APPENDIX F

AQUATIC ECOLOGY ASSESSMENT

WILPINJONG EXTENSION PROJECT
AQUATIC ECOLOGY ASSESSMENT

REPORT PREPARED FOR
PEABODY ENERGY AUSTRALIA PTY LTD

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EXECUTIVE SUMMARY

BIO-ANALYSIS Pty Ltd was commissioned by Wilpinjong Coal Pty Ltd (WCPL) to prepare an aquatic ecology assessment for the Wilpinjong Extension Project (the Project). The Project is a proposed extension of open cut operations at the Wilpinjong Coal Mine for an additional operational life of approximately seven years.

WCPL is seeking approval for the Project under Division 4.1 of Part 4 of the New South Wales (NSW) *Environmental Planning and Assessment Act, 1979* (EP&A Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act).

The primary objectives of this Aquatic Ecology Assessment were to:

- Review existing literature relevant to the aquatic ecology in the vicinity of the Project;
- Undertake field work to complement previous surveys to provide an assessment of stream characteristics, aquatic biota and aquatic habitat in the vicinity of the Project;
- Assess potential impacts of the Project on aquatic habitats and biota, including any threatened species or communities listed under the NSW *Fisheries Management Act, 1994* (FM Act) and/or EPBC Act; and
- Describe the proposed mitigation and management of potential impacts associated with the Project.

Description of the Existing Environment

The Project is contained within the Wilpinjong Creek catchment, located within the Mid-Western Regional Council Local Government Area, in central NSW. The dominant non-mining land-use within and around the Study Area is cattle and sheep grazing with some intermittent cropping (fodder crops).

Wilpinjong Creek occurs downslope of the Wilpinjong Coal Mine. Surface water flows from south to north into Wilpinjong Creek via a series of small ephemeral streams and, where relevant, up-catchment diversion structures of the Wilpinjong Coal Mine. The streams are semi-perennial, spring-fed streams in their upper reaches near the Munghorn Gap Nature Reserve, changing to relatively wide, ill-defined ephemeral drainages in the lower reaches near Wilpinjong Creek. Named waterways include Planters Creek, Spring Creek, Narrow Creek, Bens Creek and Cumbo Creek. Spring Creek, Narrow Creek and Bens Creek have been diverted or intercepted by the existing/approved Wilpinjong Coal Mine.

Wilpinjong Creek is ephemeral. After sufficient rainfall, Wilpinjong Creek flows eastwards into Wollar Creek, approximately 5 km downstream of the approved mining lease, which joins the Goulburn River in the Goulburn River National Park.

Surface water in the vicinity of the Study Area commonly has elevated salinity levels, reflecting the contribution of naturally saline groundwater contributions to base flow from the coal measures in the area. Nutrient levels are also commonly high and pH tends to be alkaline.

Riparian and instream habitats have been substantially altered by historical and ongoing agricultural land use practices. Assemblages of aquatic plants showed little diversity and were heavily infested in places by riparian and aquatic weeds. There was little evidence of bed erosion, bed lowering, knickpoints and sediment deposition due to the creek channel being obscured by stream vegetation.

Assemblages of macroinvertebrates were generally dominated by pollution-tolerant taxa, particularly midge fly larvae (Family Chironomidae). Freshwater shrimp (Family Atyidae), water beetles (Families Hydrophilidae and Dytiscidae) and the introduced freshwater snail, Physidae, were also common.

Fish habitat within Wilpinjong Creek is generally of poor to moderate ecological value. Other, semi-perennial streams within the Study Area provided fish habitat of low value. Six species of fish were recorded, comprising three native species (Longfin eels [*Anguilla reinhardtii*], Striped gudgeon [*Gobiomorphus australis*] and Australian smelt [*Retropinna semoni*]) and three alien species (Mosquito fish [*Gambusia holbrooki*], European Carp [*Cyprinus carpio*] and Goldfish [*Carassius auratus*]).

No aquatic threatened species, populations or communities listed under the FM Act, *Threatened Species Conservation Act, 1995* (TSC Act) or EPBC Act were observed in the Study Area during past or current field surveys nor are there any records of their occurrence within the Study Area.

Assessment of Impacts, Environmental Management and Monitoring

The Wilpinjong Mine is approved to remove ephemeral creek lines in the approved mining area and divert surface water flows. The Project would involve further removal of these ephemeral creeks but the impact on aquatic ecology would be minor as these ephemeral creeks provide poor aquatic habitat (due to location in the catchment, poorly defined drainage channels that is mostly colonised by pasture grasses, and lack of consistent surface flows).

