and banks at this site.

Table 6-11 Representative photographs of site CR3 (MPR, 2014b, 2015a, b, d 2016b, c)

Site	Autumn 2014	Spring 2014	Spring 2015
CR3 facing upstream			
CR3 facing downstream			

Site CR4

Table 6-12 provides a summary of photographs showing upstream and downstream conditions at site CR4.

The Coxs River at CR4 is a fifth order stream and has been classified as a Class 2 fish habitat. This site is located at the end of Maddox Lane where there is a small causeway providing a crossing over the river. The surrounding land has been cleared and there are residential properties along Maddox Lane. This site is also influenced by a number of LDPs located upstream.

During the surveys completed by GHD (2014b) the site was dominated by run and pool habitat. The banks were relatively low (1 m high), and unstable, with exotic blackberry and grasses providing stabilisation. Stream width varied between 1.5 m and 5 m and was relatively deep in sections (greater than 1 m). The substrate comprised mainly fine sediment (silt/clay) with some sand and gravel. Detritus, emergent macrophytes and trailing bank vegetation provided instream habitat. Stands of common reed (*Phragmites australis*) and common rush (*Juncus usitatus*) were observed instream and likely provided habitat.

The riparian vegetation of the site was limited to pasture grasses, exotic blackberry with just a few small shrubs and trees observed on the bank, however there was no riparian corridor present. This lack of bank stabilisation has resulted in a high erosional potential for the stream banks of this site. Emergent macrophytes were observed during the spring 2013 and 2014 survey, including common rush (*Juncus usitatus*), umbrella sedge (*Cyperus eragrostis*), jointleaf rush (*Juncus articulates*), common reed (*Phragmites australis*) and soft twig sedge (*Baumea rubiginosa)* were abundant along the bank. The green algae Charophyta were also observed instream at this site. Filamentous algae were abundant during the 2015 surveys (MPR 2016).

Table 6-12 Representative photographs of site CR4

Site	September 2013	May 2014	October 2014
CR4 facing upstream			
CR4 facing downstream towards the Castlereagh Highway			

Site CR5

Table 6-13 provides a summary of photographs showing upstream and downstream conditions at site CR5.

Site CR5 is located on the Coxs River downstream of the Main Street Bridge. The Wallerawang Power Station is located upstream of the site and downstream of the confluence of Wangcol and Pipers Flat Creeks (Cardno, 2013a).

The site is a fifth order stream and has been classified as a Class 2 fish habitat. The surrounding land has been largely cleared and is used for grazing. This site is also influenced by a number of LDPs located upstream on Wangcol Creek, Pipers Flat Creek and Coxs River.

During the GHD (2014b) surveys the site was dominated by pool habitat, with a small riffle upstream towards the Main Street bridge. The stream had an average width of 5 m and bank height of 1.5 m. The banks were steep, eroding and undercut in places, with exotic blackberry and grasses providing stabilisation.

The substrate comprised mainly fine sediment with a mixture of boulders, cobble and rock fragments along the western side of the creek. Detritus, submerged and emergent macrophytes, trailing bank vegetation and undercut banks provided instream habitat.

Stands of emergent macrophytes, including Cumbungi (*Typha* sp.), *Eleocharis* sp. and River Clubrush *(Schoenoplectus validus)* were observed during the autumn 2014 surveys. Changes in aquatic vegetation were observed during the spring 2014 surveys, with only small stands of cumbungi observed instream with isolated common rush on the banks. Submerged curly-leaf pondweed (*Potamogeton crispus*) beds and filamentous algae were observed during the 2014 surveys. Small clumps of filamentous algae were observed during the 2015 surveys (MPR, 2016).

The riparian vegetation of the site consisted of eucalypt trees with isolated willows and blackberry dominating the eastern edge of the downstream section of the site. Exotic grasses dominated the majority of the bank with isolated patches of common rush (*Juncus usitatus)*.

Table 6-13 Representative photographs of site CR5

Site	May 2014	November 2015
CR5 facing upstream towards Main Street bridge		
CR5 facing downstream		

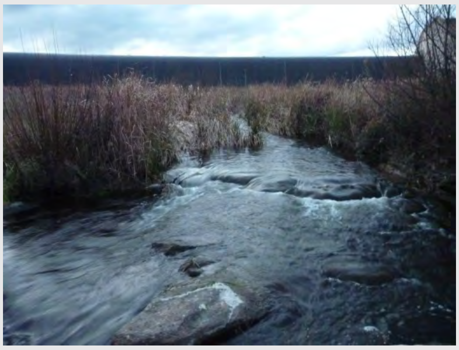
Site CR6

Table 6-14 provides a summary of photographs showing upstream and downstream conditions at site CR6.

Site CR6 is located on the Coxs River downstream of Lake Wallace. The site is a fifth order stream. The surrounding land has been largely cleared and is used for grazing. This site is also indirectly influenced by a number of LDPs located upstream on Wangcol Creek, Sawyers Swamp Creek and Pipers Flat Creek and Coxs River.

MPR (2016) reported that the substrate at this site dominated by bedrock and boulders, with a smaller proportion of cobbles and sand. Both riffle and pool habitat was observed at this site. The banks supported trailing vegetation/grasses, providing stabilisation. Detritus and the emergent macrophyte Water Cress (*Nasturtium officinale*) and undercut banks provided instream habitat. Abundant filamentous algae were observed during the 2015 surveys (MPR, 2016), smothering rocky surfaces.

Table 6-14 Representative photographs of site CR6

Site	May 2015	November 2015
CR6 facing upstream		
CR6 facing downstream		

6.2.1 Sawyers Swamp Creek

Sites SSWdn/SSCup

Table 6-15 provides a summary of photographs showing upstream and downstream conditions at sites SSWdn and SSCup. These sites were selected to provide an understanding of waterway condition upstream from LDP009 on Sawyers Swamp Creek. Site SSWdn was originally selected as a background site by MPR (2013a) but found to be dry in subsequent sampling events. Site SSCup was selected as a replacement background site but was also dry during the majority of sampling events.

Site SSWdn is located on a first order stream with maximum depths of 0.6 m and average depths of 0.2 m (MPR (2013a). Channel substrate was dominated by sand with some boulder outcrops. Orange precipitate blanketed much of the reach and filamentous algae was abundant. No macrophytes were observed.

Site SSCup was surveyed in 2014 by MPR (MPR, 2014a). The reach surveyed was described as being artificial – composed of a series of pools with no flow. Maximum stream width was 2 m and averaged 0.8 m. Maximum depth was 0.5 m, with an average of 0.2 m. Macrophytes present included Jointed Rush and Swamp Clubrush. Substrate was composed of muddy sand and gravel/pebble. Small amounts of filamentous algae were observed.

Table 6-15 Representative photographs of sites SSWdn/SSCup

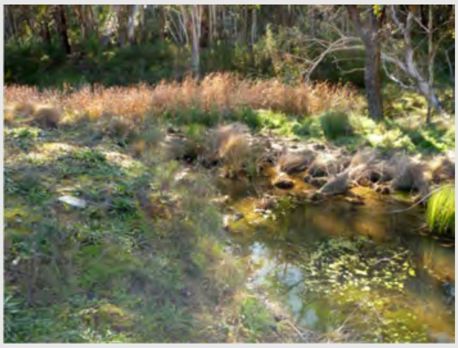
Site	May 2013 (SSWdn)	May 2014 (SScup)
SSWdn/SSCup facing upstream		
SSWdn/SSCup facing downstream		

Site DP9dn

Table 6-16 provides a summary of photographs showing upstream and downstream conditions at site DP9. This site provides an understanding of waterway condition downstream from LDP009 on Sawyers Swamp Creek.

Site DP9dn is located in a channel that runs through a former open cut mine overburden along the northern edge of the Sawyers Swamp valley floor, and consists of a broad and flat pool basin which leads into a straight Cumbungi filled channel. Maximum stream width reached 7 m and the average width was 1.5 m, the maximum depth reached 1 m, with an average depth of 0.5 m (MPR, 2013). Channel edges supporting dense stands of emergent spike and jointed rushes, grasses (*Carex sp*), Pampas grass (*Cortaderia sp*) and Cumbungi.

Table 6-16 Representative photographs of site DP9dn

Site	May 2014	November 2014
DP9dn facing upstream		
DP9dn facing downstream		

6.3 Riparian, channel and environmental inventory

The following sections summarise the RCE Inventory scores for sites selected for assessment. Mean scores recorded by MPR have been calculated across the three years of monitoring data (MPR, 2013; 2014a; 2014b; 2015a; 2015b; 2016a,b). The RCE scores for each of the sites selected for this assessment are provided in Table 6-17.

6.3.1 Neubecks Creek

Site NCdn, the only site on Neubecks Creek to hold water during the surveys, has received consistent RCE scores between the survey events. The mean RCE score of 30 (RCE% of 57) suggest that the site is subject to moderate degradation. Characteristics that contributed most to this site's score included the land use beyond the riparian zone comprising native and pasture/exotics, relatively stable banks with little undercutting, a deep channel and sediment comprising gravel with little sand or silt.

Sites upstream (NCup and NC1) were graded slightly higher, with RCE scores (based on 2011 data) of 38 (RCE% of 73) and 36 (RCE% of 69) due to increased aquatic vegetation being present and continuous riparian vegetation at these sites.

6.3.1 Wangcol Creek

Mean RCE scores for sites on Wangcol Creek varied along the creek – with the highest mean RCE score being 30 (RCE% of 58) at site WC3 and lowest scores being recorded at site WC with a mean of 25 (RCE% of 48). These scores indicate some level of degradation at all sites.

Site WCup has scored between 26.5 (autumn 2013) and 29.5 (autumn and spring 2014) with a mean(±SD) of 28.3±1.2. The relatively low score was attributed to incompleteness of the riparian strip, a lack of retention devices instream, a lack of riffle/pool sequences, a high abundance of macrophyte and filamentous algae growth and little or no organic detritus being present.

At site WC1 RCE scores varied between 23 (autumn 2013) and 29 (spring 2013) with a mean(±SD) of 26.3±2.4. This result suggests some level of degradation at this site. The low scores were attributed to incompleteness of the riparian strip, a lack of riffle/pool sequences, a lack of instream retention devices (e.g. logs and rocks) and minimal stream detritus.

At site WC2 RCE scores varied between 23 (autumn 2013 and spring 2014) and 29 (spring 2013) with a mean(±SD) of 25.1±2.3. This result suggests some level of degradation at this site. The low scores were attributed to incompleteness of the riparian strip, a lack of riffle/pool sequences, a lack of retention devices instream and minimal stream detritus.

At site WC3, RCE scores varied between 27 (autumn 2013) and 33 (spring 2013) and a mean(±SD) of 30±2.6. RCE scores for site WC3 were generally higher than other sites surveyed on Wangcol Creek. The increased scores (relative to other sites on Wangcol Creek) were attributed to lower macrophyte or algal coverage, and features of the bank and bed, including firm banks, undercutting on curves and presence of some retention devices in the streams (e.g. rocks and logs).

6.3.2 Coxs River

In the Coxs River RCE scores were found to be relatively consistent between survey events but variation was observed between sites, with scores consistently increasing with distance downstream. The highest mean RCE score was 36.4 (RCE% of 70), calculated for site CR6 and lowest mean score was recorded at site CR2 (21.2; RCE% of 40.7) - indicating moderate to poor condition.

At site CR1, RCE scores varied between 33.5 (autumn and spring 2013) and 34.5 (autumn and spring 2015) with and a mean(±SD) of 34±0.4 suggesting moderate degradation. Positive attributes included a deep natural channel with stable banks, which were countered by negative attributes such as a lack of riffle/pool sequences and a predominantly muddy/silt substrate.

The RCE scores recorded at site CR2 were relatively low with scores between 19 (spring 2014) and 22 (spring 2013 and autumn 2014) and a mean(±SD) of 21.2±1.1 suggesting that this site is severely degraded. The lack of riparian vegetation and instream retention devices and high erosional potential contributed to the low score at this site.

The RCE scores recorded at site CR3 were similar to CR1, and fairly consistent between 2014 and 2015 at scores of 32. The presence of the large water body formed by the commonwealth open cut results in a slightly increased score over CR2 and CR4 but generally the site is consistent with monitoring site conditions both up and downstream.

The RCE scores recorded at site CR4 were also relatively low, with scores between 28 (spring 2013) and 29.5 (autumn and spring 2014) and a mean(±SD) of 29±0.5, suggesting that this site is degraded. The poor condition of riparian vegetation, lack of instream retention devices and the presence of loose and mobile sediment were the main contributors to the scores at this site.

The RCE scores recorded at site CR5 were also relatively low, with scores between 28 (spring 2013) and 29.5 (autumn and spring 2014) and a mean(±SD) of 32.6±0.2, suggesting that this site is moderately degraded but supports improved ecological habitat when compared to sites further upstream. The poor channel form and the presence of loose and mobile sediment were the main contributors to the scores at this site although presence of instream retention devices, less smothering by aquatic macrophytes and algae and increased native vegetation in the riparian zone allowed for better quality habitat than sites further upstream.

The RCE scores recorded at site CR6 ranged between 36 (spring 2015) and 36.5 (all other survey events) and a mean(±SD) of 36.4±0.2, suggesting that this site supports improved ecological habitat when compared to sites further upstream. A well-formed channel, presence of a riffle/pool sequence and low coverage of loose and mobile sediment were the main contributors to the higher scores at this site.

6.3.1 Sawyers Swamp Creek

In Sawyers Swamp Creek RCE scores were found to be relatively consistent between survey events (where water allowed surveys to be completed) but variation was observed between sites, with scores higher in the upstream reaches of the creek. The highest mean RCE score was 42 (RCE% of 80.8) calculated for site SSWdn, indicating relatively good ecological condition and the lowest score being recorded at site DP9dn (27.6; RCE% of 53) indicating poor condition.

Site SSWdn recorded a relatively high mean±SD RCE score (42±0). The presence of instream logs and rocks, presence of riffle/pool sequences, firm banks with undercutting and stable substrate were the main contributors to the high score at this site.

Site SSCup recorded a relatively low RCE score during the autumn 2014 survey (30.5). An absence of instream logs and rocks, an incomplete riparian vegetation zone, unstable bank structure and an unstable substrate were the main contributors to the low score at this site.

At site DP9dn, RCE scores were consistent across the six sampling events - between 27.5 and 28 with and a mean(±SD) of 27.6±0.2 suggesting a high level of degradation. Negative attributes such as a lack of surrounding vegetation within an industrial zone, a lack of riffle/pool sequences, the absence of instream logs and rocks and a predominantly muddy/silt substrate contributed to the score. Required infrastructure related to dewatering operations has meant that areas of concrete channel, including headwalls and pits consume much of the waterway. The presence of access roads and surface water storages adjacent to the waterway results in an engineered corridor for water to migrate through which is not compatible to habitat.

Table 6-17 RCE Scores (averaged) between 2012 and 2015 (MPR, 2011; 2012a,b; 2013a, b; 2014a,b; 2015a,b; 2016a,b)

Category/Site	Neubecks Creek			Wangcol Creek				Coxs River						Sawyers Swamp Creek		
	NCup	NC1	NCdn	WCup	WC1	WC2	WC3	CR1	CR2	CR3	CR4	CR5	CR6	SSWdn	SScup	DP9dn
1. Land use pattern	4	4	3	3	2	2	2	2	2	2	2	2	2	4	3	1
2. Width of riparian strip of woody vegetation	4	4	2	2	2	2	3	3	1	3	2	2	2	4	3	3
3. Completeness of riparian strip of woody vegetation	4	4	1	1	1	1	2	3	0	2	1	2	1	4	2	4
4. Vegetation of riparian zone	4	3	2	3	3	3	3	3	1	3	2	3	3	4	4	3
5. Stream bank structure	2	2	3	2	2	2	2	4	2	3	2	2	3	2	2	2
6. Bank undercutting	4	2	3	3	2	2	2	3	2	3	3	2	3	3	2	3
7. Channel form	2	4	4	4	3	3	4	4	4	1	4	3	4	4	4	4
8. Riffle/pool sequence	2	2	2	1	2	1	1	2	2	2	3	3	4	4	1	0
9. Retention devices in stream	2	2	1	1	1	0	1	2	1	2	2	3	3	3	0	1
10. Channel sediment accumulations	2	2	2	2	3	3	2	2	2	2	3	3	3	2	2	2
11. Stream bottom	1	1	2	2	2	2	2	1	1	2	2	2	3	3	1	1
12. Stream detritus	3	3	2	2	2	2	2	3	2	3	3	3	3	3	3	2
13. Aquatic vegetation	4	4	3	3	3	3	4	3	2	3	2	3	3	3	4	2
RCE score	38	36	30	28	26	25	30	34	21	32	29	33	36	42	31	28
RCE percentage (%)	73	69	57	54	51	48	58	65	41	61	56	63	70	81	59	53

Note: RCE scores rounded up to whole numbers

6.4 Aquatic vertebrates

A total of five fish species have been caught during aquatic surveys conducted across the IAA and reference waterways between 2010 and 2015 (MPR, 2011; 2012a,b; 2013a, b; 2014a,b; 2015a,b; 2016a,b). These included:

- Three native species – Flat-headed gudgeon (*Philypnodon grandiceps*), Australian Smelt (*Retropinna smoni*) and Mountain galaxias (*Galaxias olidus*).
- Two introduced species – One introduced species, Eastern gambusia (*Gambusia holbrooki*) which is listed as noxious and indicates a KTP of invasive species colonisation is present. The introduced angling species brown trout (*Salmo trutta*) was recorded in the Coxs River. No introduced species of fish were recorded in Neubecks Creek.

Table 6-18 provides a summary of the fish species caught at each waterway. No fish caught within the IAA were listed species under the FM Act or EPBC Act.

Table 6-18 Fish species recorded across the IAA from 2010 to 2015 (MPR, 2011; 2012a,b; 2013a, b; 2014a, b; 2015a, b; 2016a,b; GHD, 2014b).

Waterway	Site	Common name	Scientific name
Neubecks Creek	NCdn only	Mountain galaxias	*Galaxias olidus*
Wangcol Creek	WCup, WC1, WC2 and WC3	Flat-headed gudgeon	*Philypnodon grandiceps*
		Mountain galaxias	*Galaxias olidus*
		Eastern gambusia	*Gambusia holbrooki*
Coxs River	CR1, CR2, CR3, CR4 and CR5	Flat-headed gudgeon	*Philypnodon grandiceps*
		Mountain galaxias	*Galaxias olidus*
		Eastern gambusia	*Gambusia holbrooki*
		Brown trout	*Salmo trutta*
		Australian Smelt	*Retropinna semoni*
Sawyers Swamp Creek	SSWdn, SSCup and DP9dn	No fish collected	

6.5 Macroinvertebrates

The following sub-sections provide a summary of macroinvertebrate community composition and condition, based on standardised biological indices. It is acknowledged that there may be some differences in metric calculation method between GHD and MPR data which may have influenced the comparability of the data across sampling events.

6.5.1 Neubecks Creek

Macroinvertebrate results for the site monitored by GHD in Neubecks Creeks are presented in Table 6-19.

Table 6-19 Macroinvertebrate biological index results for Neubecks Creek sites from 2012 to 2014 (MPR, 2012; GHD, 2014b)

	NCdn					
Metric	Au 12	Sp 12	Au 13	Sp 13	Au 14	Sp 14
Taxa richness	20	22	23	20	15	25
EPT richness	5	4	3	4	1	6
SIGNAL-2 score	4.21	4.40	4.23	4.00	3.23	3.57
O/E50	N/A	N/A	N/A	0.57	0.41	0.94
AUSRIVAS band	N/A	N/A	N/A	B	C	A

N/A – Not available due to the fact that alkalinity and substratum data (required for AUSRIVAS model input) were not collected in those years.

Results for taxa richness and EPT richness are provided in Figure 6-1 and Figure 6-2. An average of 21 macroinvertebrate taxa was calculated for site NCdn across all sampling events with a minimum of 15 taxa (autumn 2014) and maximum of 25 taxa (spring 2014) collected.

An average of four EPT taxa (representing the environmentally sensitive orders (Ephemeroptera, Plecoptera and Trichoptera) was calculated for site NCdn. One EPT taxon was collected in autumn 2014 represented by an unidentified stonefly larva (Plecoptera sp.) with six EPT taxa observed in spring 2014 (two from each EPT order).

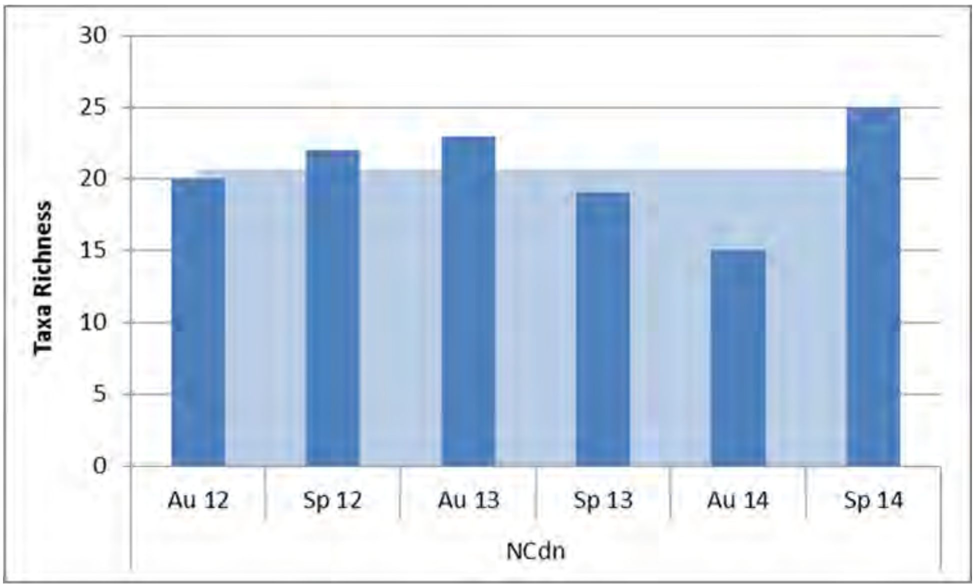


Figure 6-1 **Taxa richness at Neubecks Creek sites between 2012 and 2014. Shaded area provides average across all sampling events**

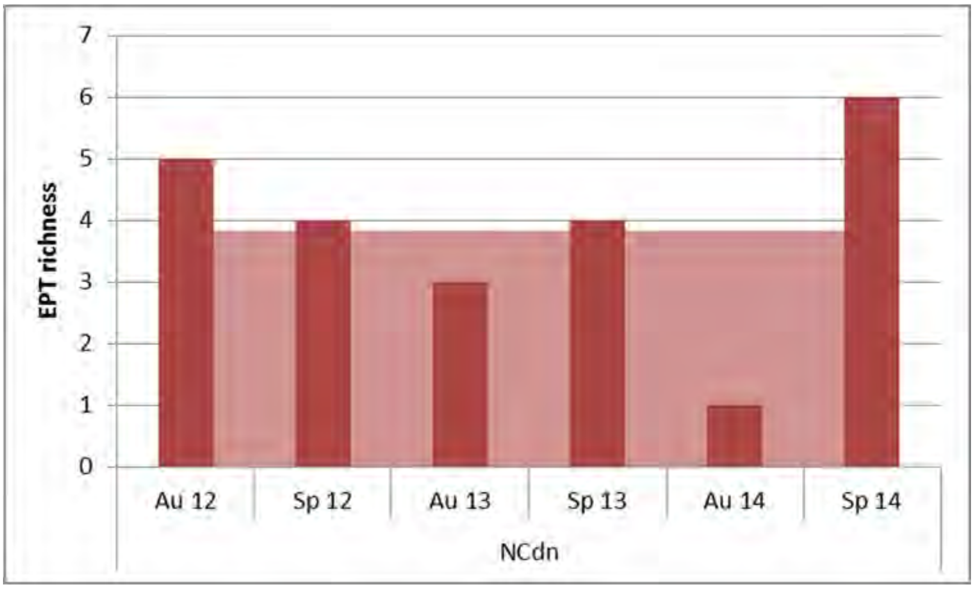


Figure 6-2 **EPT richness at Neubecks Creek sites between 2012 and 2014. Shaded area provides average across all sampling events**

SIGNAL-2 score results for site NCdn on Neubecks Creek are presented in Figure 6-3. Across all sampling events the average SIGNAL-2 score was 3.99, indicating that the site is in poor to moderate environmental condition (Chessman *et al.,* 1997) with the majority of taxa present being tolerant of poor water quality. The maximum SIGNAL-2 score recorded was 4.4 (spring 2012) and minimum was 3.2.