There would be nil or negligible change to the aquatic ecology in Wilpinjong Creek due to surface water flows given the Project would have no material impact on flows in the creek. Further, there would be nil or negligible change to the aquatic ecology in Wilpinjong Creek due to surface water quality given the range of controls incorporated into the Project.

Assessments of Significance in accordance with section 5A of the EP&A Act have been undertaken for potentially occurring threatened aquatic species and communities and it is concluded that the Project would not result in a significant impact to any threatened aquatic species or ecological communities listed under the TSC Act or FM Act. Similarly, an assessment of impacts on potentially occurring threatened aquatic species listed under the EPBC Act has been undertaken and it is concluded that none would be significantly impacted.

In conclusion, the direct impacts of the Project on aquatic ecology are minimal and the potential indirect impacts on aquatic ecology downstream of the Project would be minimised with a number of existing mitigation measures currently implemented at the Wilpinjong Coal Mine.

1.0 INTRODUCTION

1.1 Background

The Wilpinjong Extension Project (the Project) is a proposed extension of open cut operations at the Wilpinjong Coal Mine for an additional operational life of approximately seven years. The Project is located approximately 40 kilometres (km) north-east of Mudgee in central New South Wales (NSW) (Figure 1).

Wilpinjong Coal Pty Ltd (WCPL) is seeking approval from the NSW Minister for Planning for a Development Consent under Division 4.1 of Part 4 of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act).

The Project would include the following activities:

- open cut mining of run-of-mine (ROM) coal from the Ulan Coal Seam and Moolarben Coal Member in Mining Lease (ML) 1573 and in new Mining Lease Application areas in Exploration Licence (EL) 6169 and EL 7091;
- approximately 800 hectares (ha) of open cut extensions, including:
  - approximately 500 ha of incremental extensions to the existing open cut pits in areas of ML 1573 and EL 6169;
  - development of a new open cut pit of approximately 300 ha in EL 7091 (Pit 8);
- continued production of up to 16 million tonnes per annum (Mtpa) of ROM coal;
- continued use of the Wilpinjong Coal Mine Coal Handling and Preparation Plant (CHPP) and general coal handling and rail loading facilities and other existing and approved supporting mine infrastructure;

LEGEND

- Mining Lease Boundary
- Exploration Licence Boundary
- Authorisation Boundary
- Local Government Boundary
- NSW State Forest
- National Park, Nature Reserve or State Conservation Area
- Mining Operation

Source: NSW Land & Property Information (2015); NSW Dept of Industry (2015); Geoscience Australia (2011)