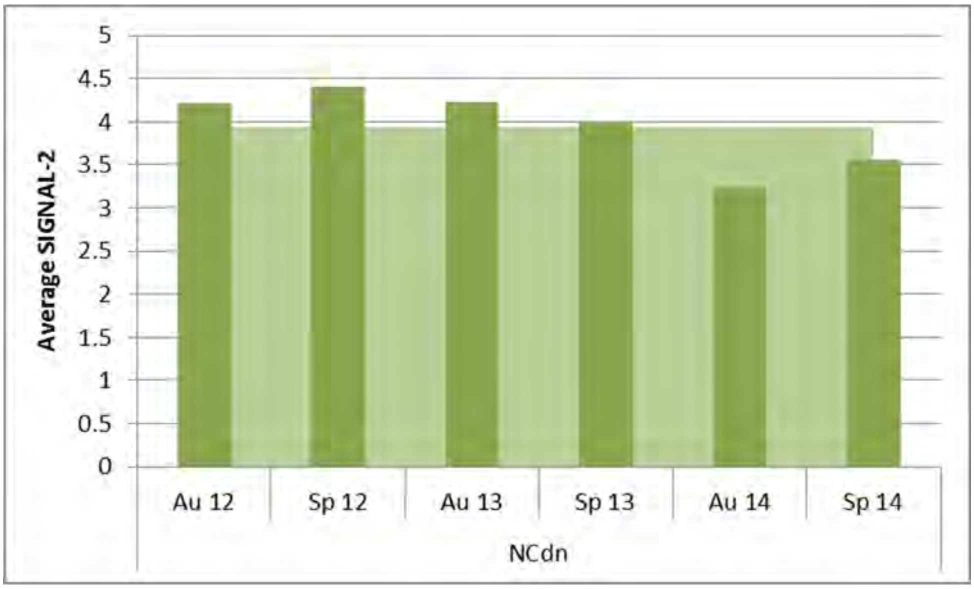


Figure 6-3 SIGNAL-2 score at Neubecks Creek sites between 2012 and 2014. Shaded area provides average across all sampling events

AUSRIVAS O/E50 scores for NCdn are presented in Figure 6-4 and have resulted in AUSRIVAS banding ratings ranging between B and C (severely degraded) in autumn 2014 to Band A (similar to reference conditions) in spring 2014. An average score of 0.64±0.3 was recorded between 2013 and 2014.

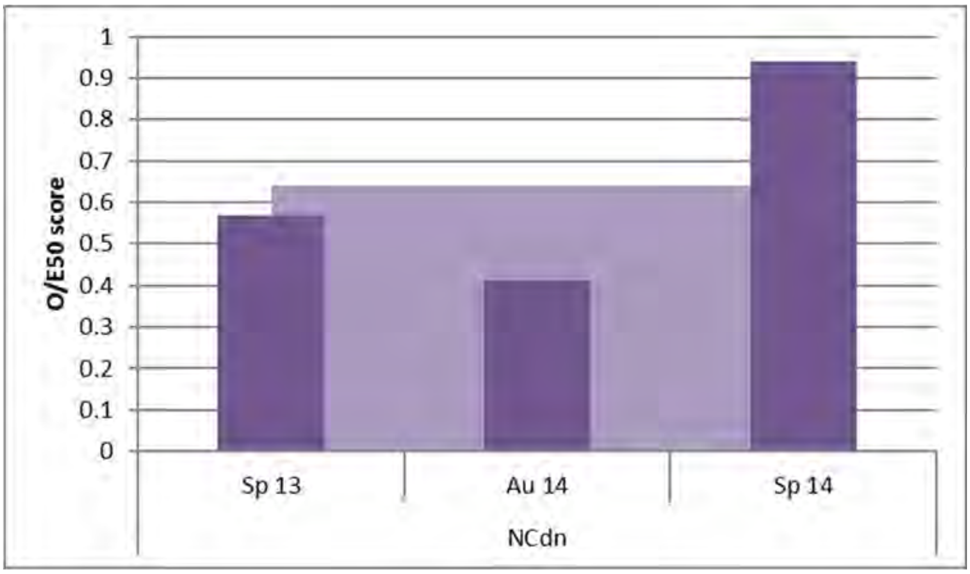


Figure 6-4 O/E50 score at Neubecks Creek between 2013 and 2014. Shaded area provides average across all sampling events

6.5.2 Wangcol Creek

Macroinvertebrate biological index results for Wangcol Creek are presented in Table 6-20 and Table 6-21.

Results for taxa richness are provided in Figure 6-5. Across the three years assessed, the greatest taxa richness was recorded at site WC3 (25 taxa; spring 2014) and lowest at site WC2 (five taxa; autumn 2014). Although a degree of variation was observed at all sites, the calculated mean taxa richness for each site indicates that diversity varies considerably between sites. Mean±SD taxa richness (across all sampling events) was 14±3, 20±4, 10±5 and 21±3 for sites WCup, WC1, WC2 and WC3, respectively. These results indicate that site WC2 supports a less diverse community than the other sites on Wangcol Creek.

Results for EPT richness are provided in Figure 6-6. Across the three years assessed the greatest taxa richness was recorded at site WC1 (6 EPT taxa; autumn and spring 2015) and lowest at site WC2 (one taxon; autumn and spring 2013 and autumn 2014). Variation was observed at most sites but the calculated mean number of EPT taxa for each site indicates that diversity also varies longitudinally. Mean±SD taxa richness (across all sampling events) was 3±1, 5±1, 2±2 and 4±1 for sites WCup, WC1, WC2 and WC3, respectively. These results indicate that site WC2 supports a macroinvertebrate community with less sensitive taxa than the other sites on Wangcol Creek.

SIGNAL-2 score results for Wangcol Creek are presented in Figure 6-7. Across the three years assessed the greatest SIGNAL-2 score was recorded at site WC1 (4.95; spring 2015) and lowest at site WC2 (3.14; spring 2014). Variation was observed at most sites but the calculated mean SIGNAL-2 score for each site indicates that diversity also varies longitudinally. Mean±SD SIGNAL-2 scores (across all sampling events) were 3.6±0.1, 4.4±0.4, 3.7±0.6 and 4.0±0.3 for sites WCup, WC1, WC2 and WC3, respectively.

These results suggest that sites WCup and WC2 support a greater proportion of pollution tolerant taxa than sites WC1 and WC3 and that they are likely to have been subject to poor water quality conditions during the historical sampling period.

In general terms, the biological indices suggest that the aquatic ecosystem condition of WC1 and WC3 are better than WCup and WC2.

Table 6-20 Macroinvertebrate biological index results for Wangcol Creek for 2013 to 2015 for sites WCup and WC1

Metric	WCup						WC1					
	Au 13	Sp 13	Au 14	Sp 14	Au 15	Sp 15	Au 13	Sp 13	Au 14	Sp 14	Au 15	Sp 15
Taxa richness	15	15	10	10	13	18	19	19	13	20	24	21
EPT richness	2	4	2	2	4	2	5	4	3	4	6	6
SIGNAL-2 score	3.79	3.73	3.44	3.60	3.75	3.47	4.11	3.95	4.46	4.10	4.61	4.95
O/E50	N/A	0.72	0.61	0.47	N/A	N/A	N/A	0.63	0.66	0.86	N/A	N/A
AUSRIVAS band	N/A	B	B	C	N/A	N/A	N/A	B	B	A	N/A	N/A

N/A – Not available due to the fact that alkalinity and substratum data (required for AUSRIVAS model input) were not collected in those years.

Table 6-21 Macroinvertebrate biological index results for Wangcol Creek for 2013 to 2015 for sites WC2 and WC3

Metric	WC2						WC3					
	Au 13	Sp 13	Au 14	Sp 14	Au 15	Sp 15	Au 13	Sp 13	Au 14	Sp 14	Au 15	Sp 15
Taxa richness	10	6	5	7	17	14	19	23	21	25	18	22
EPT richness	1	1	1	0	3	4	3	4	3	3	4	4
SIGNAL-2 score	3.30	3.33	3.80	3.14	4.13	4.69	4.00	3.82	3.76	3.63	4.35	4.29
O/E50	N/A	0.28	0.16	0.33	N/A	N/A	N/A	0.86	0.74	0.90	N/A	N/A
AUSRIVAS band	N/A	C	C	C	N/A	N/A	N/A	A	B	A	N/A	N/A

N/A – Not available due to the fact that alkalinity and substratum data (required for AUSRIVAS model input) were not collected in those years.

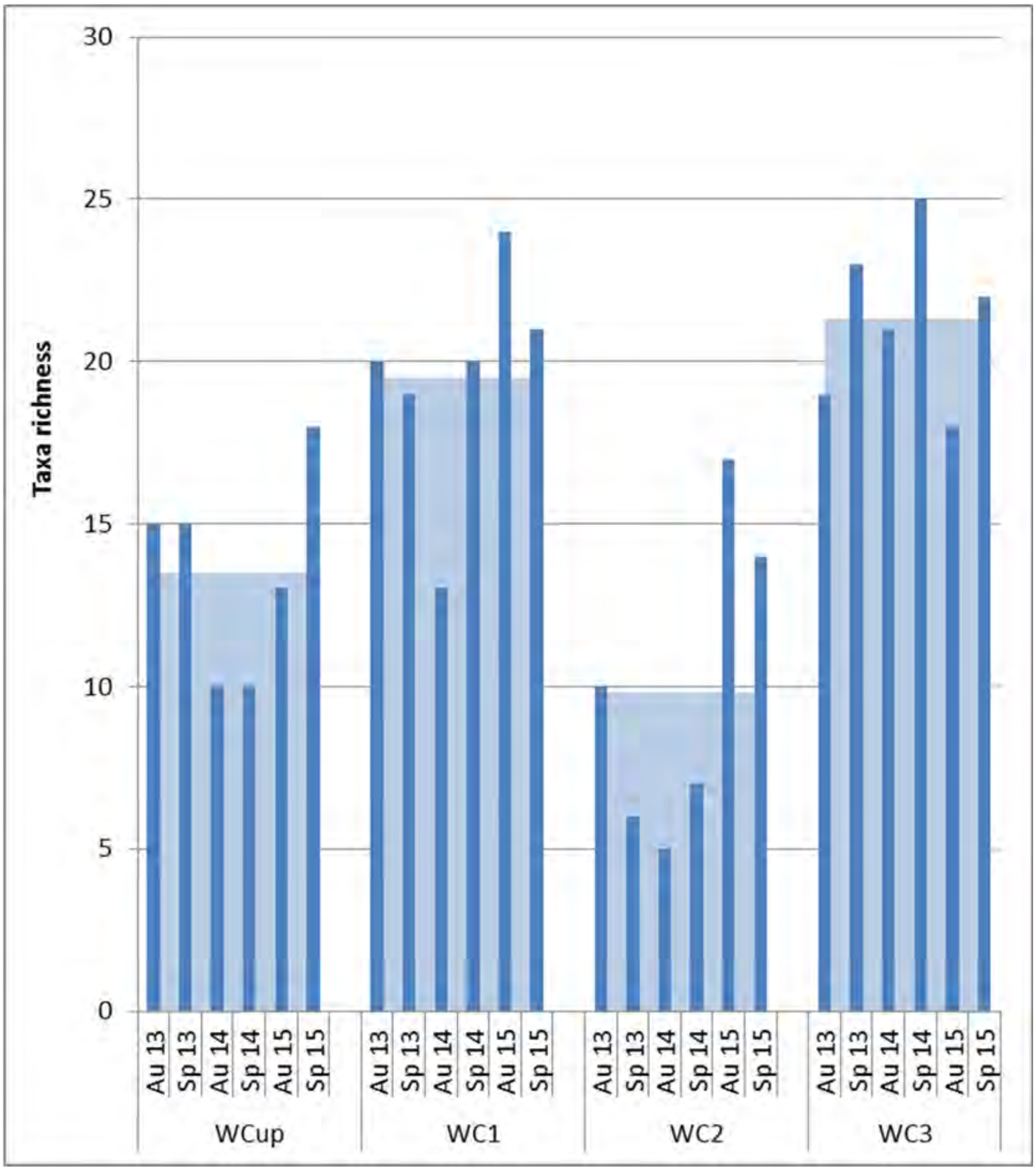


Figure 6-5 Taxa richness at Wangcol Creek sites between 2013 and 2015. Shaded area provides average across all sampling events

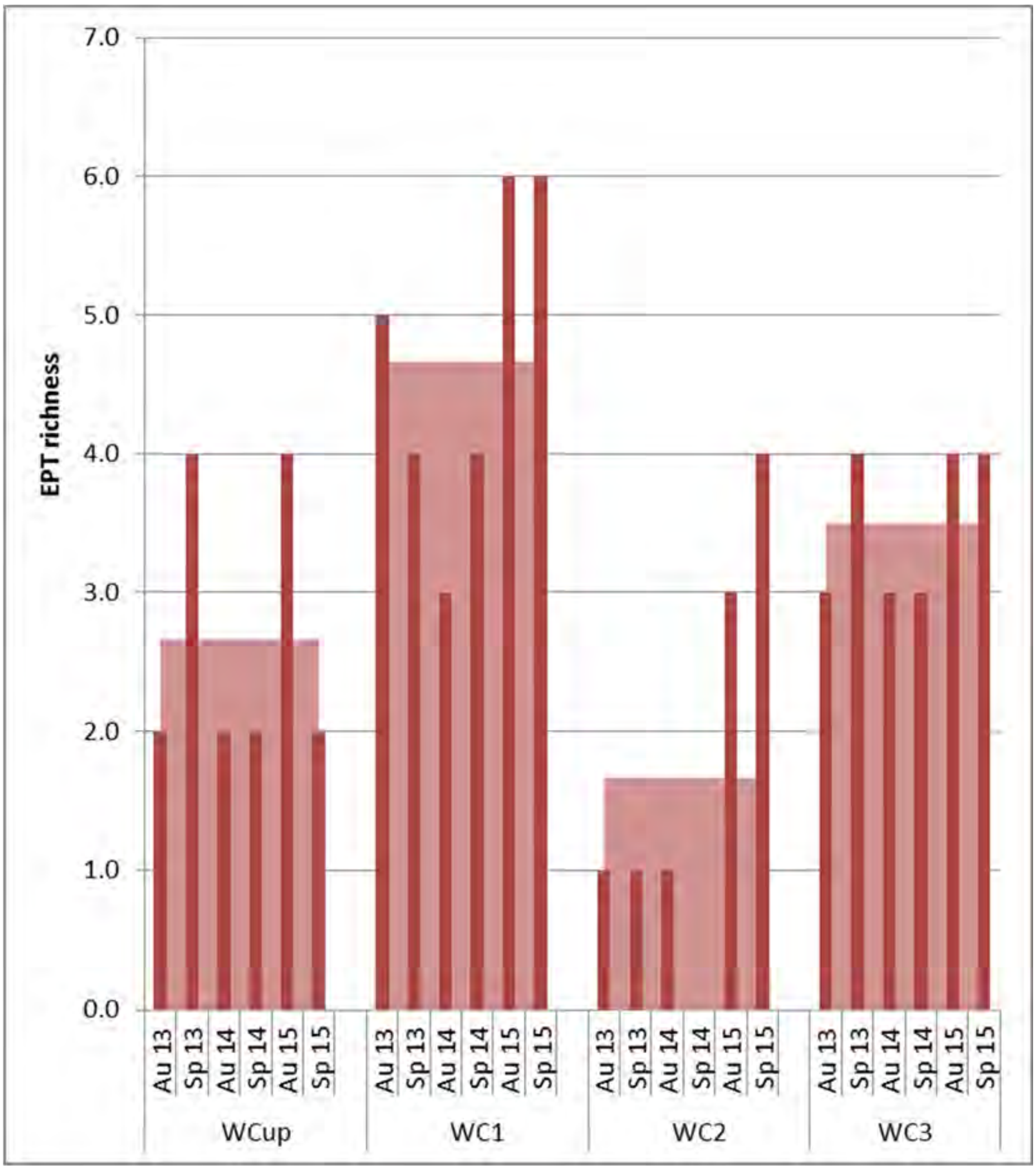


Figure 6-6 EPT richness at Wangcol Creek sites between 2013 and 2015. Shaded area provides average across all sampling events

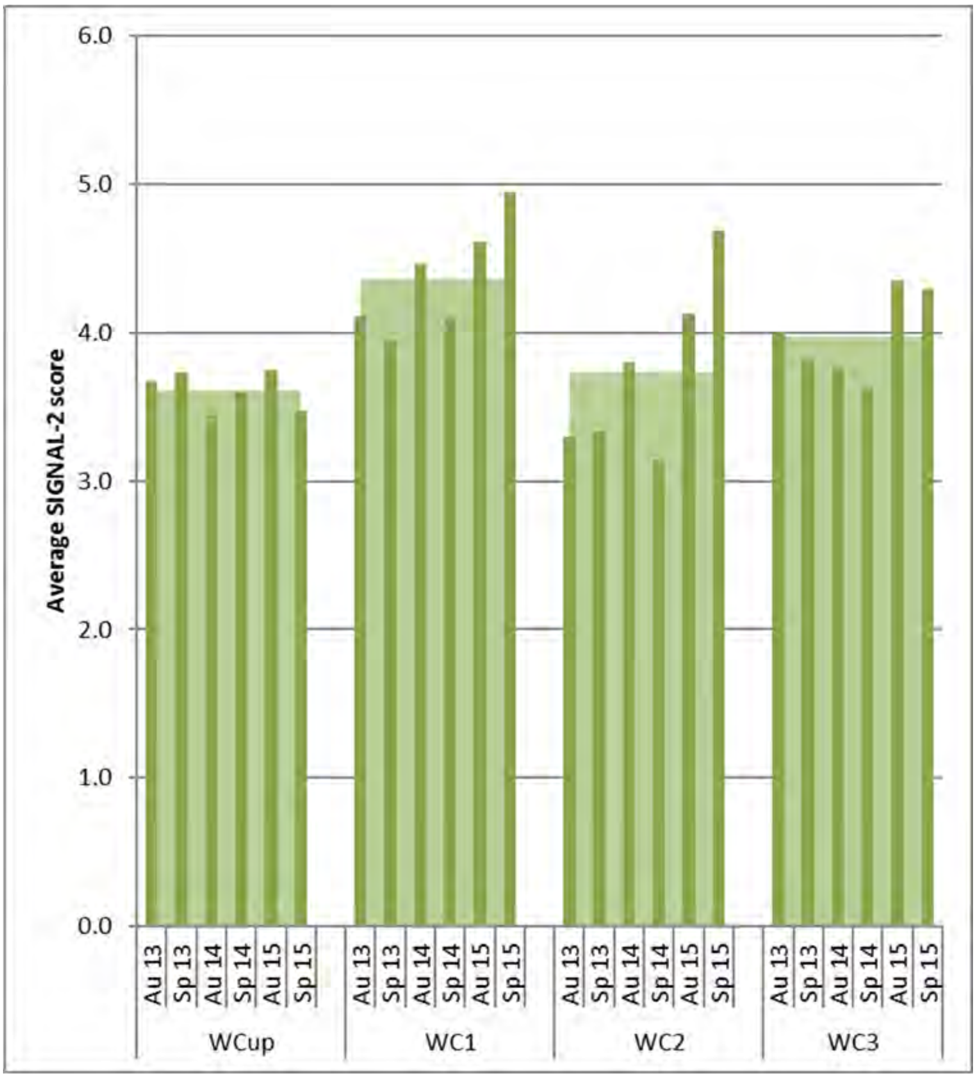


Figure 6-7 SIGNAL-2 score at Wangcol Creek sites between 2013 and 2015. Shaded area provides average across all sampling events

AUSRIVAS O/E50 scores for Wangcol Creek sites are presented in Figure 6-8. Across the three years assessed the greatest OE/50 score was recorded at site WC3 (0.9; spring 2014) and lowest at site WC2 (0.16; autumn 2014). Variation was observed at most sites but the calculated mean OE/50 score for each site indicates that diversity also varies longitudinally. Mean±SD OE/50 scores (across all sampling events) were 0.6±0.1, 0.72±0.1, 0.26±0.1 and 0.83±0.1 for sites WCup, WC1, WC2 and WC3, respectively.

These results indicate that site WC2 has been consistently classified as being severely to extremely impaired and that sites WCup, WC1 and WC3 are also significantly impaired, based on the results of the AUSRIVAS model.