WILPINJONG EXTENSION PROJECT

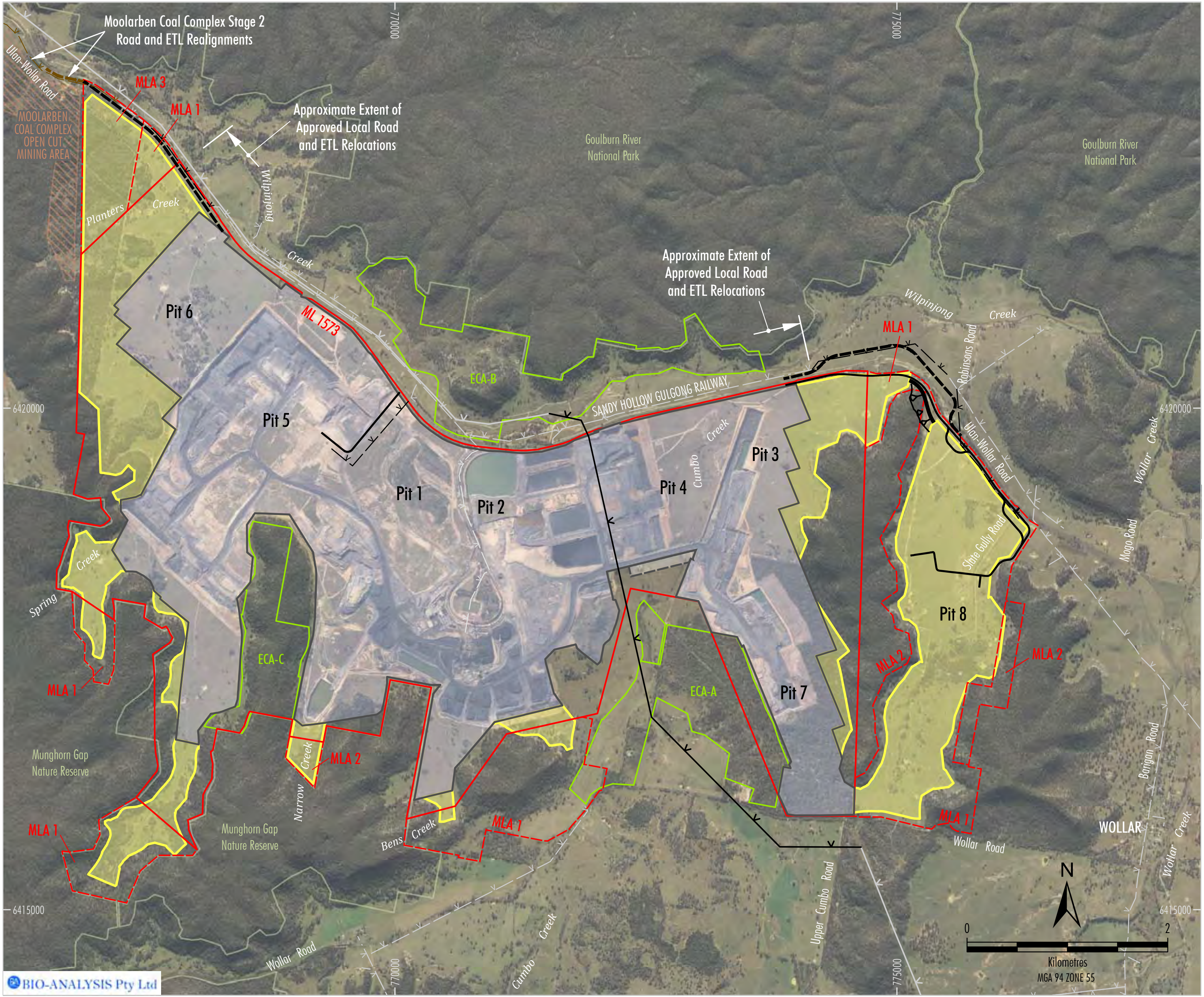
Regional Location

Figure 1

- rail transport of approximately 13 Mtpa of thermal product coal to domestic and export customers (within existing maximum and annual average daily rail limits);
- relocation of a section of the TransGrid Wollar to Wellington 330 kilovolt (kV) electricity transmission line (ETL) to facilitate mining in Pit 8;
- various local infrastructure relocations to facilitate the mining extensions (e.g. realignment of Ulan-Wollar Road and associated rail level crossings, relocation of local ETLs and services);
- construction and operation of additional mine access roads to service new mining facilities located in Pits 5 and 8;
- construction and operation of new ancillary infrastructure in support of mining, including: mine infrastructure areas, ROM pads, haul roads, electricity supply, communications installations, light vehicle roads, access tracks, remote crib huts, up-catchment diversions, dams, pipelines and other water management structures;
- extension of the approved mine life by approximately seven years (i.e. from approximately 2026 to 2033);
- a peak operational workforce of approximately 625 people;
- ongoing exploration activities; and
- other associated minor infrastructure, plant and activities.

The Project general arrangement is shown on Figure 2.

BIO-ANALYSIS Pty Ltd has been commissioned by WCPL to prepare an aquatic ecology assessment for the Project.



LEGEND
- Mining Lease Boundary
- Mining Lease Application Boundary
- Approved/Existing Open Cut and Contained Infrastructure Area
- Relocated Block Bank and Cumbo Creek Disturbance Area
- Proposed Open Cut Extension Area
- Proposed Public Road Realignment
- Proposed Pit 3/8 Haul Road
- Proposed Service Road
- Proposed Local ETL Realignment/Relocation
- Proposed Relocated TransGrid 330 kV ETL
- Existing Local ETL
- Existing TransGrid 330 kV ETL
- Enhancement and Conservation Area

Source: WCPL (2015); NSW Dept of Industry (2015)
Orthophoto: WCPL (Jun 2015; Jun 2014)

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WILPINJONG EXTENSION PROJECT

Project General Arrangement

Figure 2

WIL-12-12_WEP_EIS_Aquatic_202A

1.2 Existing and Proposed Water Management System

Consistent with the existing Wilpinjong Coal Mine, the main water requirements for the Project are for operation of the CHPP and for dust suppression. The water requirements are mostly met by re-use of ground and surface water collected within the mining footprint, but also potentially from groundwater extraction from licensed bores during extended dry periods.