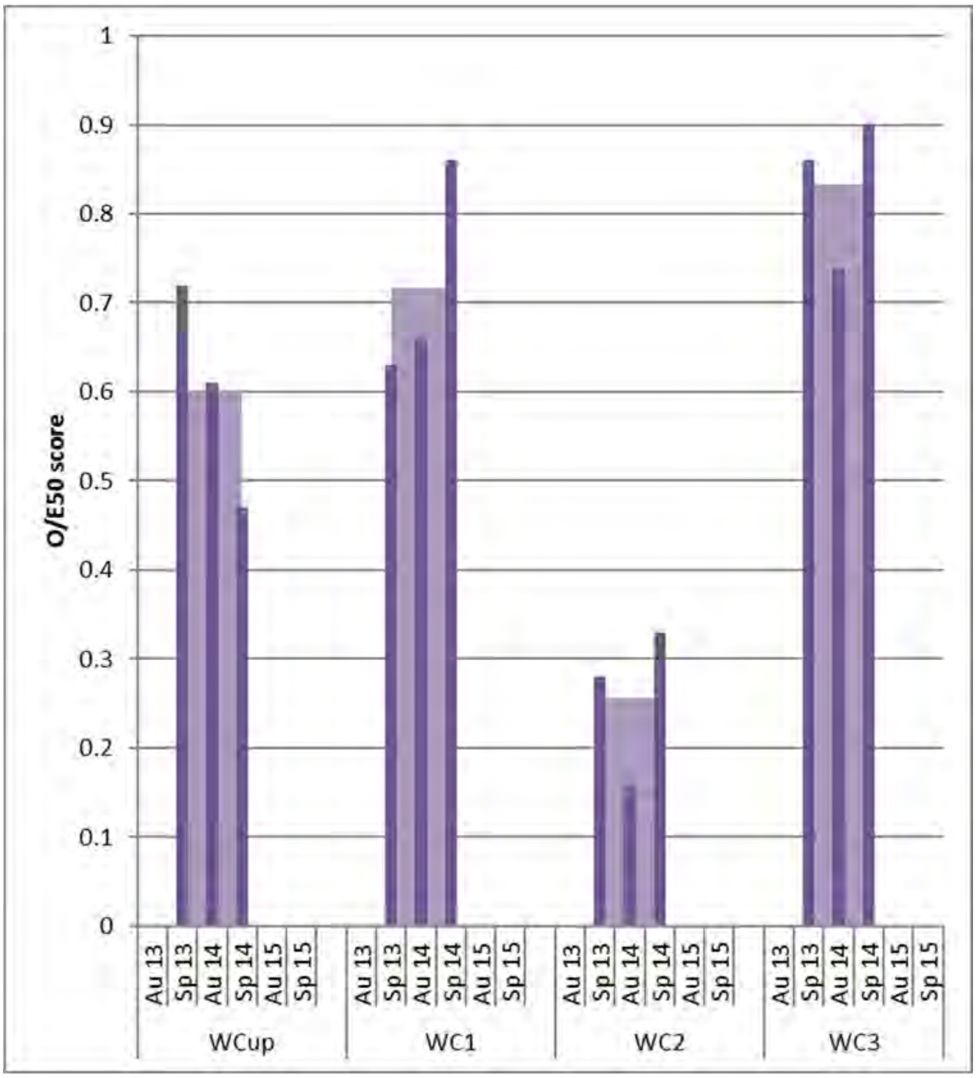


Figure 6-8 O/E50 score at Wangcol Creek sites between 2013 and 2015. Shaded area provides average across all sampling events

6.5.3 Coxs River

Macroinvertebrate biological index results for Coxs River are presented in Table 6-22. Results for taxa richness are provided in Figure 6-9. Across the three years assessed, the highest taxa richness was recorded at site CR1 (32 taxa; autumn 2013) and lowest at site CR2 (17 taxa, spring 2014) and CR6 (17 taxa; autumn 2013, autumn and spring 2015). Although a degree of variation in taxa richness was observed at all sites between seasons, the calculated mean taxa richness for each site indicates a similar range of variation between sites. Mean±SD taxa richness (across all sampling events) was 25±4, 23±2, 22±3, 21±3, 24±3 and 17±4 for sites CR1, CR2, CR3, CR4, CR5 and CR6, respectively. These results indicate that site CR6 supports a less diverse community than the other sites on Coxs River. Results from other sites were similar in the range observed.

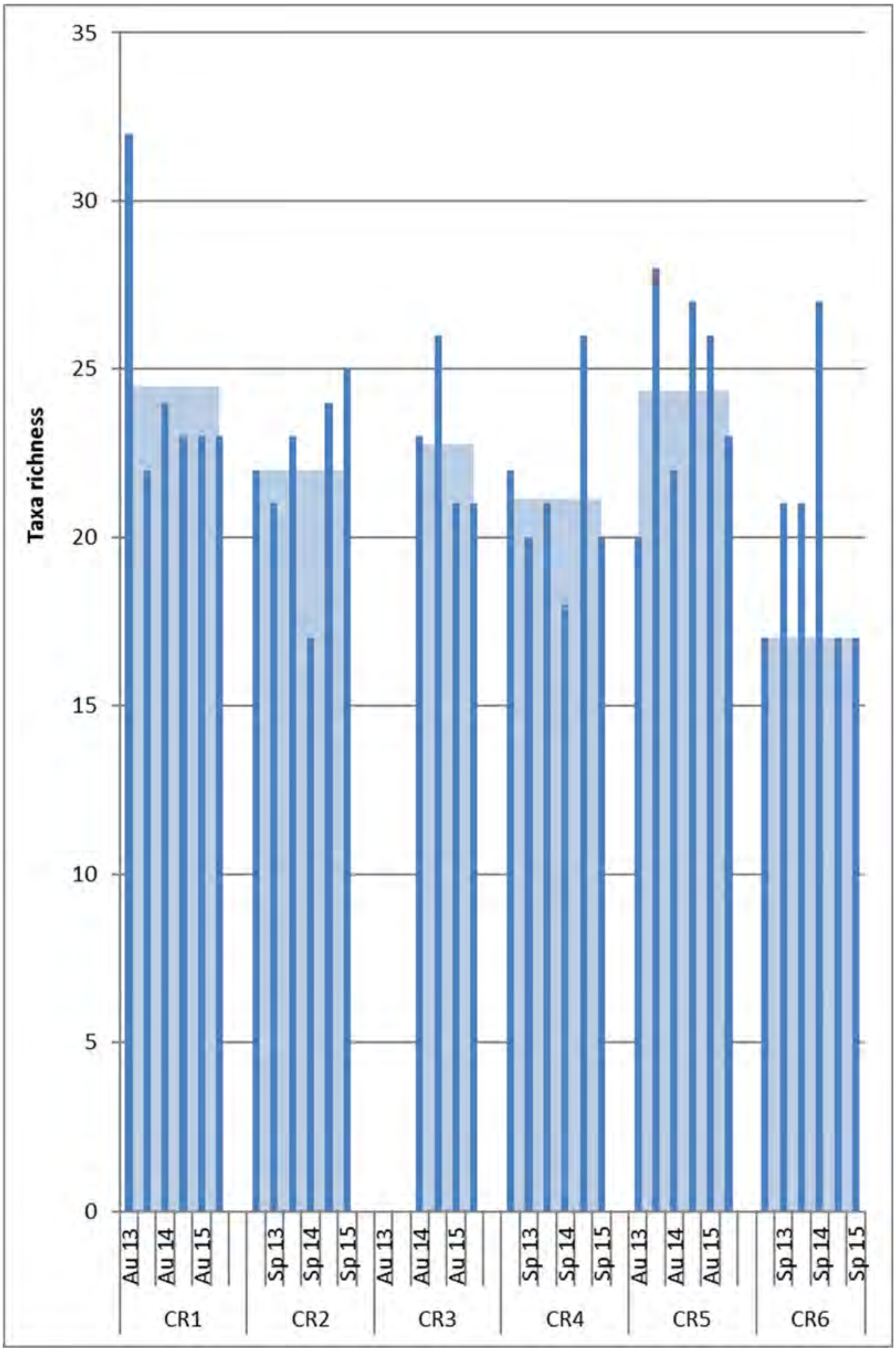


Figure 6-9 Taxa richness at Coxs River sites between 2013 and 2015. Shaded area provides average across all sampling events

Table 6-22 Macroinvertebrate biological index results for Coxs River sites CR1, CR2 and CR3 for 2013 to 2015

Metrics	CR1						CR2						CR3			
	Au 13	Sp 13	Au 14	Sp 14	Au 15	Sp 15	Au 13	Sp 13	Au 14	Sp 14	Au 15	Sp 15	Au 14	Sp 14	Au 15	Sp 15
Taxa richness	32	22	24	23	23	23	20	21	23	17	24	25	23	26	21	21
EPT richness	7	2	6	N/A	7	5	7	7	5	2	8	7	6	N/A	7	5
SIGNAL-2 score	4.50	3.95	3.86	3.60	4.05	3.57	4.15	4.57	3.50	3.50	4.52	4.71	3.91	3.88	4.24	4.19
O/E50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.99	0.87	0.73	N/A	N/A	N/A	N/A	N/A	N/A
AUSRIVAS band	N/A	N/A	N/A	N/A	N/A	N/A	N/A	A	A	B	N/A	N/A	N/A	N/A	N/A	N/A

N/A – Not available due to the fact that alkalinity and substratum data (required for AUSRIVAS model input) were not available years or raw taxa counts were not available to calculate EPT score.

Table 6-23 Macroinvertebrate biological index results for Coxs River sites CR4, CR5 and CR6 for 2013 to 2015

Metrics	CR4						CR5						CR6					
	Au 13	Sp 13	Au 14	Sp 14	Au 15	Sp 15	Au 13	Sp 13	Au 14	Sp 14	Au 15	Sp 15	Au 13	Sp 13	Au 14	Sp 14	Au 15	Sp 15
Taxa richness	21	20	21	18	26	20	17	21	22	27	17	17	17	21	21	27	17	17
EPT richness	6	7	3	5	7	8	5	5	7	7	4	5	5	5	5	N/A	4	5
SIGNAL-2 score	4.15	4.37	3.85	4.94	4.04	4.48	3.90	3.27	4.10	4.12	4.04	4.48	3.41	3.37	3.95	3.64	3.64	3.67
O/E50	N/A	0.77	0.78	0.64	N/A	N/A	N/A	N/A	0.87	1.18	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AUSRIVAS band	N/A	B	B	B	N/A	N/A	N/A	N/A	A	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

N/A – Not available due to the fact that alkalinity and substratum data (required for AUSRIVAS model input) were not collected in those years or raw data was not available to calculate EPT score.

Results for EPT richness are provided in Figure 6-10. Across the three years assessed the greatest number of EPT taxa were recorded at site CR2 (eight taxa; autumn 2015) and site CR5 (eight taxa; spring 2015) and lowest at site CR2 (two taxa, spring 2014). Although a degree of variation was observed at all sites, the calculated mean EPT abundances for each site indicates that diversity also varies longitudinally. Mean±SD taxa richness (across all sampling events) was 5±2, 6±2, 6±1, 6±1, 7±0 and 5±0 for sites CR1, CR2, CR3, CR4, CR5 and CR6, respectively. These results indicate that site CR5 supports a greater number of sensitive EPT taxa than the other sites on Coxs River. EPT richness was generally lower at CR6 relative to other sites.

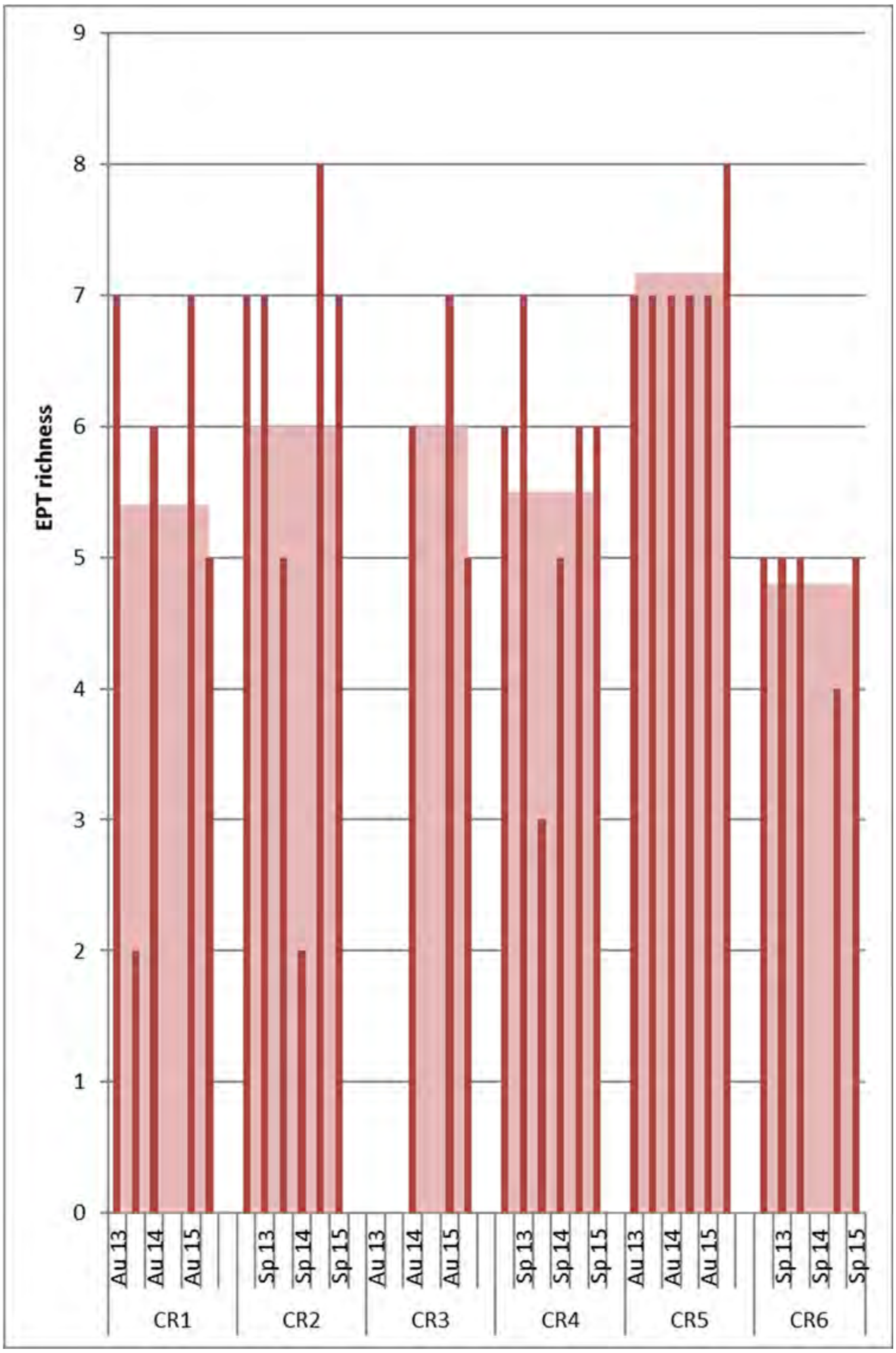


Figure 6-10 EPT richness at Coxs River sites between 2013 and 2015. Shaded area provides average across all sampling events

Results for SIGNAL-2 score are provided in Figure 6-11. Across the three years assessed the highest SIGNAL-2 score was recorded at site CR4 (4.94; spring 2014) and lowest at site CR5 (3.27, spring 2013). Although a degree of variation was observed at all sites, the calculated mean taxa richness for each site indicates that diversity also varies longitudinally. Mean±SD SIGNAL-2 scores (across all sampling events) was 3.92±0.34, 4.16±0.54, 4.05±0.19, 4.30±0.38, 3.98±0.40, and 3.61±0.21 for sites CR1, CR2, CR3, CR4, CR5 and CR6, respectively.

These results suggest that site CR6 supports a greater proportion of pollution tolerant taxa than the other sites on Coxs River. In general, all sites could be classified as being either severely impaired (score of <4) or moderately impaired (scores of 4-5) as per Chessman *et al.* 1997). Results from other sites were similar in their range across the three years of monitoring.

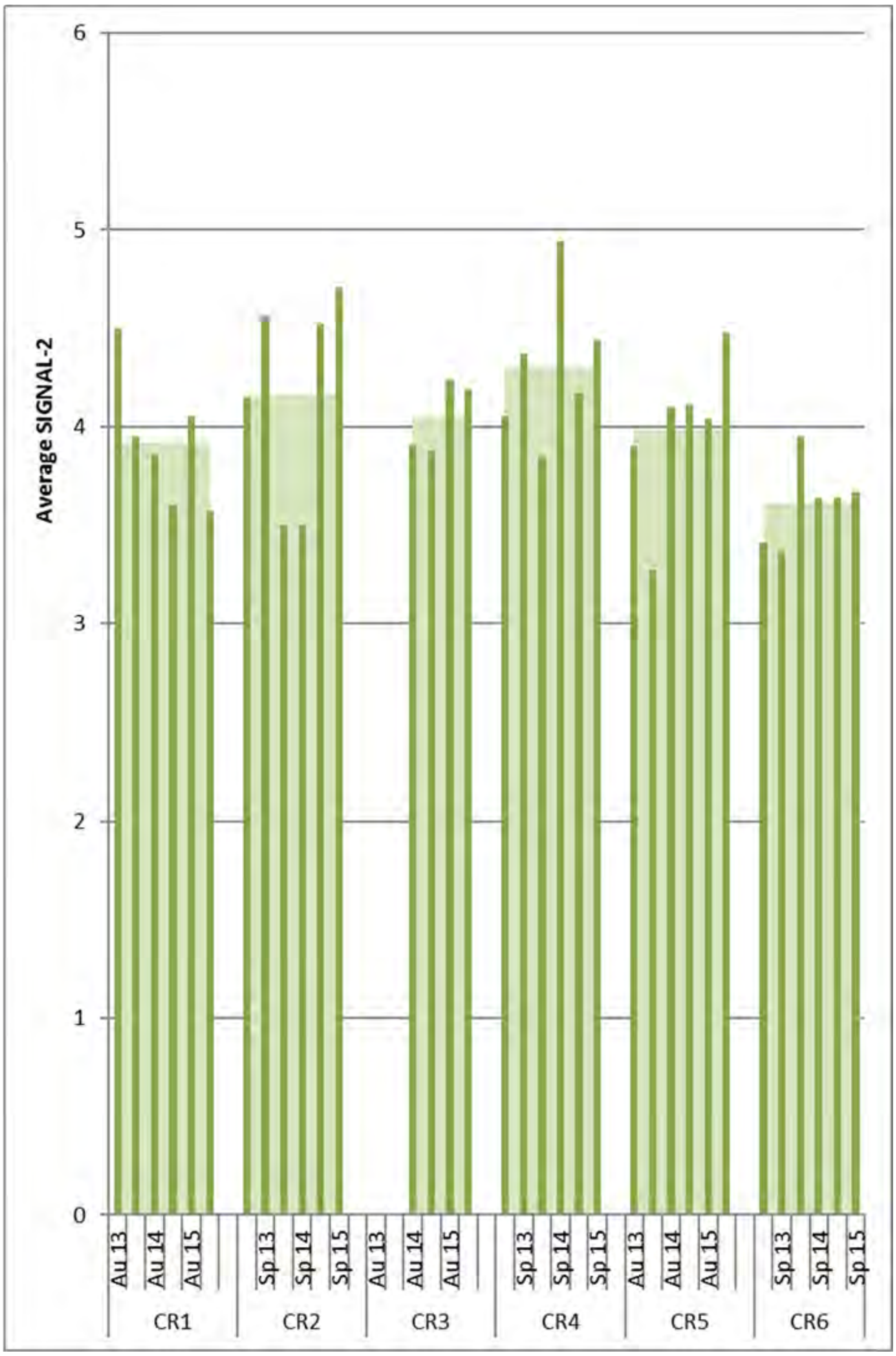


Figure 6-11 SIGNAL-2 score at Coxs River sites between 2013 and 2015. Shaded area provides average across all sampling events

AUSRIVAS OE/50 scores for the Coxs River sites are presented in Figure 6-12. Across the three years assessed the greatest OE/50 score was recorded at site CR5 (1.18; spring 2014) and lowest at site CR4 (0.64; spring 2014). Variation was observed at most sites but the calculated mean OE/50 score for each site indicates that diversity also varies longitudinally. Mean±SD OE/50 scores (across all sampling events) were 0.86±0.13, 0.73±0.08 and 1.03±0.2 for sites CR2, CR4 and CR5, respectively.

These results indicate that sites on Coxs River range from significantly impaired to close to reference condition (OE/50 ~1.0) depending on season sampled.