An objective of the water management system at the Wilpinjong Coal Mine is to protect the integrity of local and regional water sources. The existing water management strategy at the Wilpinjong Coal Mine is based on the containment and re-use of ground and surface water collected within the mining footprint, as well as the control of sediment that may be potentially carried with runoff from disturbed areas such as the waste rock emplacements or areas cleared in advance of mining. Undisturbed area runoff is separated from disturbed area runoff by up-catchment diversions. The Project water management system would generally be based on the existing water management system with augmentations undertaken progressively over the life of the Project, such as:

- additional up-catchment diversion structures to divert runoff from undisturbed areas around the open cut and waste rock emplacements;
- sediment dams to contain runoff from topsoiled/partially rehabilitated mine areas;
- contained water storages managed and operated for no uncontrolled release to downstream watercourses; and
- progressive management of groundwater inflows consistent with the existing water management system at the Wilpinjong Coal Mine (water collected in sumps and re-used for dust suppression and/or transferred to contained water storages).

Under the Wilpinjong Coal Mine Environment Protection Licence (EPL), water treated by the water treatment facility (incorporating a reverse osmosis [RO] plant) is permitted to be discharged (at up to 5 megalitres per day) to Wilpinjong Creek, providing the discharge meets certain requirements, including an upper limit on Electrical Conductivity of 500 microSiemens per centimetre (µS/cm). Monitoring using the AUSRIVAS technique has shown no evidence of any adverse impacts on quality of the aquatic environment as a result of discharges from the Wilpinjong Coal Mine (Landline Consulting, 2011 to 2014). Water treated by the water treatment facility for the Project would continue to be released to Wilpinjong Creek in accordance with EPL 12425.

The post mine drainage would be designed to integrate with the surrounding catchment and would include some permanent creek features formed within rehabilitation areas in locations similar to current creek lines. These reconstructed creek features would convey upslope runoff across the Project area to Wilpinjong Creek.

Final voids would remain at the cessation of mining for the Wilpinjong Coal Mine and for the Project. At the cessation of the Project, final voids would remain in the southern end of Pit 8, the northwest of Pit 6, and in Pit 2 (Pit 2 West Dam). The surface catchment of the final voids would be reduced to a practicable minimum. This would be achieved by progressively backfilling the landform surrounding the final voids to the natural surface and the use of up-catchment diversions and contour drains around their perimeter. A water balance of the final voids indicate that none of the voids would spill to the receiving environment (WRM Water & Environment, 2015).

1.3 Study Requirements and Scope

The primary objectives of this Aquatic Ecology Assessment were to:

- Review existing literature relevant to the aquatic ecology in the vicinity of the Project;

- Undertake field work to complement existing surveys to provide a baseline assessment of stream characteristics, aquatic biota and aquatic habitat in the vicinity of the Project;
- Assess the potential impacts of the Project on aquatic habitats and biota, including any threatened species or communities listed under the NSW *Fisheries Management Act, 1994* (FM Act) and/or EPBC Act; and
- Describe the proposed mitigation, management and monitoring of potential impacts associated with the Project.