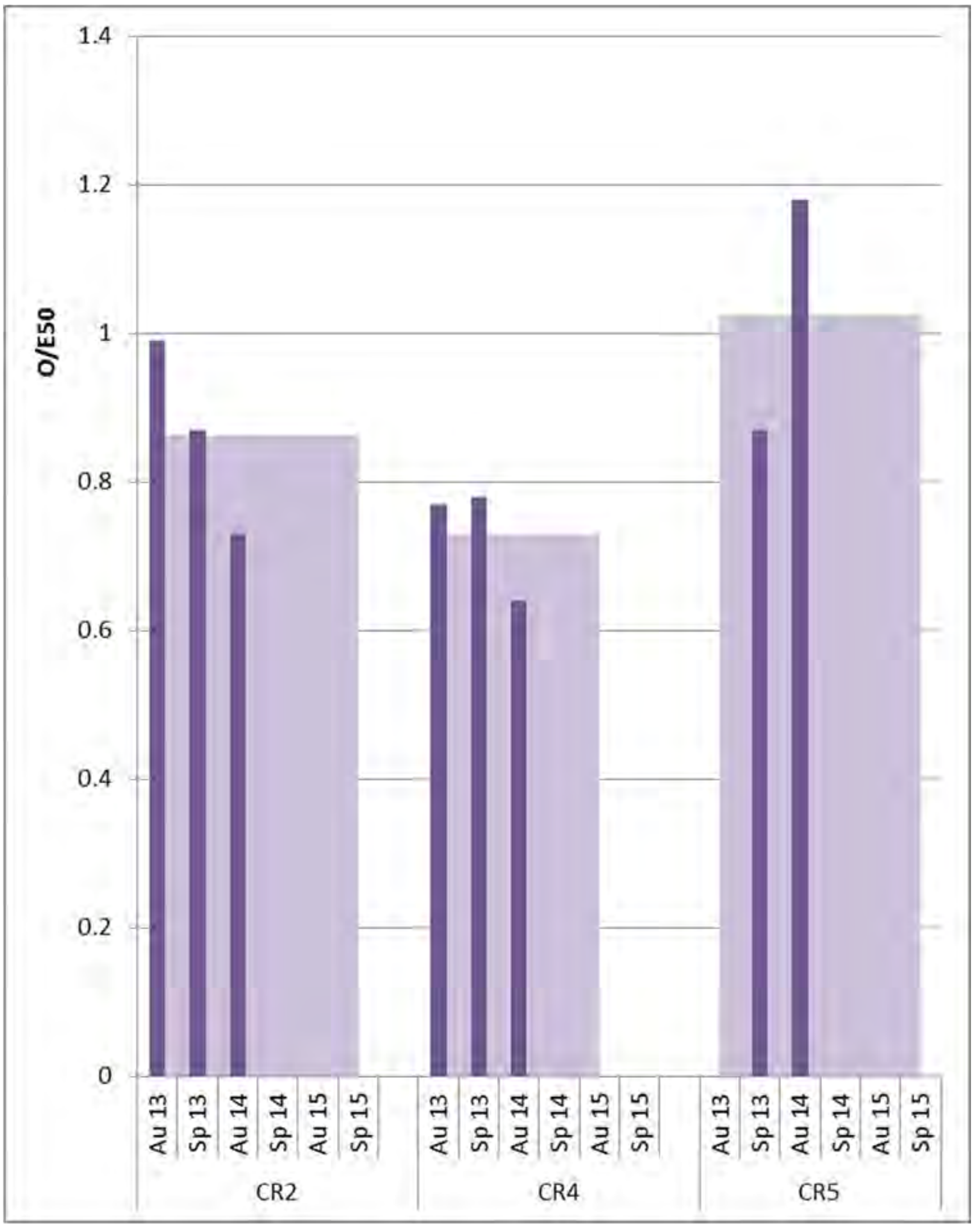


Figure 6-12 **O/E50 score at Coxs River sites between 2013 and 2014. Shaded area provides average across all sampling events.** **Note: O/E50 was not available for CR1 or CR3**

6.5.4 Sawyers Swamp Creek

Macroinvertebrate results for Sawyers Swamp Creek are presented in Table 6-24. Results for taxa richness are provided in Figure 6-13. Across the three years assessed the greatest taxa richness was recorded at site DP9dn (24 taxa; autumn 2014) and lowest at site DP9dn (nine taxa, autumn 2013). Site DP9dn displayed obvious variation over the three years assessed, with the lowest number of taxa collected in autumn and spring 2013 and greatest number in autumn and spring 2014. Mean±SD taxa richness (across all sampling events) was 16±6 for site DP9dn. The single sampling events for sites SSWdn and SSCup recorded 19 taxa from each site. These results indicate that site DP9dn supports a less diverse community than the sites further upstream on Sawyers Swamp Creek.

Table 6-24 Macroinvertebrate biological index results for Sawyers Swamp Creek

	SSWdn	SSCup	DP9dn					
Metric	Au 13	Au 14	Au 13	Sp 13	Au 14	Sp 14	Au 15	Sp 15
Taxa richness	19	19	9	11	24	22	15	14
EPT richness	3	3	2	2	4	N/S	4	5
SIGNAL-2 score	5.53	3.47	3.56	3.82	3.57	4.27	4.00	4.93
O/E50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AUSRIVAS band	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

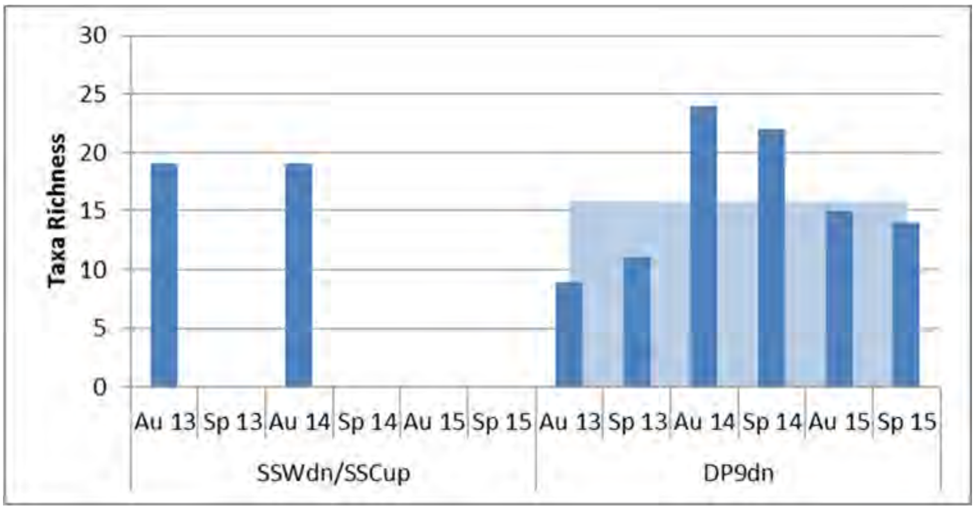


Figure 6-13 Taxa richness at Sawyers Swamp Creek between 2013 and 2015. Shaded area provides average across all sampling events

Results for EPT taxa collected are provided in Figure 6-14. Across the three years assessed the greatest taxa richness was recorded at site DP9dn (five taxa; spring 2015) and lowest at site DP9dn (two taxa, autumn and spring 2013). Site DP9dn displayed obvious variation over the three years assessed, with the lowest number of taxa collected in autumn and spring 2013 and greatest number in spring 2015. Mean±SD EPT richness (across all sampling events) was 3±1 for site DP9dn. The single sampling events for sites SSWdn and SSCup recorded 3 EPT taxa from each site. These results indicate that site DP9dn supports EPT taxa abundances that have varied, depending on year.

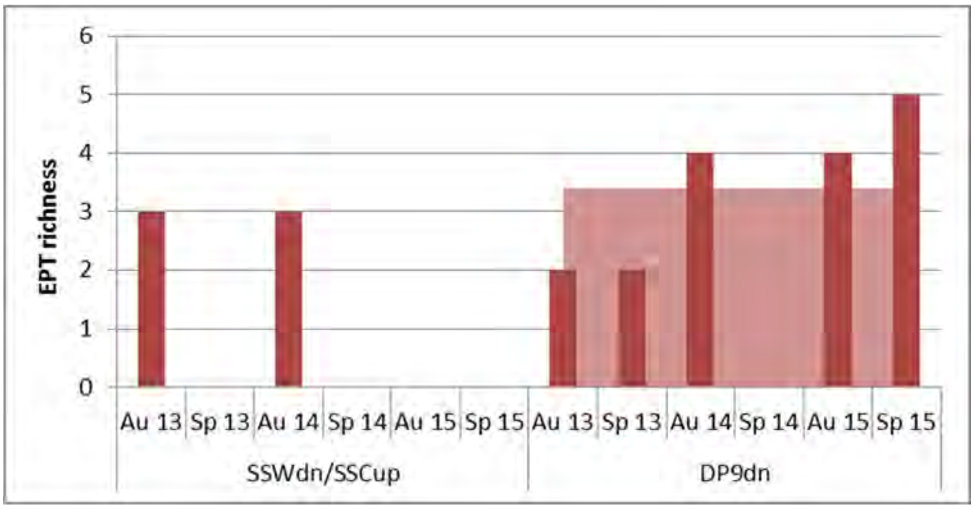


Figure 6-14 EPT richness at Sawyers Swamp Creek between 2013 and 2015. Shaded area provides average across all sampling events

SIGNAL-2 scores for Sawyers Swamp Creek are presented in Figure 6-15. Across the three years assessed the greatest SIGNAL 2 score was recorded at site SSWdn (5.53; autumn 2013) and lowest at site SSCup (3.47, autumn 2014). Site DP9dn displayed fairly consistent results over the three years assessed. Mean±SD SIGNAL 2 score (across all sampling events) was 4.02±0.5 for site DP9dn with the exception of increase observed in the spring 2015 sampling event. The single sampling events for sites SSWdn and SSCup recorded SIGNAL-2 scores of 5.53 and 3.47. These results indicate that sites SSCup and DP9dn support a macroinvertebrate community dominated by pollution tolerant taxa, whereas the limited data for SSWdn suggest that this site supports a community with a higher proportion of sensitive taxa.

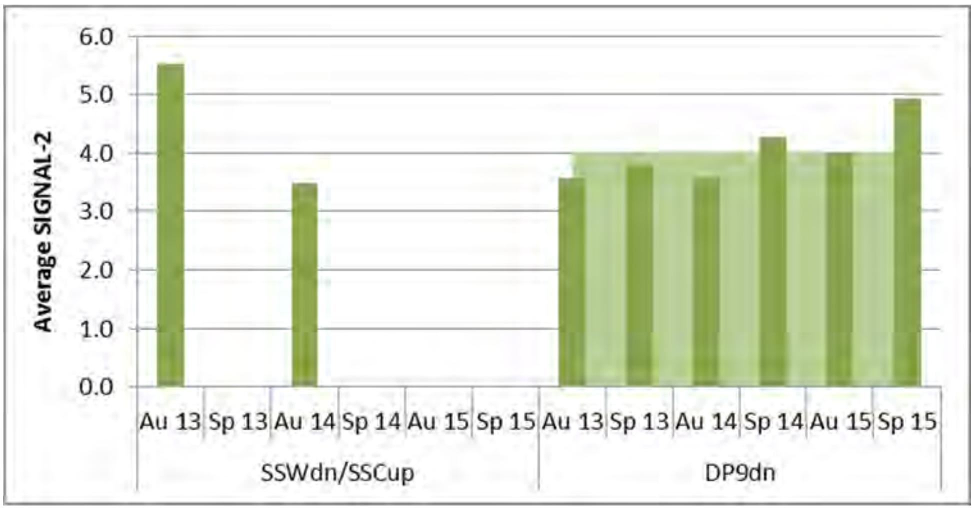


Figure 6-15 SIGNAL-2 scores at Sawyers Swamp Creek between 2013 and 2015. Shaded area provides average across all sampling events

6.5.5 Assessment of relative richness

Graphs displaying the relative number of orders present at each site during autumn and spring 2015 are displayed in Figure 6-16 and Figure 6-17. These graphs provide a comparison of relative richness during 2015, potentially allowing for the identification of differences in terms of orders present.

In autumn 2015 the greatest diversity of orders was recorded from Coxs River site CR4, with 12 orders present. These included Water beetles (Coleoptera), True flies (Diptera), Mayflies (Ephemeroptera), Moth larvae (Lepidoptera), dragonflies/damselflies (Odonata), Stoneflies (Plecoptera), Caddisflies (Trichoptera), Mites (Acarina), Yabbies/shrimps (Decapoda), Oligochaete worms (Oligochaeta), Pea shells (Bivalvia) and Snails (Gastropoda). This contrasted with the lowest number of macroinvertebrate orders being collected from Wangcol Creek site WCup (six orders, represented by Coleoptera, Diptera, Ephemeroptera, True Bugs (Hemiptera), Trichoptera and Decapoda) and Sawyers Swamp Creek site DP9dn (Coleoptera, Diptera, Ephemeroptera, Hemiptera, Trichoptera and Odonata). In general, the Wangcol Creek sites (and the Sawyers Swamp Creek site) supported a lower number of orders when compared to the Coxs River sites.

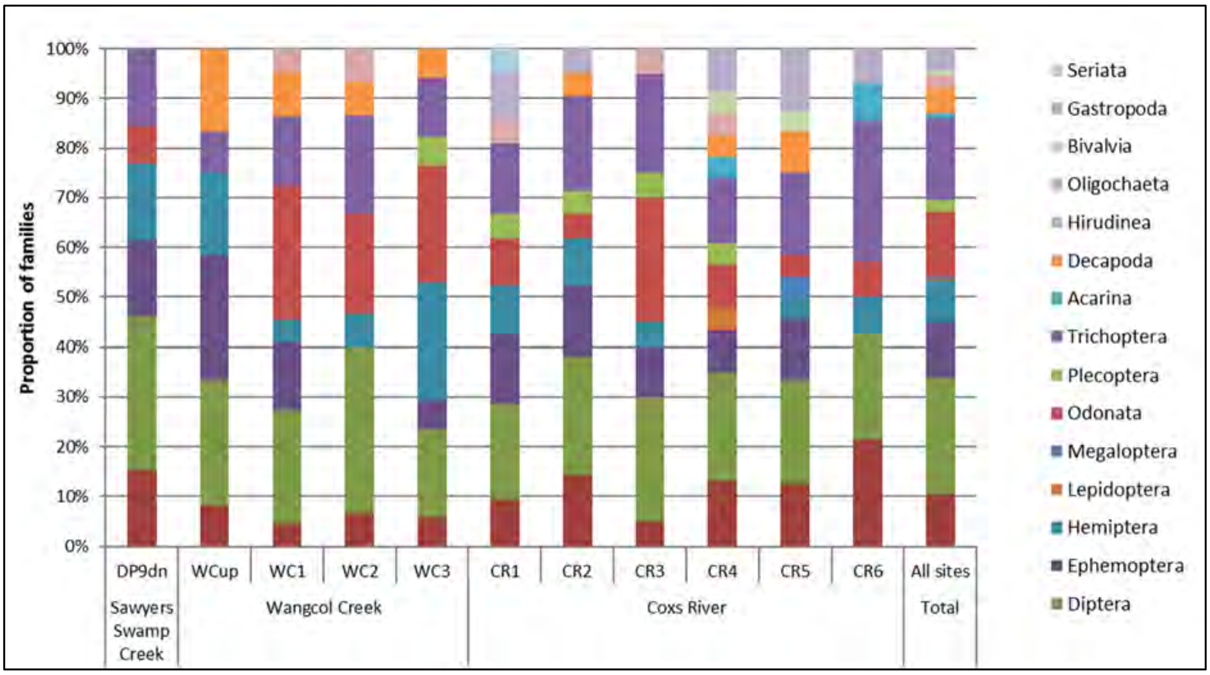


Figure 6-16 Relative richness of macroinvertebrate orders at each site sampled in autumn 2015

In spring 2015 the greatest diversity of orders was recorded from Coxs River site CR5, with 13 orders present. These included Coleoptera, Diptera, Ephemeroptera, Hemiptera, Odonata, Trichoptera, Acarina, Decapoda, Leeches (Hirudinea), Oligochaete worms, Bivalvia and Snails Gastropoda. This contrasted with the lowest number of macroinvertebrate orders (five in total) being collected from Sawyers Swamp Creek site DP9dn (Diptera, Ephemeroptera, Odonata, Trichoptera and Decapoda). Wangcol Creek site WC2 again only supported six orders. In spring there was generally less of a contrast between the Coxs River and Wangcol Creek sites (other than site WC2), with similar levels of diversity observed.

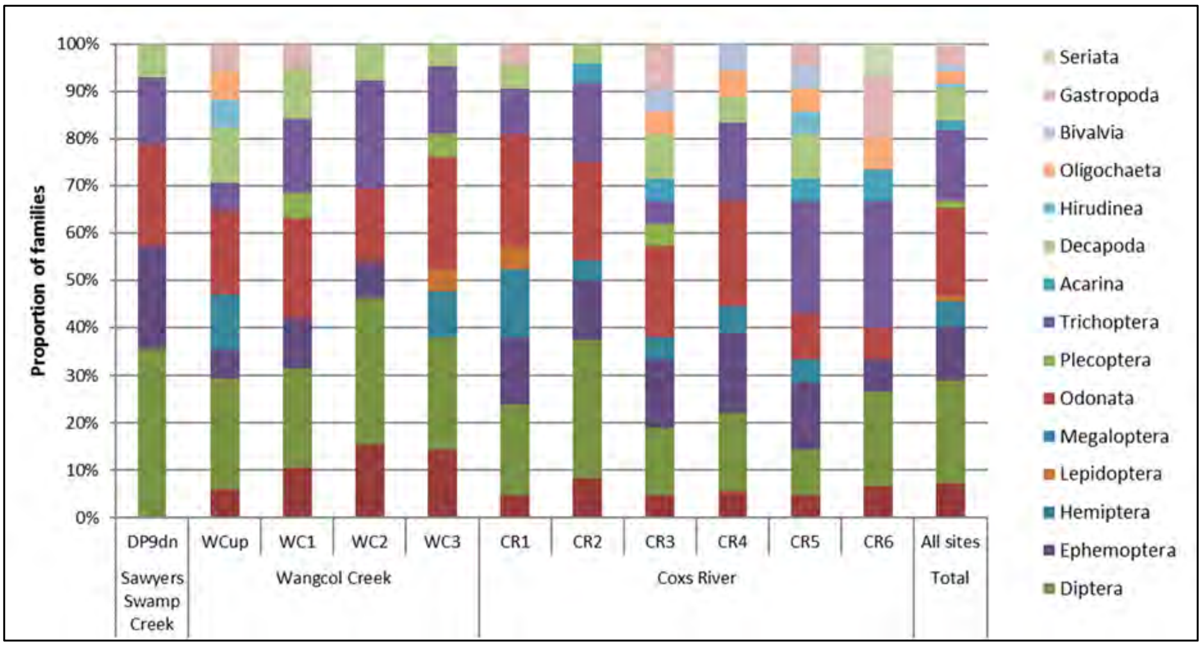


Figure 6-17 Relative richness of macroinvertebrate orders at each site sampled in spring 2015

6.5.6 Regional baseline sites - Lower Coxs River

Results for regional WaterNSW monitoring sites MMP37 and E086 are provided in Table 6-25.

Results for taxa richness are provided in Figure 6-18. Mean±SD number of families collected for site E086 were 22±1 and 21±2 for edge and riffle samples. Mean±SD number of families collected for site MMP37 were 28±6 and 21±4 for edge and riffle samples.

Results for taxa richness are provided in Figure 6-19. Mean±SD number of EPT families collected for site E086 were 6±1 and 9±1 for edge and riffle samples. Mean±SD number of EPT families collected for site MMP37 were 6±1 and 8±2 for edge and riffle samples.

Results for average SIGNAL-2 scores are provided in Figure 6-20. Mean±SD SIGNAL-2 scores for site E086 were 4.4±0.1 and 5.8±0.4 for edge and riffle samples. Mean±SD number of EPT families collected for site MMP37 were 3.9±0.1 and 5.3±0.4 for edge and riffle samples.

Table 6-25 Macroinvertebrate biological index results for Lower Coxs River (Regional baseline sites)

Index	E086								MMP37							
	Sp 12 (edge)	Sp 12 (riffle)	Sp 13 (edge)	Sp 13 (riffle)	Sp 14 (edge)	Sp 14 (riffle)	Sp 15 (edge)	Sp 15 (riffle)	Sp 12 (edge)	Sp 12 (riffle)	Sp 13 (edge)	Sp 13 (riffle)	Sp 14 (edge)	Sp 14 (riffle)	Sp 15 (edge)	Sp 15 (riffle)
Taxa richness	22	22	23	23	23	19	21	18	31	19	19	17	31	26	29	21
EPT richness	5	10	7	9	7	8	6	9	5	7	6	7	7	10	6	7
SIGNAL-2 score	4.6	5.5	4.3	5.7	4.2	5.7	4.5	6.4	3.9	4.7	4	5.5	3.9	5.6	4	5.3

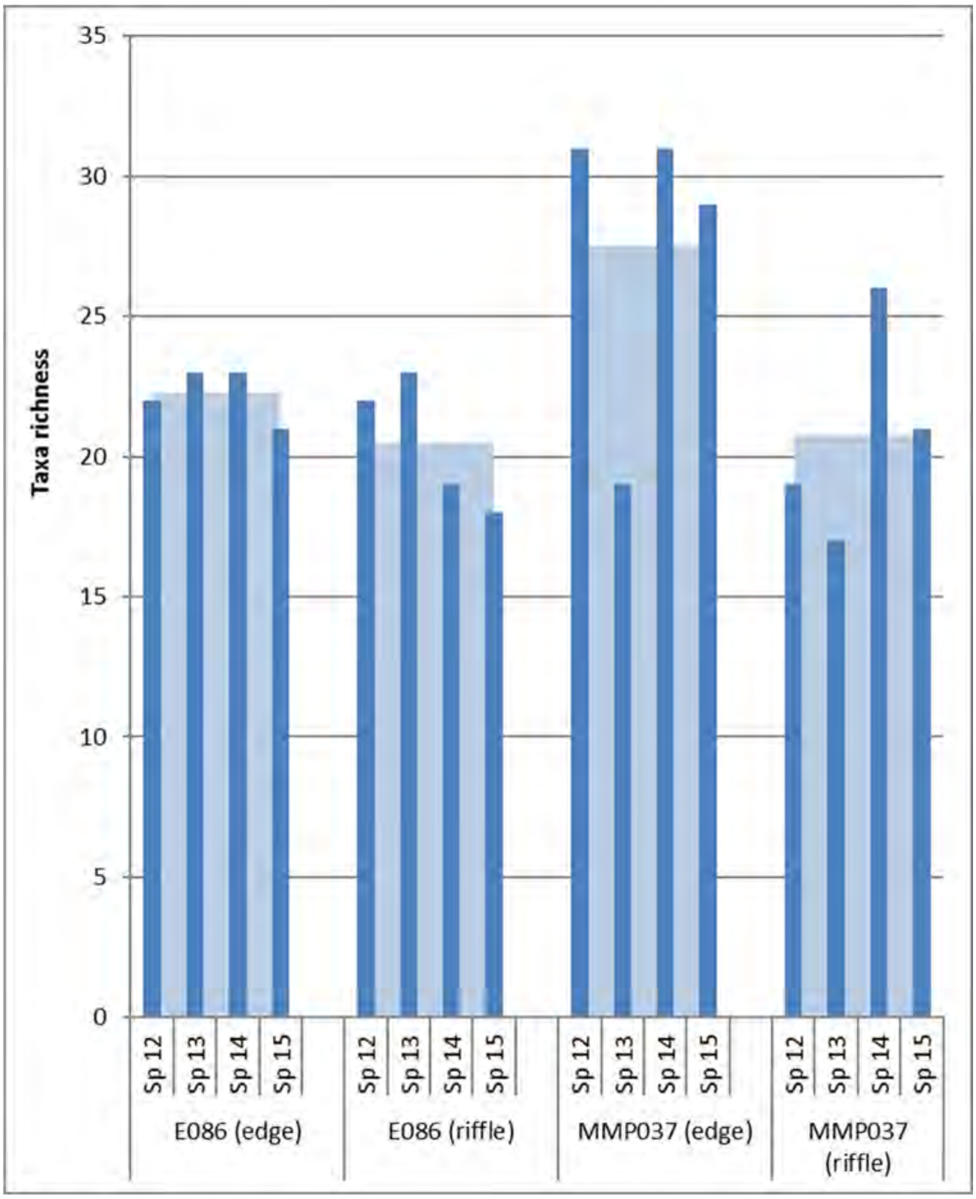


Figure 6-18 Taxa richness at Lower Coxs River between 2012 and 2015. Shaded area provides average across all sampling events

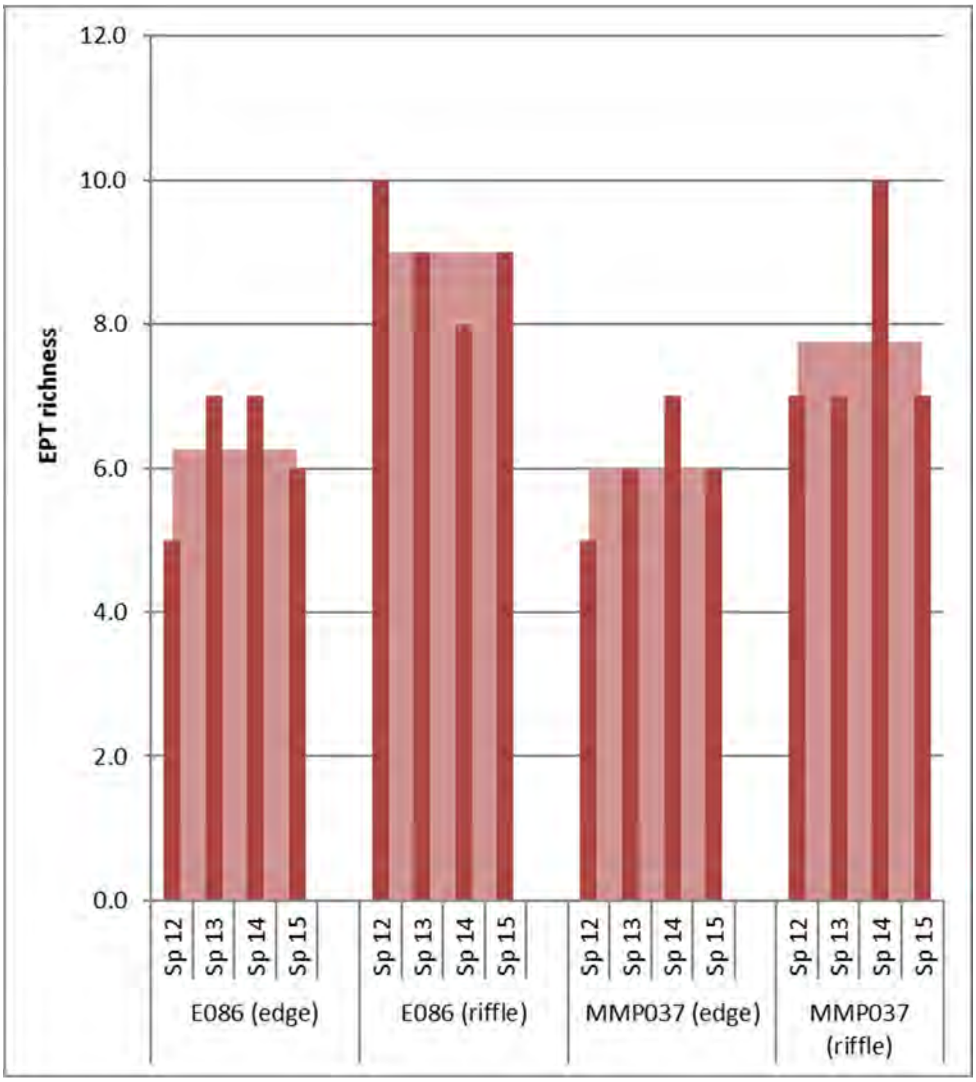


Figure 6-19 EPT richness at Lower Coxs River between 2012 and 2015. Shaded area provides average across all sampling events

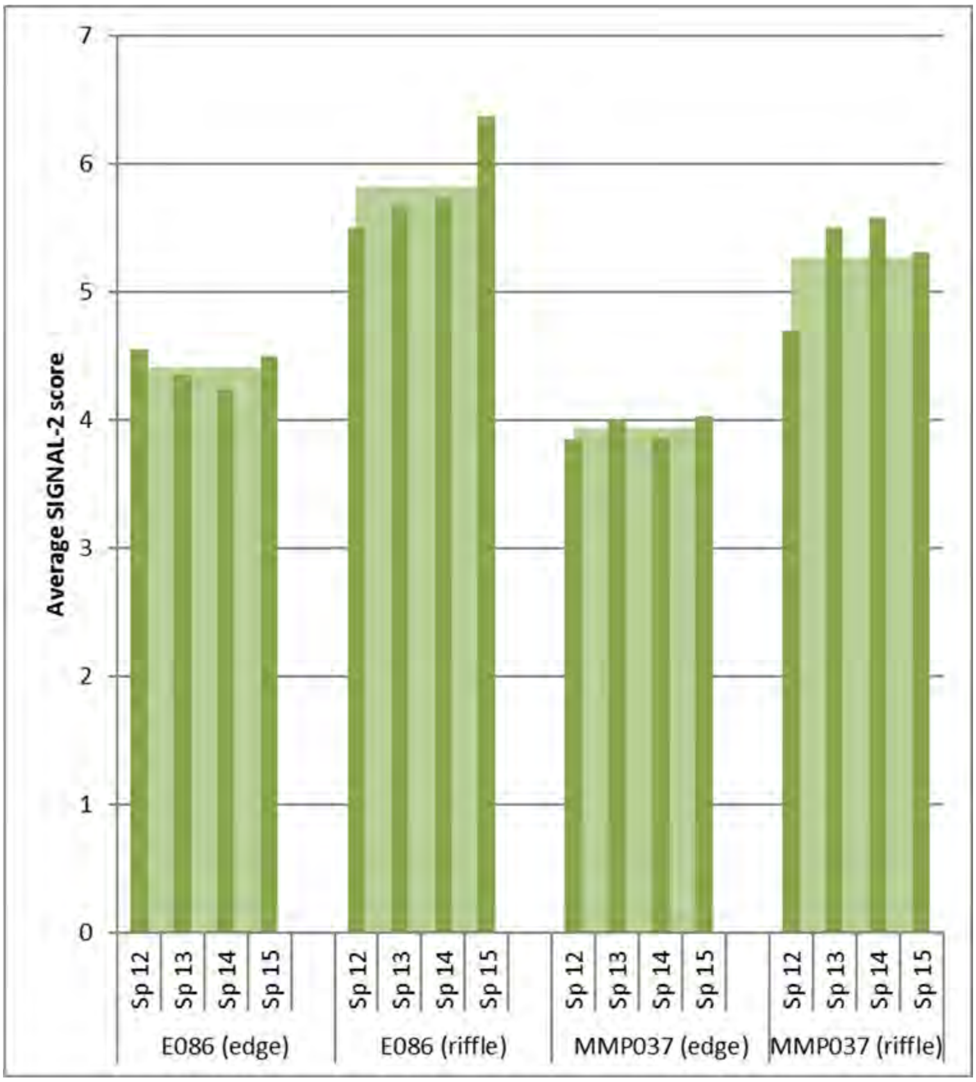


Figure 6-20 **SIGNAL-2 scores at Lower Coxs River between 2012 and 2015. Shaded area provides average across all sampling events**

6.5.7 Summary of macroinvertebrate community composition

Neubecks Creek

The single site on Neubecks Creek (NCdn) has displayed variable results between 2012 and 2014 in terms of macroinvertebrate taxa richness, with between 15 and 25 taxa recorded. This also applies with respect to EPT richness, where between one and six taxa have been recorded over six monitoring events. SIGNAL-2 scores have been more consistent, ranging from 3.2 to 4.4. Variation across seasons was observed for OE/50 score which ranged from conditions indicating severe degradation of water or habitat quality (autumn 2014) to conditions that are close to reference condition for the region (spring 2014).

Wangcol Creek

The sites located on Wangcol Creek vary in terms of macroinvertebrate community condition. Between 2013 and 2015 Site WC2 and to a lesser extent site WCup have consistently supported very low diversity, low EPT richness, low SIGNAL-2 scores and AUSRIVAS band ratings of severely impaired. Sites WC1 and WC3 have generally supported moderate to high diversity, moderate EPT richness, SIGNAL-2 scores and AUSRIVAS band ratings.

Variation was observed between years in terms of taxa richness but there was no consistent trend. There was some indication that there has been an increase in the number of EPT taxa collected in 2015 which was evident specifically at site WC2. SIGNAL-2 scores indicate that macroinvertebrates in this system are likely to be subjected to poor water quality. However, macroinvertebrate communities located at site WC3 (1.72 km downstream of WC2) showed some sign of recovery with a slightly greater mean SIGNAL-2 score. AUSRIVAS modelling suggested that site WC3 was in a condition similar to reference sites on occasion and had displayed the highest average AUSRIVAS score. This could suggest that there is sufficient dilution of contaminants to facilitate recovery of macroinvertebrate communities at site WC3. Other sites on Wangcol Creek had fewer macroinvertebrate families than expected and were considered to be significantly impaired, especially site WC2.

Coxs River

In general, monitoring sites on the Coxs River were found to have macroinvertebrate communities in relatively good condition. Sites CR1 to CR5 have recorded moderate to high taxa richness, EPT richness and SIGNAL-2 scores and AUSRIVAS ratings have not fallen below Band B (significantly impaired) at sites CR1, CR2 and CR4. However, site CR6 (downstream from Lake Wallace) appears to support a less diverse macroinvertebrate community, with lower index scores.

Between 2013 and 2015 site CR5 recorded AUSRIVAS scores which indicate that this site is of reference condition. Species richness and EPT scores were also relatively higher at site CR5. Variation was observed between years in terms of index results but no noticeable trends were observed at any of the sites monitored.

Sawyers Swamp Creek

Sawyers Swamp Creek was regularly monitored at one site (DP9dn) between 2013 and 2015. Results indicate that this site, downstream from the discharge point LDP009, displayed variable results that ranged from moderate to very low diversity but consistent SIGNAL-2 scores indicative of moderately degraded water quality. Sites upstream from discharge point LDP009 (SSWdn/SSCup) indicate that a more diverse macroinvertebrate community exists when water is present. The RCE inventory scores indicate that sites upstream have higher quality instream and riparian habitat than downstream from discharge point LDP009.

Regional baseline sites (Lower Coxs River)

Results for sites E086 and MMP37 indicate that, in general, the regional monitoring sites on the Coxs River were found to have macroinvertebrate communities in relatively good condition with moderate to high taxa richness, EPT richness and SIGNAL-2 scores, especially in samples collected from riffle habitat.

6.6 Macrophytes

Aquatic vegetation was recorded in all of the waterways within the Project. Macrophytes mainly comprised emergent growth forms, and were dominated by species of *Juncus*, *Typha* and *Eleocharis*. Three types of submerged macrophyte (curly leaf pondweed [*Potamogeton crispus*], Starwort [*Callitriche* sp.] and River buttercup [*Ranunculus inundatus*]) were observed.

No aquatic vegetation recorded within the IAA or reference waterways were listed as threatened under FM Act or EPBC Act. Macrophyte taxa observed at each site by GHD (2014b) and MPR (2014b; 2015a, b, c and d) are shown in Table 6-26.

In the Coxs River the greatest number of macrophytes were recorded from site CR1 (eight taxa), located upstream of the Wangcol Creek confluence. The lowest number of taxa were recorded from sites CR5 and CR6 (five taxa). In Wangcol Creek the greatest number of taxa were recorded at WC1 and WC2 (four taxa) and the lowest number recorded from site WC3 (two taxa). In Sawyers Swamp Creek a greater number of macrophytes were observed at the upstream site SSCup (seven taxa) than at site DP9dn (four taxa).

In general, a greater diversity of macrophytes were therefore observed in the Coxs River, when compared to Wangcol and Sawyers Swamp Creeks.

Table 6-26 Macrophyte taxa observed between 2013 to 2015 (GHD 2014b; MPR 2014b; 2015a, b, c and d)

Family	Common name	Scientific name	NCdn	WCup	WC1	WC2	WC3	CR1	CR2	CR4	CR5	CR6	SSWdn^	SSCup	DP9dn
Emergent growth form															
Cyperaceae	Soft twig sedge	*Baumea rubiginosa*				✓*				✓				✓*	✓*
	Umbrella sedge	*Cyperus eragrostis**								✓					
	Tall spike rush	*Eleocharis sphacelata*						✓*						✓*	
	Spike rush	*Eleocharis sp.*	✓			✓*		✓*	✓						✓*
	River clubrush	*Schoenoplectus validus*						✓*			✓*	✓*			
	Fen sedge	*Carex gaudichaudiana*			✓*	✓*		✓*	✓	✓				✓*	
Juncaceae	Joint leaf rush	*Juncus articulatus**		✓*	✓*		✓*	✓*	✓*	✓		✓*		✓*	✓*
	Common rush	*Juncus usitatus*	✓	✓	✓	✓	✓	✓*	✓	✓					
	Bulbous rush	*Juncus bulbosus*												✓*	
Poaceae	Common reed	*Phragmites australis*								✓		✓*			
Typhaceae	Cumbungi	*Typha sp.*		✓	✓				✓		✓*	✓*		✓*	✓*

Family	Common name	Scientific name	NCdn	WCup	WC1	WC2	WC3	CR1	CR2	CR4	CR5	CR6	SSWdn^	SSCup	DP9dn
Polygonaceae	Knotweed	*Persicaria sp.*						✓*				✓*			
Schrophulariaceae	Blue water speedwell	*Veronica anagallis-aquatica*									✓*			✓*	
Brassicaceae	Watercress	*Nasturtium officinale*									✓*	✓*			
Submerged growth form															
Potamogetonaceae	Curly leaf pondweed	*Potamogeton crispus*	✓						✓*		✓*	✓*			
Plantaginaceae	Starwort	*Callitriche spp.*						✓							
Ranunculaceae	River buttercup	*Ranunculus inundatus*													
Taxa richness			**3**	**3**	**4**	**4**	**2**	**8**	**6**	**5**	**5**	**7**		**7**	**4**
Algae															
	Charophyta				✓	✓*		✓*		✓	✓*				

* indicates records added by MPR (2014b, 2015a, b, c & d)

^ indicates site not surveyed for aquatic macrophytes

6.7 Summary of water quality assessment

The WRIA (GHD, 2016) undertaken for the Project characterised current surface and groundwater quality of the environment specific to the Project. The main outcomes of this included:

- Waterways with the potential to be influenced by the Project were considered to include the wider Coxs River catchment downstream to Lake Burragorang.
- The Project will result in direct changes in water quality within the Coxs River catchment through the cessation of discharges from Springvale Mine LDP009 and intermittent discharge from a new LDP into Wangcol Creek located adjacent to LDP006 discharging into Wangcol Creek via Lamberts Gully.
- Catchment specific guideline values were derived based on water quality from Neubecks Creek given the influences of the MPPS and SCSS on the water of Wangcol Creek. Wangcol Creek quality was more subject to groundwater influences and existing discharges whereas Coxs River was dominated by LDP009 discharges downstream of Sawyers Swamp Creek.

6.7.1 LDP006 (Lamberts Gully/Wangcol Creek)

Currently, water discharges at a rate of approximately 1.29 ML/day from LDP006 into Wangcol Creek. Key components of the water quality of the current LDP006 discharges are:

- Exceedance of ANZECC (2000) guideline values for electrical conductivity (EC) (median of 3,040 μ/cm).
- Low turbidity and TSS (median 9 NTU and 5 mg/L, respectively).
- Near-neutral pH (median 6.8 pH units).
- Concentrations of some metals exceed ANZECC (2000) guideline values (boron, copper, manganese, nickel, zinc).
- Nutrient concentrations below ANZECC (2000) guideline values.
- Extremely hard water (median hardness 1,060 mg/L).
- Elevated sulfate concentrations (median 1,505 mg/L).
- Sodium dominated (relative to other cations).

6.7.2 LDP009 (Sawyers Swamp Creek)

Currently water discharge at a rate of approximately 20 to 25 ML/day from LDP009 into Sawyers Swamp Creek. Key components of the water quality of the current LDP009 discharges are:

- Exceedance of ANZECC (2000) guideline values for electrical conductivity (EC) (median of 1,170 μ/cm) of upland NSW rivers.
- Turbidity and TSS within recommended ANZECC (2000) range for upland NSW rivers (median 4 NTU and 5 mg/L, respectively).
- Near-neutral pH (median 7.8 pH units), within recommended ANZECC (2000) range for upland NSW rivers.
- Concentrations of some metal exceed ANZECC (2000) guideline values (arsenic, zinc).
- Nutrient concentrations generally below ANZECC (2000) guideline values.
- Soft water (median hardness 15.5 mg/L).

- Low sulfate concentrations (median 37 mg/L).
- Sodium dominated (relative to other cations).

6.7.3 Receiving water quality

Water quality varied between the creek systems with Neubecks Creek generally recording the best water quality conditions for those parameters sampled. In Wangcol Creek, EC generally exceeded the ANZECC (2000) guideline value of 350 µS/cm at most sites, with median concentrations of 361 µS/cm, 244 µS/cm, 1,640 µS/cm and 1,930 µS/cm at sites WCup, WC1, WC2 and WC3, respectively. Median pH was within the ANZECC (2000) guideline range at all Wangcol Creek sites and median turbidity also fell below the guideline value at all sites. Total nitrogen concentrations exceeded the ANZECC (2000) guideline value of 0.25 mg/L with a median concentration of 0.3 mg/L at sites WCup and WC1, total phosphorus exceeded the guideline value of 0.02 mg/L with a median concentration of 0.02 and 0.03 mg/L at sites WCup and WC1. The median ammonia concentration was below the guideline value at all Wangcol Creek sites. Elevated dissolved metal concentrations were recorded at Wangcol Creek sites with copper elevated at sites WCup and WC1 (median 0.002 mg/L) and aluminium elevated at site WC1 only (median 0.11 mg/L). Dissolved iron concentrations were found to exceed the ANZECC guideline value of 0.3 mg/L on occasion at site WC1. Orange iron precipitate was also noted instream during all surveys at site WC2 on Wangcol Creek (GHD 2014b). GHD (2014b) reported that dissolved oxygen (DO) concentrations were low during sampling carried out in 2013 and 2014.

In the Coxs River (site CR4) EC generally exceeded the ANZECC (2000) guideline value with a median of 1030 µS/cm. MPR (2015d; 2016b) indicate that low EC (<100 µS/cm) has been recorded consistently in the Coxs River upstream from Wangcol Creek however EC is periodically influenced by Angus Place LDPs. Low turbidity was observed consistently. Median dissolved metal concentrations were generally below ANZECC (2000) guideline values.

No data was available for the site downstream of LDP009 on Sawyers Swamp Creek. However, water quality at downstream monitoring sites within Coxs River is representative of LDP009 discharge quality. Discharges from LDP009 are regulated by discharge limits defined within EPL 3607 which typically are above ANZECC (2000) guideline values.

6.8 Summary of instream ecology

Monitoring data collected at Neubecks Creek indicate that the creek is an ephemeral stream with limited aquatic habitat and riparian vegetation that was dominated by sedges and terrestrial grasses. The creek also has limited riparian shading and instream habitat diversity which provides little in the way of habitat for fish. Where water was available, the creek displayed relatively low salinity and no evidence of significant influence from historical mining which is typical of waterways in the IAA. The macroinvertebrate community has displayed moderate diversity over time.

Wangcol Creek is a third to fourth-order stream which is highly degraded due to past land-use activities. Minimal instream habitat remains within the creek and there is evidence to suggest that site WC2, located closest downstream of the LDP006 discharge, is the most degraded of the sites. Poor water quality (consistently high EC and occasional low DO) was also evident within the creek. These results are reflected on the macroinvertebrate results from monitoring where a low level of diversity was observed, especially at site WC2. Signs of recovery in terms of habitat condition and macroinvertebrate diversity was noted at site WC3, near to the Coxs River confluence.

Coxs River is a perennial waterway with evidence of moderate to good instream habitat but generally poor riparian zone condition in the upper sections of the catchment. Monitoring data indicates that site CR2 has more degraded riparian and aquatic habitat conditions than the other sites on the Coxs River, although this has not necessarily contributed to a more impacted macroinvertebrate community at this site. In general, monitoring sites on the Coxs River were found to have macroinvertebrate communities in relatively good condition, despite evidence of elevated EC downstream from the Wangcol Creek confluence and Sawyers Swamp Creek. Site CR6 (downstream from Lake Wallace) appears to support a less diverse macroinvertebrate community, with lower index scores which is generally inconsistent with observed water quality and diversity relationships.

The macroinvertebrate community of Sawyers Swamp Creek displayed very low to moderate diversity with variability between monitoring location and season. Results indicate that sites upstream from LDP009 have higher quality instream and riparian habitat than downstream from discharge point LDP009. Elevated EC was evident downstream from LDP009 as a result of current discharge activities. Macroinvertebrate diversity was higher at sites upstream of the LDP009, likely due to this combination of factors

Table 6-27 provides a summary of the instream ecology of the IAA and reference waterways.