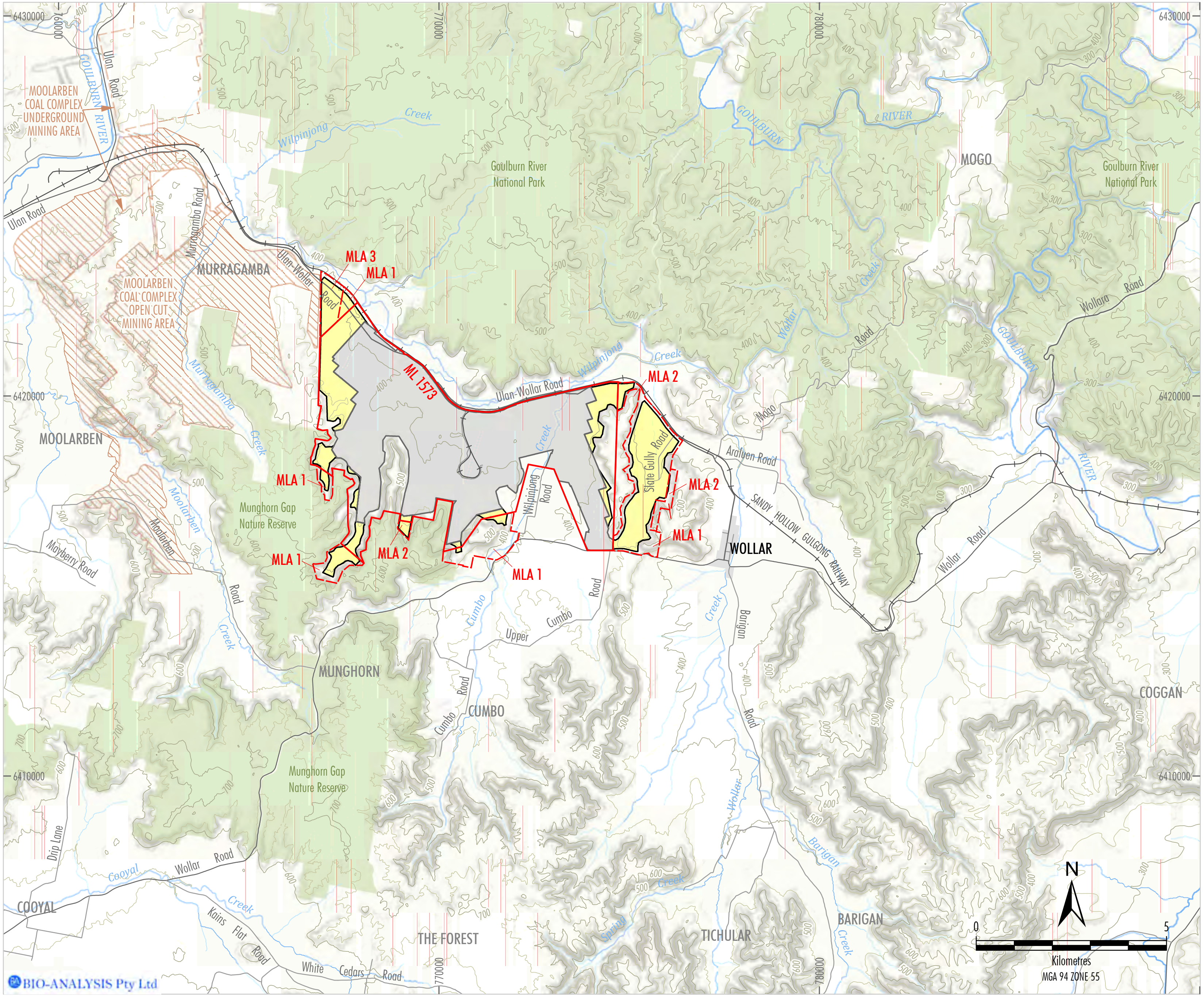
2.0 DESCRIPTION OF THE STUDY AREA

The Project area is located to the west of the Village of Wollar and south of Wilpinjong Creek (Figure 1). The mining area is drained by a number of north-flowing headwater tributaries of Wilpinjong Creek, including Cumbo Creek and Spring Creek (Figure 2). Other streams include Planters Creek, Narrow Creek and Bens Creek. Other unnamed tributaries also cross the Project area.

Wilpinjong Creek ultimately flows eastwards into Wollar Creek, approximately 5 km downstream of the approved mining lease, which joins the Goulburn River in the Goulburn River National Park (Figure 3). The Goulburn River joins the Hunter River at Denman.

The Study Area for this assessment has been defined as aquatic habitats within the following watercourses and waterbodies (Figure 4):

- the reach of the Wilpinjong Creek extending from immediately upstream of the Project area downstream to the confluence with Wollar Creek;
- the reach of Wollar Creek extending approximately 0.5 km downstream from the confluence with Wilpinjong Creek;
- Spring Creek;
- Narrow Creek;
- Bens Creek;
- Planters Creek;
- Cumbo Creek;
- an unnamed drainage line west of Slate Gully Road; and
- an unnamed tributary south-east of Spring Creek.



LEGEND
- Mining Lease Boundary
- Mining Lease Application Boundary
- Approved/Existing Open Cut and Contained Infrastructure Area
- Proposed Open Cut Extension Area
- National Park or Nature Reserve

Source: WCPL (2015); NSW Dept of Industry (2015); NSW Land & Property Information (2015)