Table 6-27 Summary of instream ecology results

Waterway	Neubecks Creek	Wangcol Creek	Coxs River	Sawyers Swamp Creek
Water quality and stream type	Ephemeral fourth order stream Sites Ncup and NCdn dry during spring 2013 and 2014 surveys. Flow observed at site NCdn but known to dry to isolated pools Elevated nutrient concentrations Low EC High background concentration of some dissolved metals	Perennial stream (groundwater fed). WCup third order; WC1-WC3 fourth order Series of connected pools, slight surface flow observed during surveys. Elevated nutrient concentrations High EC Some evidence of dissolved metal contamination	Perennial river. Series of connected pools with moderate flow during surveys. High EC downstream from Wangcol Creek	Ephemeral stream. Consistent flow downstream from LDP009 Upper reaches predominantly dry between 2013-2015 High EC downstream from LDP009
Riparian and aquatic habitat	Average RCE% range = 57-73% Moderately degraded due to previous land use impacts such as grazing. Minimal instream habitat remains.	Average RCE% range = 48-58% Highly degraded due to impacts of historical mining and regional industrial activities. Minimal instream habitat remains.	Average RCE% range = 41-70% Moderately degraded due to land use impacts, such as mining and agriculture. Moderate instream habitat present.	Average RCE% range = 53-81% Lower reaches moderately degraded due to land use impacts, such as mining. Upper reaches largely intact. Good instream habitat present at upstream sites. Poor instream habitat downstream of LDP009.
Aquatic flora	Three taxa observed	Two - four taxa observed	Five - eight taxa observed	Four - seven taxa observed.
Vertebrate fauna	One native fish species recorded (Mountain galaxias). No threatened species encountered and none	Two native fish species recorded (Flat-headed gudgeon and Mountain galaxias). One introduced species recorded (Eastern gambusia).	Two native fish species recorded (Flat-headed gudgeon and Mountain galaxias). Two introduced species recorded (eastern gambusia and brown	No fish observed. No threatened species encountered and none expected to occur due to the

Waterway	Neubecks Creek	Wangcol Creek	Coxs River	Sawyers Swamp Creek
	expected to occur due to the highly ephemeral nature of the waterway. Class 3-4 fish habitat.	No threatened species encountered and none expected to occur due to the ephemeral nature of the waterway. Class 3 fish habitat.	trout). No threatened species encountered and none expected to occur in theses reaches of the waterway based on past records and likely distribution. Class 2 fish habitat.	ephemeral nature of the waterway. Class 3 fish habitat.
Macroinvertebrates	Moderate diversity, with some EPT taxa present, moderate SIGNAL 2 scores and AUSRIVAS scores indicating pollution and/or poor habitat. Average taxa richness: 21 Average EPT score: 4 Average SIGNAL-2 score: 4 Average AUSRIVAS score: 0.6	Low to moderate diversity, with some EPT taxa present, moderate SIGNAL 2 scores and AUSRIVAS scores indicating pollution and/or poor habitat. Evidence of improved waterway health at most downstream site (WC3). Results indicate poorest river health at site WC2. Average taxa richness: 10-21 Average EPT score: 2-5 Average SIGNAL 2 score: 3.7-4.4 Average AUSRIVAS score: 0.3-0.7	Moderate to high diversity, including numerous EPT taxa and moderate SIGNAL-2 scores. AUSRIVAS scores indicate moderate to reference condition community present with existing condition likely due to poor water quality. Results indicate good river health at site CR5. Average taxa richness: 21-25 Average EPT score: 5-7 Average SIGNAL 2 score: 3.9-4.3 Average AUSRIVAS score: 0.7-1.0	Low to high diversity, including low numbers of EPT taxa and moderate SIGNAL-2 scores. Evidence of improved waterway health at site upstream of LDP009 (SSWdn). Average taxa richness: 16-19 Average EPT score: 3 Average SIGNAL 2 score: 3-5 Average AUSRIVAS score: n/a

7. Groundwater dependent ecosystems (GDEs)

7.1 Terrestrial GDEs

No terrestrial GDEs were determined to be associated with the waterways within the IAA. Discussions of any potential terrestrial GDEs associated with the proposed disturbance areas are discussed within the Biodiversity Assessment Report (RPS, 2016).

The mapping undertaken on groundwater dependence (Figure 7-1) indicates little or no potential for groundwater interaction associated with the waterways within the IAA. This reflects the disturbed nature of the PAA. The threatened species, Black Gum, which was discussed in Section 5 is known to have a preference for waterlogged conditions and hence does not fulfil the requirement of a GDE as per the *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* of being substantially dependent on groundwater.

7.2 Subterranean GDEs

Stygofauna are entirely groundwater dependent (obligate) and are restricted to locations of groundwater discharge or within aquifers. Due to this dependence, stygofauna communities are particularly sensitive to, and can be impacted by, a range of factors that alter groundwater levels such as water pressure, water chemistry and aquifer structure.

7.2.1 Stygofauna in Australia and NSW

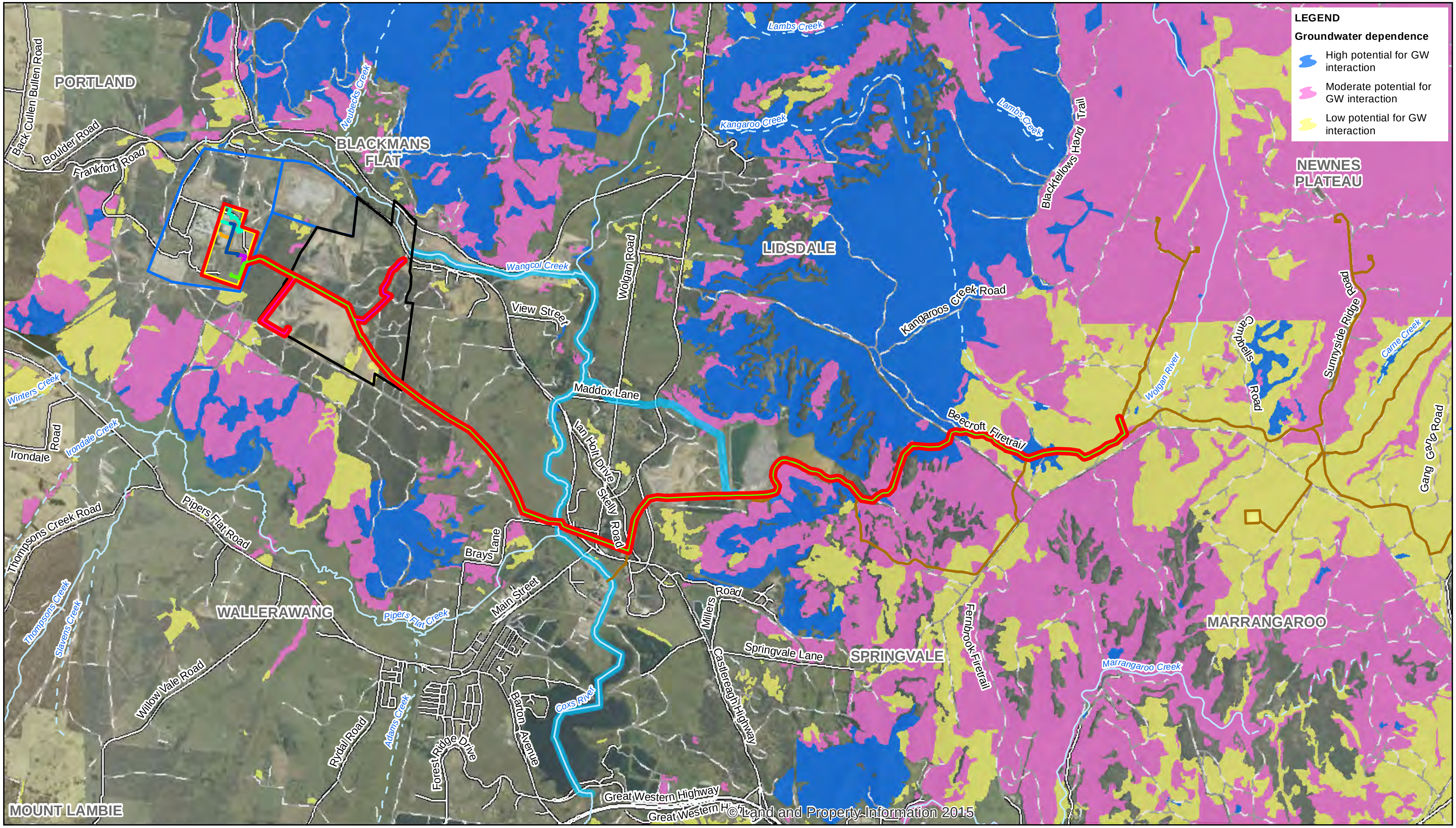
The National Water Commission reported that extensive gaps exist in our knowledge of the distribution, composition and biodiversity value of Australian stygofauna (Richardson *et al.*, 2011). Despite this incomplete inventory it is apparent that stygofauna are present across a variety of Australian subsurface environments and are generally characterised by high diversity and local-scale endemicity.

In NSW there are currently more than 360 taxa that have been collected from approximately 60% of the known cavernous karst systems. Available information on the distribution of stygofauna within NSW aquifers is both sparse and scattered and the need for further work, particularly in the shallow unconsolidated aquifers, has been identified (Serov *et al*., 2012). In NSW, stygofauna have been collected mostly from alluvial aquifers, particularly aquifers with coarse sediments, shallow water tables and low EC (Hancock and Boulton, 2008).

One coal mining area that has a longer history of stygofauna sampling is the Hunter Valley in NSW, where surveys of alluvial aquifers were conducted between 2000 and 2008. Surveys of the groundwater/surface water interface along the Hunter River between Singleton and Glenbawn Dam from 2000 and 2003 found a diverse community of stygofauna (Hancock, 2004).

A follow-up project was carried out from 2004 to 2008 and surveyed groundwater monitoring bores in agricultural areas and on several mine sites of the upper Hunter Valley (Hancock and Boulton, 2008). The latter work found at least 40 taxa new to science (this number is likely to increase since not all specimens have yet been identified to species) and confirmed that stygofauna can exist in areas dominated by coal mining.

Recent stygofauna surveys in Gunnedah and Bengalla (ELA, 2011; ELA, 2013), located in the NSW coalfields which are located within approximately 300 km of the PAA, also support that these areas of NSW can support stygofauna. Six stygofauna taxa were collected from the Bengalla study area.



Paper Size A4

0 0.275 0.55 1.1 1.65 2.2

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
- Brine transfer pipeline
- Crystallised salt transfer pipelines
- Proposed raw water transfer pipeline
- Residuals transfer pipeline
- Treated water pipeline
- Treated water pipeline to cooling tower forebay
- Existing and approved SDWTS
- Road
- Vehicular track
- Watercourse - Non Perennial
- Watercourse - Perennial

GHD

Centennial Coal
EA/CEY Water Treatment Project
Aquatic Ecology Impact Assessment

Job Number	21-25109
Revision	0
Date	12 Aug 2016

Groundwater dependence

Figure 7-1

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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. Created by: tmorton, kpsroba

7.2.2 Stygofauna in the regional area

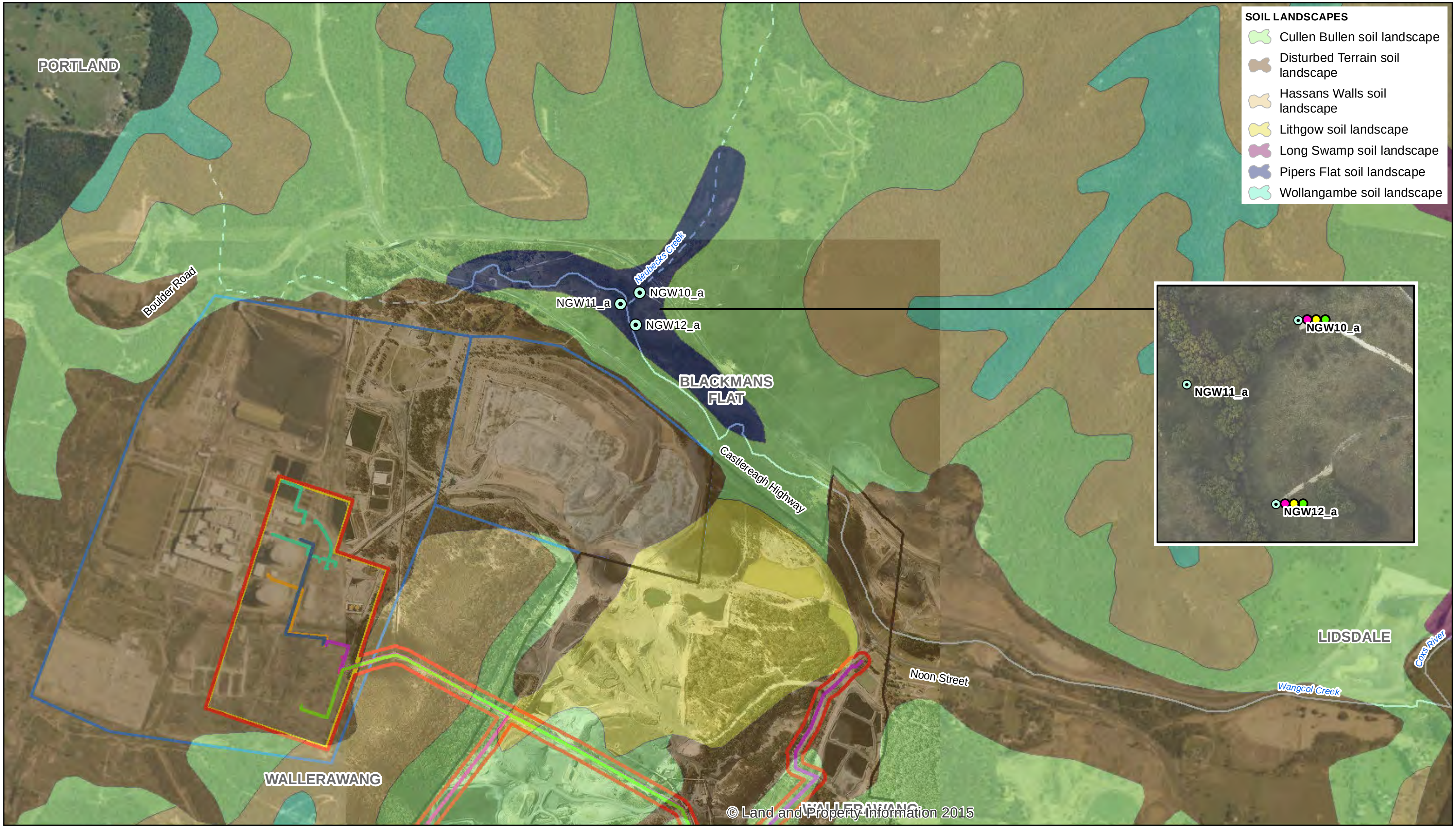
Stygofauna communities have been observed within the groundwater environments associated with the Springvale Mine and Angus Place Colliery (MPR, 2012b; Cardno, 2013b; Cardno, 2013c). The studies revealed the following:

- The pilot survey conducted at Angus Place Colliery (MPR, 2012b; Cardno, 2013b) was undertaken in May 2012 targeting the shallow groundwater below individual swamps and near-surface aquifer in the Banks Wall Sandstone below the PAA. Cardno (2013b) determined that stygofauna were patchy. Two likely stygofauna taxa were collected from the eight bores sampled.
- The pilot survey was conducted at Springvale Mine (MPR, 2012b; Cardno, 2013c) in May 2012. A total of 17 bores were sampled for stygofauna. Cardno (2013c) determined that the occurrence of invertebrates was patchy. Four likely stygofauna were collected from the 17 bores.
- MPR (unpublished data 2012) found five possible stygofauna taxa from eight of the 12 bores sampled within the vicinity of the proposed Neubeck Coal Project.

7.2.3 Stygofauna in the vicinity of PAA

Results of the monitoring program conducted by GHD (2014b) in relation to the Neubeck Coal Project are summarised below. Of particular significance to this assessment are the bores located in close proximity to Neubecks Creek and Wangcol Creek within the alluvial groundwater environment, where obligate stygofauna were collected. The sampled shallow alluvial bores, located in the vicinity of Wangcol Creek and Neubecks Creek, are shown in Figure 7-2.

Their presence in such close proximity to the PAA indicates the potential for stygofauna to be present in alluvial aquifers within the vicinity of the Project. However, these bores are up-gradient of the PAA. Furthermore, the alluvial groundwater environment has been identified as discontinuous along Wangcol Creek with soil mapping indicating no alluvial material past the confluence of Wangcol and Neubecks Creek (GHD, 2016). This is likely due to the high levels of disturbance in the PAA. This would be expected to limit the potential for stygofauna to be present within the PAA.



Centennial Coal
EA/CEY Water Treatment Project
Aquatic Ecology Impact Assessment

Job Number 21-25109
Revision 0
Date 12 Aug 2016

Location of groundwater monitoring bores

Figure 7-2

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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. Created by: tmorton, kpsroba

8. Potential impacts on aquatic ecology

8.1 Scale of assessment

Based on results of water and salt balance modelling undertaken as part of the WRIA (GHD, 2016), the Project is predicted to likely have a varying degree of influence on the aquatic environment at different scales. The highest potential for influence from the Project will be as a result of the potential releases into Wangcol Creek in the event that transferred water is not recycled within MPPS.

Influences of the Project are likely to also occur on the Sawyers Swamp Creek catchment and generally the Coxs River downstream of the confluence with each of these waterways.

The potential influences to these creeks (including the Coxs River between the Wangcol Creek confluence and Lake Wallace) are classified as localised impacts. The influences of the Project on the Coxs River, between Lake Wallace and Lake Burragorang are classified as regional impacts.

8.2 Impacts to water resources

The impacts to aquatic ecology have been characterised through the potential impacts to water resources. This has been assessed against the Projects potential for:

- Hydrological change to waterways downstream of the Project.
- Changes to surface water quality of waterways downstream of the Project.
- Potential impacts to regional waterways.

8.2.1 Changes to hydrology and hydraulics

Wangcol Creek and Coxs River downstream of Wangcol Creek confluence

The Project will result in new intermittent discharges of up to 32 ML/day into Wangcol Creek (GHD, 2016). Discharges from the new discharge point, adjacent to the existing LDP006 at SCSS, will occur in the event that all water transferred to the WTP is not reused as part of cooling water demands at MPPS. Demands at MPPS typically vary with power generation which currently has a diurnal cycle. Historically the power station has required at least 30 ML/day for cooling water. As the proposed transfers from the SDWTS are predicted to vary between 17 ML/day to 36 ML/day and currently average 24 ML/day, a discharge of any significant volume to Wangcol Creek is only likely to occur during a period of WTP maintenance or power plant shut down. Previously, shut-down periods have lasted only 1-2 days. The Project proposes not to discharge untreated water to Wangcol Creek and proposes to maintain emergency storage volumes in the event of any unforeseen circumstance which may lead to the shutting down of the WTP (GHD, 2016).

Wangcol Creek is not considered a high value waterway in terms of fish populations and generally supports a pollution-tolerant macroinvertebrate community that has demonstrated high variability in community condition (based on richness, EPT richness and SIGNAL-2) between sampling events (see section 6.5). This variability in the macroinvertebrate community has been observed both upstream of LDP006 discharges which suggests that environmental conditions are naturally variable within this system and that the macroinvertebrate community responds to these changes. The current macroinvertebrate community in Wangcol Creek is characteristic of the poor habitat, intermittent flows and poor water quality (e.g. elevated salinity) of Wangcol Creek. The current flow regime in Wangcol Creek includes an estimated baseflow contribution of 1.2 ML/day through groundwater inputs associated with recharging underground mining voids. Based on a Wangcol Creek flow volume and level gauging station (212055), between 1991 and 2010, Wangcol Creek had been dry only sporadically, however since 2010 water in the creek has been maintained (GHD, 2016).

Flow volume data provided from the gauge site suggests that significant flow events have occurred within Wangcol Creek with magnitudes of more than 300 ML/day in the order of 10 times between 1991 and 2015. Less significant flow events (less than 50 ML/day) have occurred more regularly between 1991 and 2015. The WRIA (GHD, 2016) considered the potential effect of a 'worst case' discharge event of 32 ML/day on hydrology and hydraulics within Wangcol Creek. The outcome from these assessments indicated that the likely change in water level in Wangcol Creek as a result of a 'dry day' discharge of 32 ML/day is likely to change the depth of water within the creek from 0.1 to 0.2 metres. This corresponded to a velocity increase of between 0.5 to 1.0 m/s within the creek. In the event of a design rainfall event such as a 1-year Average Recurrence Interval (ARI) event, the influence of discharges decreases further with the proposed 'worst case' discharge being 1.1% of the total flow rate produced within the creek in that event. Further assessment and presentation of gauge data is provided in the WRIA (GHD, 2016).

MPR (2016) reported that a 9-day rainfall event of approximately 46 mm (based on the BOM Lidsdale gauge) in the lead up to the spring 2015 aquatic ecology sampling resulted in flows of approximately 25.6 ML/day at the Wangcol Creek NOW gauge, located upstream of LDP006. With the addition of LDP006 discharge volume, this would have resulted in flows of greater than 25 ML/day downstream of LDP006 which is approaching the proposed maximum discharge rate of 32 ML/day. Macroinvertebrate diversity (taxa richness) following this flow event was reportedly lower at WC2 located downstream of LDP006, when compared to the autumn 2015 event (14 taxa compared to 17 taxa observed in autumn). However, macroinvertebrate sensitivity (SIGNAL-2) at WC2 in spring 2015 was found to be higher than in autumn 2015 and higher than the average calculated over 11 sampling events (MPR, 2016). A corresponding reduction in EC (was observed by MPR in spring 2015 compared to autumn 2015 (from 1,468 to 951 µS/cm), which is likely to be linked to the increased macroinvertebrate sensitivity. This result demonstrates that the proposed maximum discharge rate of 32 ML/day is within the natural experience of the macroinvertebrate community in Wangcol Creek, and although some changes to community composition may occur as a result of such occasional high flow events, impacts to diversity, if they occur, would likely be minor. There is also the potential for improvements to the macroinvertebrate community as a result of the proposed discharges through improved water quality as indicated by the increase in SIGNAL-2 observed in spring 2015.

The geomorphology review of the proposed discharges, as part of the WRIA (GHD, 2016), has suggested that whilst the predicted velocity is below erosion thresholds, it is likely that potential channel adjustment risks will arise with a higher discharge rate maintained over long durations at or close to the maximum proposed discharge rate. However, discharges to Wangcol Creek as a result of the Project will vary daily to seasonally depending on power demands, with discharges on average being much less than the 'worst case' discharge rate. Given this, widespread and systemic channel adjustment along Wangcol Creek downstream of the existing LDP006 is not expected to occur as a result of the Project (GHD, 2016). It is more probable that isolated localised erosion of toe banks may occur depending on the local channel morphology and existing vegetation associations at any point along the creek. Given that erosive processes respond differently dependent on exposure time, the consideration of duration of a 'worse case' was considered. The likelihood of a 'worst case' discharge extending for any significant period of time is low due to the management mechanisms that are to be considered in the overall design of the WTP.

Based on the geomorphology assessment, it is unlikely that the physical characteristics of Wangcol Creek such as substrate type, channel shape and presence of undercut banks will be altered. Therefore, impacts to macroinvertebrates and fish through reduction in instream habitat is not expected as a result of the Project. It is possible that there will be small-scale, temporary changes in velocity-based micro-habitat such as edge or riffle through increased flows during periods of reduced power requirement. However, although specific patches of micro-habitat may be altered in nature i.e. increased water level in previously shallow sections, there is not expected to be any loss of these micro-habitats across the Wangcol Creek system. Therefore, no loss of macroinvertebrate diversity is expected to occur within Wangcol Creek as a result of the changes to the flow regime.