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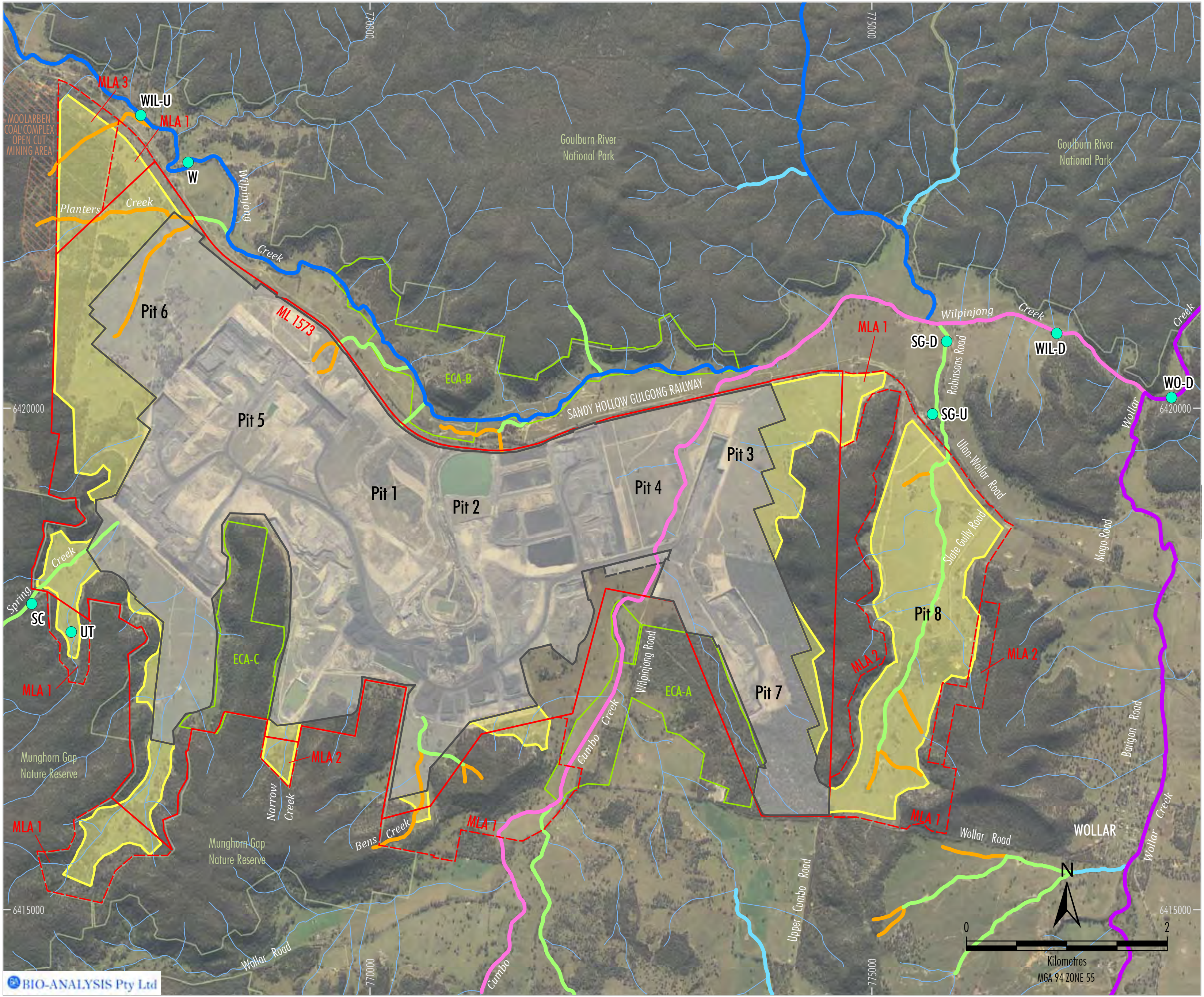
WILPINJONG EXTENSION PROJECT

Topography and Drainage

WIL-12-12_WEP_EIS_Aquatic_203A

Figure 3

Sites on these waterways were assessed during field surveys in 2004 and/or 2014 (Figure 4). Where appropriate, records and observations were made on the condition, quality and geomorphology of each creek as well as a description of the habitat and any anthropogenic disturbance. A survey of aquatic biota was done at selected sites (Section 4.1).