Mountain Galaxias are the only native species observed in Wangcol Creek across the MPR and GHD surveys. Mountain Galaxias have been found to have wide habitat preferences, having been observed within fast-flowing and slower flowing systems. This has been demonstrated by the widespread observation of this species across sites in Neubecks Creek, Coxs River and Wangcol Creek despite vast differences in water availability and flow regime. Therefore, the proposed intermittent discharges into Wangcol Creek are highly unlikely to reduce the distribution of Mountain Galaxias in Wangcol Creek. The additional flows contributed by the proposed discharge is likely to increase fish habitat, if anything, within Wangcol Creek.

The invasive Gambusia have already been recorded in Wangcol Creek and Coxs River and, therefore, there is no risk of this species spreading as a result of the Project. There is a possibility that if flow velocity is increased due to the new discharges, Gambusia may move out Wangcol Creek as they are preferential of ponded water. The temporarily increased flows contributed to Wangcol Creek by the new discharge is not likely to be of a scale that would promote the spread of the introduced Brown Trout upstream into Wangcol Creek, however, there is the possibility of this species to move further upstream in Coxs River. Brown Trout were not observed, in the GHD or MPR studies conducted between 2012 and 2015, further upstream than CR4.

Given the larger volume of water in Coxs River the fluctuations in flow from the proposed discharge point are unlikely to be of a magnitude that would influence the instream ecology of the Coxs River. The Coxs River, at the confluence of Wangcol Creek, is characterised by a lake-like environment created by the past capture of the river into the open cut pit voids of an abandoned Commonwealth Mine. The velocity of water entering the Coxs River from Wangcol Creek would be buffered by the large waterbody located at the confluence.

Given the low frequency of discharges expected, there are not expected to be impacts to the aquatic ecology of Wangcol Creek and the Coxs River as a result of the altered flow regime as a result of the Proposed discharges. The response of the aquatic communities in Wangcol Creek and Coxs River will be monitored as part of the existing aquatic ecology monitoring programs at SCSS, the aim being to determine a discharge and response relationship in order to refine future management of discharge volume.

Sawyers Swamp Creek

The habitat conditions within Sawyers Swamp Creek vary significantly due to the presence of infrastructure and emplacement area. This has resulted in multiple realignments along Sawyers Swamp Creek which not only degrade habitat and riparian vegetation quality, but also increase flow velocities within areas with engineered channel. No fish have been observed within Sawyers Swamp Creek and macroinvertebrate diversity was very low to moderate. The Project proposes to cease LDP009 discharges into Sawyers Swamp Creek. The cessation of discharges to Sawyers Swamp Creek will result in a reduction in water availability and, thus, instream habitat which will likely result in a decline of the macroinvertebrate population during dry periods. However, as this system is naturally ephemeral, the removal of discharges is considered to be a return towards the natural flow regime and, thus, an acceptable outcome of the Project.

Coxs River, downstream of Sawyers Swamp Creek

At present the Coxs River, receives flows from Sawyers Swamp Creek via discharges from LDP009 of approximately 20 to 25 ML/day. The Project will lead to the cessation of these flows. Macroinvertebrate community condition is improved in Coxs River downstream of the Sawyers Swamp Creek confluence, compared to some sites upstream. However, this is considered to be due to improvements in habitat and riparian vegetation rather than increased water availability. Further, the Coxs River is a perennial river and the cessation of LDP009 discharges will not alter this status. Therefore, the cessation of LDP009 is not expected to impact on the aquatic ecology of Coxs River through changes to hydrology.

It is unlikely that flow rate effects (such as velocity, water depth) will be observed downstream of Lake Wallace of a magnitude that would influence aquatic ecology. This is due to the regulation that not only Lake Wallace provides but also Lake Lyell. This regulation allows for the controlled capture and release of water within specific thresholds defined as part of their function, defined within the respective management licences. This influencing factor is more significant at Lake Lyell with transfers to MPPS to supplement cooling water demands as required.

8.2.2 Changes to water quality

Proposed discharge quality

The new LDP for the Project is proposed to be located on the Lamberts Gully draining to Wangcol Creek. The recommended volumetric discharge limit for the proposed LDP is 32 ML/day, which is based on the maximum discharge specification for the WTP. The recommended water quality limits are provided in the Water Resources Impact Assessment (GHD, 2016) and will be consistent with both consent conditions of SSD-5594 and the recommended guideline values determined as part of the assessment. The recommended guideline values for the Project are provided in Table 8-1.

Table 8-1 Recommended guideline values for the Project to protect the aquatic ecosystem

Parameter	ANZECC (2000) guideline value	SW1 80th percentile values	Additional information for ANZECC (2000) guideline values
	Units are mg/L unless otherwise specified		
Physicochemical parameters			
pH	**6.5–8.0 pH units**	6.4*–7.1 pH units	Recommended site specific guideline value 20th – 80th percentile range. NSW upland river (Table 8.2.8).
Electrical conductivity (EC)	**350 µS/cm (500 µS/cm as per consent conditions of SSD-5594)**	100 µS/cm	NSW upland river (Table 8.2.9).
Total suspended solids (TSS)	**25**	12	NSW upland river (Table 8.2.12).

Parameter	ANZECC (2000) guideline value	SW1 80^{th} percentile values	Additional information for ANZECC (2000) guideline values
	Units are mg/L unless otherwise specified		
Turbidity	25 NTU	**35 NTU**	NSW upland river (Table 8.2.11).
Nutrients			
Ammonia	**0.9**	0.01^	Guideline value for TN in upland rivers (Table 3.3.2) used in place of ammonia guideline values.
Total nitrogen (TN)	0.25	**0.5**	Upland river (Table 3.3.2).
Total phosphorus (TP)	**0.02**	0.01^	
Filterable/dissolved metals			
Aluminium	0.055	**0.24**	Freshwater guideline for 95% species protection (Table 3.4.1). Applies for pH>6.5.
Antimony	–	**0.001^**	No ANZECC guidelines available. ADWG (NHMRC 2016) health guideline value used.
Arsenic	**0.024**	0.001^	Freshwater guideline for 95% species protection for As(V) (Table 3.4.1).
Barium	–	**0.047**	No ANZECC guidelines available.
Boron	**0.37**	0.05^	Freshwater guideline for 95% species protection (Table 3.4.1).
Cadmium	**0.0026[b]**	0.0001^	[a] Freshwater guideline for 95% species protection (Table 3.4.1). [b] Modified for hard water.
Chromium	0.001	–	Freshwater guideline for 95% species protection (Table 3.4.1).
Cobalt	**0.0025**	–	Canadian guideline as recommended by ANZECC (2000a) (Section 8.3.7.1).
Copper	0.0014	**0.004**	Freshwater guideline for 95% species protection (Table 3.4.1).
Iron	0.3	**0.31**	Canadian guideline as recommended by ANZECC (2000a) (Section 8.3.7.1).
Lead	**0.129**	0.001^	[a] Freshwater guideline for 95% species protection (Table 3.4.1). [b] Modified for hard water.
Manganese	**1.9**	0.150	Freshwater guideline for 95% species protection (Table 3.4.1).
Mercury	**0.0006**	0.0001^	
Molybdenum	–	**0.001^**	No ANZECC guidelines available.

Parameter	ANZECC (2000) guideline value	SW1 80th percentile values	Additional information for ANZECC (2000) guideline values
	Units are mg/L unless otherwise specified		
Nickel	**0.125**	0.003	[a] Freshwater guideline for 95% species protection (Table 3.4.1). [b] Modified for hard water. [c] Guideline value for sites with soft water.
Zinc	**0.091**	0.032	[a] Freshwater guideline value for 95% species protection (Table 3.4.1). [b] Modified for hard water.

Bold text indicates the derived trigger value.

– = Indicates insufficient or no data.

[a] Freshwater guideline for 95% species protection (Table 3.4.1) default guideline values already modified for soft water (total hardness 30 mg/L).

[b] Modified for hard water (total hardness 525 mg/L) using Wangcol D/S 50th percentile concentrations as this produced more stringent values, sites assessed against hard water were Wangcol D/S, Wangcol far D/S and LDP006.

c Derived dissolved nickel guideline value for sites with water hardness categorised as soft (< 30 mg/L).

It must be noted that the water quality limits proposed as part of this Project are not applicable to discharges currently undertaken at LDP006 as part of the EPL 3607.

Treatment Technology

The WTP to be developed as part of the Project will utilise a reverse osmosis technology to reduce conductivity and improve overall water quality. In such an effective treatment, there exists the possibility that the treated discharge (if discharged to Wangcol Creek) will be stripped of trace elements and nutrients required for aquatic flora and fauna. As part of the design intent of the treatment plant, the operation of the plant will be such that within the process cycle treated and untreated water will be mixed to achieve a water quality that both meets developed criteria but also mitigates potential toxicity to the receiving environment.

The discharges from LDP006, adjacent to the LDP proposed as part of the Project, somewhat mitigates potential toxicity from ‘too clean’ water also, however, mixing would occur within Lamberts Gully and its confluence with Wangcol Creek.

The quantification of the resulting water quality from the WTP is to be determined as part of commissioning phases.

As part of the commissioning stage of the WTP, the confirmation of water quality treatment performance will be evaluated along with toxicology testing and the review operational conditions. Much of this stage will be utilised in the development of a final EPL for the Project.

Wangcol Creek and Coxs River downstream of Wangcol Creek confluence

GHD (2016) identified that the LDP006 discharge currently exceeds ecosystem protection guidelines (predominantly due to high EC) and therefore this discharge will have the potential to impact on Wangcol Creek compared to the objectives of the Project. Outcomes from seasonal monitoring suggests that the macroinvertebrate community downstream from LDP006 has been negatively impacted by the SCSS discharge and surrounding land-use historically. As part of the

Western Coal Services Project, SCSS is currently investigating current surface and groundwater quality conditions from the operations.

The Project proposes to discharge periodically into Wangcol Creek. Although the volume and duration of discharges will potentially vary with power generation at MPPS, in the event that discharges do occur, the predicted water quality of the new WTP discharge will be improved when compared to the current LDP006 discharge. Water discharges from the proposed LDP is likely to ameliorate the current influence of LDP006 with improvements predicted in EC above discharges of 2 ML/day. In the event of a large discharge (that is greater than or equal to 30 ML/day) an improvement is predicted for the entire length of Wangcol Creek. Therefore, the Project is likely to improve the condition of aquatic ecology in Wangcol Creek through improvements to water quality, during periods of discharge. These improvements to water quality would be expected to positively influence the aquatic ecology of Wangcol Creek. As previously discussed, the macroinvertebrate community of Wangcol Creek has been previously observed to exhibit improvements in response to reduced EC following rainfall events.

Due to the creation of waste streams from the WTP, in events where no discharge from the Proposed LDP occurs (that is, complete uptake of WTP water by MPPS), Wangcol Creek may be subject to a slight worsening of water quality (elevated EC) compared to existing conditions through increased discharges from LDP006 (GHD, 2016) as a result of residual transfers. Therefore, the aquatic ecology of Wangcol Creek may potentially be impacted downstream of the discharge point during these periods. However, as has been discussed, the aquatic ecology within this system is largely comprised of tolerant taxa which are accustomed to high EC.

As stated previously, there is a possibility that ‘worse case’ flow events may induce isolated erosive processes leading to an increased sedimentation risk in Wangcol Creek (GHD, 2016). If this is the case, it is likely that increased total suspended solids (TSS) and turbidity may result. Current turbidity levels and TSS concentrations generally meet ANZECC (2000) guideline values in both Wangcol Creek and in the LDP006 discharge. As such, an increase in these parameters due to increased erosion may pose a risk to aquatic ecological values. The potential risk can be effectively mitigated through monitoring and management response plans as detailed in section 11 and the WRIA (GHD, 2016).

Given the larger volume of water in the Coxs River, changes to water quality as the result of the Project are not expected to be of a scale that would negatively impact on the aquatic ecology of the Coxs River downstream of the confluence with Wangcol Creek.

Sawyers Swamp Creek

Removal of LDP009 discharge is likely to have a positive improvement on water quality of Sawyers Swamp Creek. Macroinvertebrate monitoring carried out upstream and downstream from LDP009 indicates that the condition of the macroinvertebrate community is impaired and this may be due to the discharge of mine water with a median EC of 1,170 µS/cm which makes up majority of the water volume at this site. It is expected that macroinvertebrate community health will be improved through the removal of this high EC water, although water availability is likely to limit diversity in this naturally ephemeral system.

Coxs River, downstream of Sawyers Swamp Creek

Cessation of discharges from LDP009 discharge will have positive improvement on water quality of Sawyers Swamp Creek and consequentially Coxs River downstream of the Sawyers Swamp confluence. The WRIA (GHD, 2016) predicted improvements in water quality of the Coxs River from the confluence of Sawyers Swamp Creek, as far downstream as Lake Burragorang based on the scenario of 50% power generation. As part of the WRIA (GHD, 2016), it was demonstrated that projected water quality improvements and reduction of pollution loads are predicted to occur in Coxs River downstream of the Sawyers Swamp Creek confluence as far downstream as Lake Burragorang. Water quality improvements are expected through reductions in loads of salt and other pollutants. At present, the Coxs River, downstream from Wangcol Creek and Sawyers Swamp Creeks is influenced by elevated EC and this seems to be negatively influencing aquatic ecology in this area. The improvement in water quality is expected to result in improvements in aquatic ecology within the Coxs River downstream of the confluence with Sawyers Swamp Creek.

8.2.3 Impacts to regional waterways

Regional waterways (more so the lower portion of Coxs River) are in better condition in terms of riparian vegetation and waterway condition, compared with those subject to potential impacts from land-use, industry and development.

Proposed discharges from the WTP, if they are required, are likely to have a minimal influence on flow regime within the lower portion of the Coxs River due to the regulating effect of Lake Wallace and Lake Lyell. Operational variation, as a result of power generation, in discharge volume and frequency from the WTP is unlikely to influence this outcome.

Water quality improvements are expected as a result of the Project as far downstream as Lake Burragorang (GHD, 2016). This will largely be achieved through cessation of LDP009 discharges to Sawyers Swamp Creek. This is likely to have a positive influence on the aquatic ecology of the wider catchment to the extent that water quality improvements are observed.

8.3 Impacts on state and national listed biota

The Project is unlikely to impose a significant impact on any threatened fauna or flora species listed under the EPBC Act, TSC Act or the FM Act.

8.4 Key threatening processes

The Project has the potential to contribute to the following KTPs listed under the FM Act and TSC Act due to the alteration to natural flow regimes in Wangcol Creek and Coxs River:

1. Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams.
2. Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands.

The impact that the Project will have on these KTPs are likely to be minimal as discussed within Section 8.2.1 of this report and the WRIA (GHD, 2016).

8.4.1 Conclusions

The Project is unlikely to directly or indirectly result in a change to water hydrology or quality that that is of sufficient scale or intensity as to reduce the current or future utility of the water for aquatic ecology. It is likely that there will be some localised changes to macroinvertebrate and fish communities as a result of the new discharge into Wangcol Creek and the removal of discharges to Sawyers Swamp Creek. However, the Project is likely to be of benefit, overall, to the Coxs River as a result of improvements in water quality.

No threatened species or habitat for such species are expected to be impacted as a result of the Project.

9. Potential impacts on GDEs

9.1 Terrestrial GDEs

Surface and groundwater activities that alter environmental parameters of GDEs outside of any known natural range will have an adverse impact on the ecosystem and its value (Serov *et al.,* 2012). The *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (NOW, 2012a) within the NSW Groundwater Dependent Ecosystems Policy assesses changes to water quantity, quality, aquifer integrity and biological integrity to determine an overall risk assessment for the Project. In this case, the Project would not result in direct clearing of terrestrial GDEs (RPS, 2016) and changes to existing groundwater quality and/or level are not expected.

The Project is not predicted to have an impact on the recharge of groundwater systems in the PAA or downstream of the Project. The hydraulic connectivity between groundwater and surface waters is not predicted to be altered by the Project. The Project is not predicted to adversely affect the current water quality of the underlying groundwater system (GHD, 2016). Therefore, there is a low risk of impacts to GDEs as a result of the Project.

9.2 Subterranean GDEs

Stygofauna have been found within alluvial groundwater bores located upgradient of the PAA within the Neubeck Coal Project. However, the alluvial groundwater environment has been identified as discontinuous along Wangcol Creek with soil mapping, indicating no alluvial material past the confluence of Wangcol and Neubecks Creek. Therefore, there is limited potential for stygofauna to be present within the PAA.

The Project is unlikely to alter the connectivity and or groundwater conditions. No aquifer storage depletion (water table decline) is expected as a result of the Project. There will be no excavation below the water table. There will be no drawdown of groundwater as a result of the Project. There is not expected to be a change to existing groundwater quality as a result of the Project.

Therefore, even if stygofauna communities exist within the PAA, they are unlikely to be impacted by the Project.

9.3 Conclusion

It has been determined that there is limited potential for stygofauna to be present within the PAA. No changes to groundwater quality or groundwater hydrology are expected to occur as a result of the Project. Therefore, it is unlikely that any GDEs within the vicinity of the Project will be impacted as a result of the Project.

10. Cumulative impacts

The Project will operate within a region where various other projects operate. These are detailed in Section 3.6. The WRIA included a water quality assessment to determine the influence of the Project on water quality of the catchment (GHD, 2016). Improvements in water quality were predicted for the Coxs River as far downstream as Lake Burragorang based on the scenario of 50% power generation (GHD, 2016). Water quality improvements are expected to occur through reductions in loads of salt and other pollutants. The Project will also reduce the volume of mine water discharge into the Coxs River which will result in partial restoration of the natural flow regime. Furthermore, the Project will result in reductions in water extraction requirements of MPPS allowing for greater environmental flows to contribute back to the Coxs River. These predicted improvements in water quality are expected to result in improvements in the aquatic ecology of the Coxs River and the wider catchment.

Due to the creation of waste streams from the WTP, in events where no discharge from the Proposed LDP occurs (that is, complete uptake of WTP water by MPPS), Wangcol Creek may be subject to a slight worsening of water quality (elevated EC) compared to existing conditions through increased discharges from LDP006 (GHD, 2016) as a result of residual transfers. Therefore, the aquatic ecology of Wangcol Creek may potentially be impacted downstream of the discharge point during these periods. This small change in water quality is not expected to be measurable on a regional scale as volumes are minor comparative to benefits from cessation of LDP009 discharges of waterways downstream of Sawyers Swamp Creek.

The assessment of how other operations and Projects within the Coxs River catchment may influence or interact with the outcomes of this Project are discussed within the WRIA (GHD, 2016). Regional assessments have been considered as part of this Project utilising regional aquatic ecology monitoring programs already in place for Springvale Coal.

11. Avoidance, mitigation and management measures

11.1 General

The management of adverse effects arising from the Project has been presented according to the hierarchy of:

1. Avoidance.
2. Mitigation.
3. Offsetting of impacts.

Potential impacts of the Project on aquatic biota, GDEs and their habitats are associated with direct habitat loss (reduced water availability in Sawyers Swamp Creek) and changes to water quality or water quality variability and hydrology in Wangcol Creek (and Coxs River). Mitigation measures have been recommended in order to minimise impacts of the Project on aquatic biota within groundwater, adjacent surface watercourses and downstream environments.

11.2 Avoidance of impacts

Direct impacts to aquatic ecosystems resulting from the Project have been minimised by using the existing pipeline and infrastructure easements where possible. Direct disturbance to waterways has been limited to:

- The Lamberts Gully channel, which will need to be modified in order to construct the new discharge point adjacent to LDP006.
- The under drilling of Coxs River and localised impacts to low order waterways along the path of the pipeline.

Cessation of discharges from LDP009 will address potential water quality risks to Sawyers Swamp Creek and the upper Coxs River catchment.

11.3 Mitigation of impacts

Toxicity based protection limits will be established for water discharged from the proposed discharge point to ensure that the aquatic ecology of Wangcol Creek is protected. These concentration limits will be incorporated into the EPL for the Project and monitored through the Surface Water Monitoring Program (GHD, 2016).

The increased volume and velocity of water in Wangcol Creek has potential to create isolated erosive processes within Wangcol Creek and, as a result, increase turbidity of the water. Elevated turbidity above natural levels may impact on aquatic fauna and flora. Visual inspections of watercourse stability will be undertaken following commencement of discharges, as outlined in the WRIA (GHD, 2016). Water quality, including TSS and turbidity will continue to be monitored under the existing Surface Water Monitoring Program (GHD, 2016). Review of results from this monitoring program will provide an early warning if TSS and/or turbidity of Wangcol Creek increases as a result of the proposed discharges.

Given the elevated concentrations of some pollutants in the existing LDP006 discharge, there is a potential opportunity to improve the overall water quality of Wangcol Creek through dilution using water treated from the proposed WTP.

11.4 Management of impacts

11.4.1 Monitoring

Water quality

Water quality of Wangcol Creek and Coxs River will be monitored through existing Springvale Coal and EnergyAustralia Surface Water Monitoring Programs as detailed in the WRIA (GHD, 2016). Water quality of the WTP discharge will be compared against EPL concentration limits to ensure protection of instream ecology.

Macroinvertebrates

Macroinvertebrate monitoring will be conducted in Wangcol Creek and Coxs River biannually (autumn and spring) for two years following commencement of initial discharge from the new discharge point into Wangcol Creek. The requirement for ongoing macroinvertebrate monitoring beyond this point will be determined depending on the frequency and volume of discharges from the new discharge point over that two-year period and the outcomes of aquatic ecology and water quality monitoring.

The monitoring program seeks to capture the monitoring of the following Project components:

- Wangcol Creek upstream of the proposed discharge.
- Wangcol Creek downstream of the proposed discharge.
- Coxs River upstream of Kangaroo Creek (Angus Place discharges).
- Coxs River downstream of Kangaroo Creek, upstream of Wangcol Creek confluence.
- Coxs River downstream of Wangcol Creek confluence (LDP006 and new discharges), upstream of Sawyers Swamp Creek confluence.
- Coxs River downstream of Sawyers Swamp Creek confluence (LDP009 discharges).

Where possible, previously sampled monitoring sites (such as those specified in Table 6-1) should be resampled following commencement of discharges to allow for comparison to baseline data available for these waterways. Monitoring will include a visual habitat assessment and general assessment of riparian vegetation condition. The macroinvertebrate information collected will be reviewed in conjunction with environmental information such as rainfall, discharge volumes and water quality. Depending on results of the local scale survey, it may be relevant to obtain further data from WaterNSW for regional sites and compare to baseline data provided in this document.

The cessation of discharges to Sawyers Swamp Creek will result in a reduction in water availability and, thus, instream habitat which will likely result in a decline of the macroinvertebrate population during dry periods. However, as this system is naturally ephemeral, the removal of discharges is considered to be a return towards the natural flow regime and, thus, an acceptable outcome of the Project. It is recommended that the macroinvertebrate community of Sawyers Swamp Creek be monitored biannually (autumn and spring) for two years following cessation of discharges to ensure that there are no unintended consequences of the Project on the macroinvertebrate community.

A typical assessment criteria or trigger that can be applied within monitoring program is:

- No change (or improvement) in macroinvertebrate metrics (i.e. taxa richness, EPT richness, SIGNAL-2) between baseline and post-discharge event, beyond natural variation at reference sites.

Fish

Fish monitoring and fish habitat assessment will be conducted annually for two years following commencement of initial discharge from the new discharge point into Wangcol Creek. This monitoring will focus on sites which were classified as having Class 1 (major) or Class 2 (moderate) fish habitat (Fairfull and Witheridge, 2003). The fish assessment will include examination of species composition and abundance classes and the presence of invasive species.

A typical assessment criteria or trigger that can be applied to monitoring programs is:

- No change (or improvement) in the distribution of fish species within impacted waterways between baseline and post-discharge events.

GDEs

Impacts to groundwater dependent vegetation is not expected as a result of the changes to surface water quality and hydrology associated with the Project. Therefore, a groundwater dependent vegetation assessment is not considered to be necessary as part of the ongoing monitoring. Impacts to vegetation due to physical disturbance and associated monitoring requirements are discussed in the Biodiversity Assessment Report (RPS, 2016).

Impacts to groundwater dependent fauna (e.g. stygofauna) as a result of the Project would be expected only if there is a change to groundwater quality or groundwater level within alluvial sources. These changes are not predicted to occur as a result of the Project. However, the risk of potential impacts to groundwater dependent fauna will be managed via the existing Springvale Coal and EneryAustralia groundwater monitoring programs as detailed in the WRIA (GHD, 2016).

11.5 Offsetting of impacts

Given the above consideration of potential impacts and proposed mitigation measures, it is considered unlikely that the Project would result in any significant impacts to native aquatic flora and fauna or their habitats or overall aquatic biodiversity values in the locality. As such, no specific offset is considered necessary to compensate for proposed impacts to aquatic habitats, flora or fauna as a result of the Project.

12. Conclusion

12.1 Methodology

The scope of the current investigation included a review of relevant available literature, background information and searches of wildlife databases as well as aquatic field surveys and data analysis to assess the existing character of the watercourses within the Impact Assessment Area and the potential impacts of the Project on aquatic biodiversity values and in particular, threatened fauna species and their habitats. Threatened species listed under the TSC Act, FM Act and the EPBC Act including fish, plant and macroinvertebrate species as likely to occur in the PAA were considered. The existing environment was established via a desktop assessment given that long-term aquatic ecology monitoring has been carried out at relevant sites on the waterways that have the potential to be impacted by the Project.

The impact assessment considered the following:

- Desktop literature review (including relevant database searches).
- Aquatic habitat assessment.
- Water quality assessment.
- Groundwater quality assessment.
- AUSRIVAS macroinvertebrate sampling.
- Fish sampling.
- Stygofauna sampling.
- Riparian vegetation surveys.

12.2 Summary of key findings

Instream habitat at the sites included in the assessment ranged from low to moderate ecological value. Most sites in the IAA had relatively low macroinvertebrate diversity, dominated by pollution-tolerant taxa. Few native fish were recorded which is to be expected given the competition from exotic noxious species, numerous fish barriers within the system and the low stream order. The existing and ongoing anthropogenic impacts of land use and its influences on riparian and aquatic vegetation, water quality, quantity and flow regime and impacts of invasive fauna remain the key constraints to aquatic ecosystems of the area.

Wangcol Creek is a highly modified fourth order stream located to the north of MPPS and SCSS. This creek has been previously diverted and modified and the riparian zone is in poor condition. Approximately 1.29 ML/day of mine water currently discharges via LDP006 to a small drainage channel known as Lamberts Gully which flows into Wangcol Creek. It is proposed that a new discharge point be constructed adjacent to LDP006 and within the channel of Lamberts Gully. The operation of the discharge point will be required in the event that treated water is not completely reused by MPPS. The water quality of the new discharge will be representative of the background catchment which will be protective and improve aquatic ecology within Wangcol Creek and waterways downstream.

The predicted water quality of discharges from the WTP will be of an improved nature, however, the intermittent nature of the discharges may in themselves represent a source of disturbance for aquatic ecology of Wangcol Creek. The impact that the variable flows into Wangcol Creek will have on aquatic flora and fauna currently inhabiting instream habitats downstream of the proposed discharge will depend on the magnitude and duration of flows. The majority of the macroinvertebrate families and fish observed in Wangcol Creek are pollution-tolerant. Further, the small order streams in the vicinity of the PAA are ephemeral and, therefore accustomed to fluctuations in flow. Historic monitoring within Wangcol Creek has indicated that the maximum discharge rate of 32 ML/day is of a similar magnitude to natural flow events experienced in the system and the aquatic ecology community has not been strongly impacted as a result. Therefore, the aquatic ecology communities of Wangcol Creek are expected to be robust against the changeable nature of the proposed discharges and the maximum flow rate proposed, given that discharges are expected to be infrequent. The buffering capacity of the WTP considered within its design will seek to mitigate the severity of operational changes.

Water quality of the upper Coxs River sub-catchment is strongly influenced due to the current mine discharge quality and volume. The Coxs River sub-catchment forms part of the Hawkesbury/Nepean catchment which is within the Sydney drinking water catchment. Currently, an average of approximately 20 to 25 ML/day of flocculated water is currently discharged from Springvale Mine and Angus Place Colliery into Sawyers Swamp Creek, which flows into the Coxs River. Sawyers Swamp Creek currently supports a relatively degraded macroinvertebrate community, due to the LDP009 discharge, amongst other disturbances. There is the potential for short-term impacts to the aquatic ecology of Sawyers Swamp Creek due to the cessation of discharges from LDP009 and the resultant reduction of the water, and thus habitat, within the creek. However, given the impaired quality of current discharges into this creek, and the improvements to aquatic ecology of the wider catchment that would result from the Project, the short-term impacts to Sawyers Swamp Creek are considered to be acceptable. Further, the cessation of mine water discharge into Sawyers Swamp Creek represents a return to the natural flow regime of this system. Improvements to water quality in Sawyers Swamp Creek are expected following cessation of LDP009 discharges and this is likely to result in improvements in macroinvertebrate community health.

The Coxs River supports a moderate to high diversity of macroinvertebrates and has the potential to support a range of fish species, based on habitat assessments. However, diversity is currently limited compared to reference streams due to poor water quality in the catchment, particularly high EC. Water modelling indicates that the Project will result in a benefit in water quality, particularly reduced EC, for the Coxs River at the confluence with the Sawyers Swamp Creek (GHD, 2016) and further downstream. The cessation of untreated mine discharge from LDP009 provides an opportunity for improvements to the aquatic ecology of the Coxs River catchment through improvements to water quality.

12.2.1 Groundwater dependent ecosystems

Monitoring in the area indicated the potential for stygofauna to be present upgradient of the PAA. However, the Atlas of Groundwater Dependent Ecosystems identified limited or low potential for groundwater dependence within the PAA or IAA. There is unlikely to be changes to current groundwater quality of volumes as a result of the Project. Therefore, even if GDEs were present within the PAA, it is unlikely that they would be impacted by the Project.

12.2.2 Threatened species

A search of the *Protected Matters Search Tool* for MNES listed under the EPBC Act identified potential habitat may occur within the locality for three threatened fish, the Macquarie perch (endangered under both the FM Act and EPBC Act), the Murray cod (vulnerable under the EPBC Act) and the Australian grayling (vulnerable under the EPBC Act and protected under the FM Act). Given the habitat preferences of these species, the presence of large physical barriers to fish movement within the system and the lack of sightings within the IAA, these fish species are not expected to be present. There is the potential for the Macquarie Perch to be present within the Regional Assessment Area although as this is greater than 100 km downstream of the PAA, impacts are not expected.

A BioNet Atlas search identified the potential for the presence of the endangered Giant Dragonfly, listed as Endangered under the TSC Act within 10 km of the PAA. There are two records of this species within 10 km of the Project, one within Ben Bullen State Forest and one within Newnes State Forest. There are no records of this species within the local waterways relevant to the Project. Based on the outcomes of the field surveys undertaken by MPR and GHD, habitat availability and the lack of sightings recorded in the Atlas, it is considered highly unlikely that the Giant Dragonfly occur within the IAA. Therefore, the Giant Dragonfly is unlikely to be impacted by the Project.

The threatened Blue Mountains Water Skink was identified as likely to occur within 10 km of the PAA. However, there are no records of this species in the IAA. Further, RPS (2016) have determined that there is no suitable habitat for these species within the PAA. Therefore, the Blue Mountains Water Skink is unlikely to be impacted by the Project.

On the basis of the assessments undertaken, it is concluded that the Project is unlikely to impose a significant impact on any threatened aquatic fauna species listed under the EPBC Act, TSC Act or the FM Act and therefore a species impact statement is not required for the Project.

12.2.3 Summary

No impacts to threatened species or GDEs are expected due to the Project. There will be potential impacts and benefits to the Coxs River catchment due to the Project. Cessation of LDP009 discharge into Sawyers Swamp Creek will benefit both Sawyers Swamp Creek and Coxs River through improvements to water quality and a return towards more natural flow regimes. There is the potential for localised impacts to the aquatic ecology of Wangcol Creek at times due to the proposed discharge. However, given that this system is already highly modified, the low volume and frequency of discharges predicted and the tolerant taxa that dominate this system, the potential impacts to Wangcol Creek are considered to be minor, given the potential for wider scale improvements to the aquatic ecology of the catchment.

13. References

Allen, G.R., Midgley, S.H. and Allen, M. (2002), *Field Guide to the Freshwater Fishes of Australia*, Western Australian Museum, Perth.

ANZECC and ARMCANZ (2000), *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, National Water Quality Management Strategy, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

Boulton, A.J., W.F. Humphreys and S.M. Eberhard (2003), Imperilled subsurface water in Australia: Biodiversity, threatening processes and conservation, *Aquatic Ecosystem Health and Management*, 6(1), 41–54.

Cardno (2013a), *Aquatic Ecology and Stygofauna Assessment: The Neubeck Coal Project*. prepared by Cardno Pty Ltd for Centennial Angus Place Pty Limited

Cardno (2013b). *Aquatic Ecology and Stygofauna Assessment: Angus Place Mine Extension Project*, prepared by Cardno Pty Ltd for Centennial Angus Place Pty Limited.

Cardno (2013c), *Aquatic Ecology and Stygofauna Assessment: Springvale Mine Extension Project,* prepared by Cardno Pty Ltd for Springvale Coal Pty Limited.

Chessman, B.C. (1995), Rapid assessment of rivers using macroinvertebrates: A procedure based on habitat-specific sampling, family level identification and a biotic index, *Australian Journal of Ecology*, 20(1), 122–129.

Chessman, B.C. (2003), New sensitivity grades for Australian river macroinvertebrates, *Marine and Freshwater Research*, 54(2), 95–104.

Chessman, B.C., Growns, J.E. and Kotlash, A.R. (1997), Objective derivation of macroinvertebrate family sensitivity grade numbers for the SIGNAL biotic index: application to the Hunter River system, New South Wales, *Marine and Freshwater Research*, 48(2), 159–72.

DEC (2006), *The Vegetation of the Western Blue Mountains including the Capertee, Coxs, Jenolan and Gurnang Areas*, prepared by the Department of Environment and Conservation (NSW Government).

Department of the Environment (2016a). Eucalyptus aggregata in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat.

Department of the Environment (2016b). *Maccullochella peelii* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat.

Department of the Environment (2016c). *Macquaria australasica* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat.

Department of the Environment (2016d). *Prototroctes maraena* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat.

Department of the Environment (2013a), *Matters of National Environmental Significance: Significant impact guidelines 1.1*, prepared by Department of the Environment (Australian Government).

Department of the Environment (2013b), *Matters of National Environmental Significance: Significant impact guidelines 1.3:* Coal seam gas and large coal mining developments - impacts on water resources, prepared by Department of the Environment (Australian Government).

DLWC (1997), *The NSW State Groundwater Policy Framework Document*, prepared by Department of Land & Water Conservation (NSW Government).

Domm, S. (1977). Seabirds and waders of the Lizard Island area. *Sunbird*. 8:1-8.

DPI (2006a), *Murray Cod (*Maccullochella peelii*),* prepared by Department of Primary Industries (NSW Government).

DPI (2006b), *Australian Grayling (*Prototroctes maraena*) – Primefact 162*, prepared by Department of Primary Industries (NSW Government).

DPI (2013a), *Threatened and Protected Species – Records Viewer*, Department of Primary Industries (NSW Government), retrieved from http://www.dpi.nsw.gov.au/fisheries/species-protection/records.

DPI (2013b), *Adams Emerald dragonfly* (Archaeophya adamsi*) – Primefact 187*, prepared by Department of Primary Industries (NSW Government).

Dumas P. and Fontanini G. (2001), Sampling fauna in aquifers: a comparison of net-sampling and pumping, *Archiv für Hydrobiologie*, 150(4), 661–676

Eberhard S.M. and Spate, A.P. (1995), *Cave invertebrate survey: Toward an Atlas of NSW cave fauna*, A report under NSW Heritage Assistance program NEP94765, NSW National Parks and Wildlife Service.

Fairfull, S. and Witheridge, G. (2003), *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings*, NSW Fisheries, Office of Conservations.

Fleming, M.R. (1987). The Osprey *Pandion haliaetus* in central Australia. *Australian Bird Watcher*. 12:30-32.

Frith, H.J. (1970). The Japanese Snipe *Gallinago hardwickii* - a preliminary report. *CSIRO Division of Wildlife Research Technical Memorandum 6*.

FSC (2008), Final determination: *Macquaria australasica – Macquarie perch*, Fisheries Scientific Committee, retrieved from http://www.dpi.nsw.gov.au/data/assets/pdffile/0017/251342/FD37-Macquarie-perch.pdf.

GHD (2014a), *Neubeck Coal Project: Groundwater Impact Assessment*, prepared by GHD Pty Ltd for Centennial Angus Place Pty Limited.

GHD (2014b), *Neubeck Coal Project: Aquatic Ecology Impact Assessment*, prepared by GHD Pty Ltd for Centennial Angus Place Pty Limited, in draft.

GHD (2016) *Centennial Coal/Energy Australia: Water Treatment Project Water Resources Impact Assesment*, prepared by GHD Pty Ltd for Centennial Angus Place Pty Limited. 17 June 2016 draft.

Hancock P.J. (2004), *The effects of river stage fluctuations on the hyporheic and parafluvial ecology of the Hunter River, New South Wales*, PhD thesis, University of New England, Armidale.

Hancock P.J., Boulton A.J. and Humphreys W.F. (2005), Aquifers and hyporheic zones: Towards an ecological understanding of groundwater, *Hydrogeology Journal* 13(1), 98–111.

Hancock, P.J. and Boulton, A.J. (2008), Stygofauna biodiversity and endemism in four alluvial aquifers in eastern Australia, *Invertebrate Systematics,* 22(2), 117–126.

Harvey, M.S. (2002), Short range endemism among the Australian fauna: some examples from non-marine environments, *Invertebrate Systematics*, 16(4), 555–570.

HNCMA (2010), *Hawkesbury Nepean River Health Strategy*, Hawkesbury Nepean Catchment Management Authority.

Humphreys, W.F. (2002), Groundwater ecosystems in Australia: an emerging understanding. Keynote address, *Proceedings of the International Association of Hydrogeologists Conference*, Darwin, 12–17 May, 2002.

Humphreys, W.F. (2008), Rising from Down Under: developments in subterranean biodiversity in Australia from a groundwater perspective, *Invertebrate Systematics*, 22(2), 85–102.

MPR (2012a), *Centennial West Aquatic Ecology Monitoring: Neubecks and Piper Flat Creeks – Autumn and Spring 2011*, prepared by Marine Pollution Research Pty Ltd for Centennial Coal Pty Ltd.

MPR (2012b), *Aquatic Ecology Monitoring: Newnes Plateau Pilot Stygofauna Study – Autumn 2012*, prepared by Marine Pollution Research Pty Ltd for Angus Place Colliery and Springvale Colliery.

MPR (2013), *Aquatic Ecology Monitoring: Coxs and Wolgan River Catchments – Autumn 2013*, prepared by Marine Pollution Research Pty Ltd for Springvale Colliery Pty Ltd.

MPR (2014a), *Aquatic Ecology Monitoring: Coxs and Wolgan River Catchments – Spring 2013*, prepared by Marine Pollution Research Pty Ltd for Springvale Colliery Pty Ltd.

MPR (2014b), *Aquatic Ecology Monitoring: Coxs and Wolgan River Catchments – Autumn 2014*, prepared by Marine Pollution Research Pty Ltd for Springvale Colliery Pty Ltd.

MPR (2015a), *Aquatic Ecology Monitoring: Coxs and Wolgan River Catchments – Spring 2014*, prepared by Marine Pollution Research Pty Ltd for Springvale Colliery Pty Ltd.

MPR (2015b), *Aquatic Ecology Monitoring: Coxs and Wolgan River Catchments – Autumn 2015*, prepared by Marine Pollution Research Pty Ltd for Springvale Colliery Pty Ltd.

MPR (2015c) *Aquatic Ecology Monitoring: Wangcol and Pipers Flat Creeks – Autumn 2015*, prepared by Marine Pollution Research Pty Ltd for Centennial Coal Pty Ltd.

MPR (2015d), *Aquatic Ecology Monitoring: Coxs and Wolgan River Catchments – Autumn 2015*, prepared by Marine Pollution Research Pty Ltd for Angus Place Colliery Pty Ltd.

MPR (2016a) *Aquatic Ecology Monitoring: Wangcol and Pipers Flat Creeks – Spring 2015*, prepared by Marine Pollution Research Pty Ltd for Centennial Coal Pty Ltd.

MPR (2016b), *Aquatic Ecology Monitoring: Coxs and Wolgan River Catchments – Spring 2015*, prepared by Marine Pollution Research Pty Ltd for Springvale Colliery Pty Ltd.

MPR (2016c), *Aquatic Ecology Monitoring: Coxs and Wolgan River Catchments – Spring 2015*, prepared by Marine Pollution Research Pty Ltd for Angus Place Colliery Pty Ltd.

Marmonier, P., Vervier, P., Gibert, J. and Dole-Olivier, M.-J. (1993), Biodiversity in ground waters, *Trends in Ecology and Evolution*, 8(11), 392–395.

NOW (2012a), *Risk Assessment Guidelines for Groundwater Dependent Ecosystems*, Department of Primary Industries, NSW Office of Water.

NOW (2012b), *Controlled Activities on Waterfront Land – Guidelines for In-stream Works on Waterfront Land*, Department of Primary Industries, NSW Office of Water.

NOW (2012c), *Controlled Activities on Waterfront Land – Guidelines Riparian Corridors on Waterfront Land*, Department of Primary Industries, NSW Office of Water.

NSW National Parks and Wildlife Service (2002), Environmental Impact Assessment Guidelines: Blue Mountains Water Skink, retrieved from http://www.environment.nsw.gov.au/resources/nature/BMWskinkEia0502.pdf, accessed 10 June 2016.

OEH (2016), *Veronica blakelyi – profile*, Department of Planning and Environment, NSW Office of Environment and Heritage, retrieved from http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10217.

OEH (2015), *Giant Dragonfly – profile,* Department of Planning and Environment, NSW Office of Environment and Heritage, retrieved from http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10600.

Petersen R. C. (1992), The RCE: a Riparian, Channel, and Environment Inventory for small streams in the agricultural landscape, *Freshwater Biology*, 27(2), 295–306.

Plafkin, J.L., Barbour, M.T., Porter, K.D., Gross S.K. and Hughes R.M. (1989), *Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish*, U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, D.C.

Richardson, S., Irvine, E., Froend, R., Boon, P., Barber, S. and Bonneville, B. (2011), *Australian Groundwater Dependent Ecosystem Toolbox Part 1: Assessment Framework*, Waterlines Report Series No. 69, National Water Commission.

RPS (2016) Biodiversity Assessment Report: Springvale Coal Mine Water Transfer Pipeline. In draft.

RPS (2014), *Neubeck Coal Project: Flora and Fauna Assessment*, prepared by RPS Australia East Pty Ltd for Centennial Angus Place Pty Limited, in draft.

Serov, P., Kuginis, L., Byrne, G.T. and Williams, J.P. (2012), *Risk Assessment Guidelines for Groundwater Dependent Ecosystems, Volume 1 – The Conceptual Framework*, National Water Commission and NSW Office of Water.

Sket, B. (2010), Can we agree on an ecological classification of subterranean animals?, *Journal of Natural History,* 42(21–22), 1549–1563.

SKM (2010), *Framework for Assessing Potential Local and Cumulative Effects of Mining on Groundwater Resources*, Report 15: Guidelines for Conducting a Groundwater Effects Statement, Version 3, National Water Commission.

Turak, E., Waddell, N. and Johnstone. G. (2004), *New South Wales (NSW) Australian River Assessment System (AUSRIVAS) Sampling Processing Manual*.

WA EPA (2007), *Guidance for the Assessment of Environmental Factors (in Accordance with the* Environmental Protection Act 1986*): Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia*, Guidance Statement 54a: Technical appendix for Guidance Statement 54, Environmental Protection Authority, Western Australia.

WA EPA (2013), *Environmental Assessment Guideline for Consideration of Subterranean Fauna in Environmental Impact Assessment in Western Australia*, Environmental Assessment Guideline 12, Environmental Protection Authority, Western Australia.

Ward, J.V., Malard, F., Stanford, J.A., Gonser, T., Wilkens, H., Culver, D.C. and Humphreys, W.F. (2000), Interstitial aquatic fauna of shallow unconsolidated sediments, particularly hyporheic biotopes, pp: 41–58, *Ecosystems of the World. Vol. 30. Subterranean Ecosystems*, Elsevier, Amsterdam.

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Cover photos: Rock Formations on Newnes Plateau and Coxs River

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