LEGEND
- Mining Lease Boundary
- Mining Lease Application Boundary
- Approved/Existing Open Cut and Contained Infrastructure Area
- Relocated Block Bank and Cumbo Creek Disturbance Area
- Proposed Open Cut Extension Area
- Enhancement and Conservation Area
- Aquatic Sampling Location
- Stream

Strahler Stream Order
- 1st Order
- 2nd Order
- 3rd Order
- 4th Order
- 5th Order
- 6th Order

Source: WCPL (2015); NSW Land & Property Information (2015); NSW Dept of Industry (2015)
Orthophoto: WCPL (Jun 2015; Jun 2014)

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WILPINJONG EXTENSION PROJECT

Aquatic Ecology Survey Locations

Figure 4

WIL-12-12_WEP_EIS_Aquatic_204E

3.0 LITERATURE REVIEW

3.1 Previous Studies

A number of aquatic surveys, monitoring reports and assessments have been undertaken across the Project area and surrounds from 2004 onwards as summarised below.

i Wilpinjong Coal Project Aquatic Ecosystem Assessment

The *Wilpinjong Coal Project Aquatic Ecosystem Assessment* (BIO-ANALYSIS, 2005) included surveys of water quality, aquatic plants, macroinvertebrates and fish surveys and an impact assessment for the Wilpinjong Coal Project. In May 2004, four sites were sampled along Wilpinjong Creek (WP1, WP2, WP3 and WP4), two sites along Cumbo Creek (CC1 and CC2), two sites along Wollar Creek (WO1 and WO2) and one site within each of Planters Creek and Spring Creek.

The main findings included:

- the aquatic habitats were found to be in very poor condition and generally reflected the degraded nature of their immediate catchments;
- water quality was found to be poor with many sites having high salinity and nutrients;
- assemblages of aquatic plants were heavily infested in places by riparian and aquatic weeds;
- vegetation on the banks and overbank areas of all of the creeks surveyed was predominantly grass with occasional trees and little riparian vegetation;
- relatively low diversity and abundance of macroinvertebrates at most sites indicated anthropogenic disturbance;
- assemblages of macroinvertebrates were generally dominated by pollution dominant taxa, indicating generally poor water quality across the Study Area;

- richness and abundance of fish was poor with alien species Mosquito fish (*Gambusia holbrooki*) and Goldfish (*Carassius auratus*) dominating assemblages; and
- no threatened aquatic species listed under the FM Act or EPBC Act were recorded.

ii Macroinvertebrate and Water Quality Monitoring Programme for Wilpinjong Creek and Cumbo Creek

BIO-ANALYSIS Pty Ltd implemented the *Macroinvertebrate and Water Quality Monitoring Programme for Wilpinjong Creek and Cumbo Creek* in spring 2006 for WCPL (Roberts, 2006). A 'Beyond BACI' style experimental design was implemented in order to distinguish potential changes associated with mining activities from natural spatial and temporal variation. The study design required that two sites be sampled within each of twelve locations (Wilpinjong Creek: locations WP1-8; Cumbo Creek: CC1 and CC2; Wollar Creek: WO1 and WO2) (Roberts, 2006). Sampling was done in spring 2006, 2008 and 2009 (Roberts, 2006; 2008; 2009).

The main findings included:

- Chironomidae, Atyidae and Dytiscidae were consistently the most abundant macroinvertebrate families;
- Mosquito fish were collected at a number of the locations;
- macroinvertebrate families that were most abundant are considered to be pollution tolerant;
- SIGNAL values calculated for all locations in Spring 2009 indicated severe water pollution;
- physico-chemical water quality was generally outside the Australian and New Zealand Environment Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) guidelines; and

- multivariate and univariate analyses examining spatial and temporal changes in selected variables (e.g. the structure and distribution of assemblages, total abundance, total diversity) found no evidence of impacts associated with mining operations (Roberts, 2006; 2008; 2009).

iii Stream Health Monitoring Aquatic Macroinvertebrate Surveys

The design of the *Macroinvertebrate and Water Quality Monitoring Programme for Wilpinjong Creek and Cumbo Creek* was reduced in spring 2010 to the collection of three replicate samples of macroinvertebrates and one water quality sample at each of the twelve location's established by BIO-ANALYSIS (Roberts, 2006) (Landline Consulting, 2010). Since then, stream health and aquatic macroinvertebrate surveys have been done in spring 2011, 2012, 2013 and 2014 (Landline Consulting, 2011; 2012; 2013; 2014).

Landline Consulting apply a variety of interpretive indices (Shannon diversity index, Shannon evenness value, SIGNAL-2) to the macroinvertebrate data collected. In general, Landline Consulting (2013) found:

- sites normally sampled on Cumbo Creek could not be sampled in spring 2013 due to insufficient aquatic habitat at the most upstream site and expansion of mining at the most downstream site;
- Chironomid and ceratopogonid flies, baetid mayflies, coenagrionid damselflies, corduliid dragonflies, dytiscid and hydraenid beetles, corixid bugs, planorbid snails, ostracods and water mites (hydracarina) are the eleven most ubiquitous taxa collected;
- generally, the assemblage of macroinvertebrates collected in 2013 was similar to that in the three previous surveys;
- freshwater shrimps (Family Atyidae) previously abundant in 2010, 2011 and 2012 were absent in 2013;

- environmental health indicator values had decreased at most sites compared to 2012 and 2011. Higher salinities resulting from low flow conditions were thought to have caused the decline; and
- there was no evidence of any adverse impacts on quality of the aquatic environment as a result of discharges from the Wilpinjong Coal Mine.

v Wilpinjong and Cumbo Creek Stability Assessment

The *Wilpinjong and Cumbo Creek Stability Assessment 2012-2013* (Barnson, 2014) examined creek stability along Wilpinjong and Cumbo Creeks using a visual, rapid assessment method. In general, the assessment found the following for Wilpinjong Creek:

- of the 40 sites sampled, 15 were rated within the unstable range;
- there was little evidence of bed erosion, bed lowering, knickpoints and sediment deposition due to the creek channel being obscured by stream vegetation;
- instream species diversity remains low, compared to surveys done in 2011 and 2012; and
- riparian health along much of the creek remains poor, mostly due to dominance by grasses, absence of a tree and shrub layer and presence of noxious weeds such as blackberry and prickly pear (Barnson, 2014).

In general, in Cumbo Creek:

- channel and bed stability remains stable, largely due to low slopes and a high degree of groundcover; and
- the creek channel remains obscured by instream vegetation (Barnson, 2014).

Most notably, differences observed in both creeks related to changes in groundcover and groundcover health as a result of a lack of rainfall over the past 2 years (Barnson, 2014). There is currently no visible evidence that mining within the vicinity of the creek has resulted in any creek bed lowering or increased erosion beyond natural processes (Barnson, 2014).

3.2 Physical Setting

The Wilpinjong Coal Mine is located within the Mid-Western Regional Council Local Government Area (LGA), in central NSW (Figure 1). The local coals are part of the Permian Illawarra coal measures and are overlain by Triassic Wollar Sandstones which dominate the surface geology of the area. The dominant non-mining land-use within and around the Study Area is cattle and sheep grazing with some intermittent cropping (fodder crops). As such, land within the local area has been cleared extensively.

There are two existing open cut coal mines within the local area. They are the Moolarben Coal Complex (located immediately west of the Wilpinjong Coal Mine), and the Ulan Mine Complex (located approximately 8 km north-west of the Wilpinjong Coal Mine).

A number of streams occur within the Study Area and surrounds, the largest of which is Wilpinjong Creek (Figure 3). The headwaters of Wilpinjong Creek are in the Goulburn River National Park (Figure 3). The creek initially flows westward toward Ulan and then flows south-east, joining the Murragamba Creek before continuing south-east, ultimately joining Wollar Creek (a tributary of the Goulburn River), approximately 5 km downstream of the approved mining lease (Figure 3). The Goulburn River joins the Hunter River at Denman.

Wilpinjong Creek is incised into the valley floor and forms a series of semi-permanent soaks fed primarily from drainage from the surrounding alluvial plain and colluvium, which is recharged from the adjacent sandstone plateau (WRM Water and Environment, 2015). The creek is a 4th order stream and is ephemeral (WRM Water and Environment, 2015).

Surface water drainage from the mine area flows from south to north to Wilpinjong Creek via a series of small streams. The streams are semi-perennial, spring-fed streams in their upper reaches near the Munghorn Gap Nature Reserve, changing to relatively wide, ill-defined ephemeral drainages in the lower reaches near Wilpinjong Creek (WRM Water and Environment, 2015). Named waterways include Planters Creek, Spring Creek, Narrow Creek, Bens Creek and Cumbo Creek (Figure 2). Spring Creek, Narrow Creek and Bens Creek have been diverted or intercepted by the existing/approved Wilpinjong Coal Mine (Figure 2).

After Wilpinjong Creek, Cumbo Creek is the largest drainage feature (a 5th order stream) crossing the mine site, draining a pre-mine catchment area of approximately 70 square kilometres, including some of the eastern parts of the mine area. A significant section of Cumbo Creek would be relocated and the current alignment mined as part of the approved Wilpinjong Coal Mine (Figure 2). The pre-mine catchment areas of Wilpinjong and Cumbo Creeks have been reduced by the development of open cut pits as part of the approved Wilpinjong Coal Mine.

Long-term rainfall data were sourced from a Bureau of Meteorology (BOM) weather station in Wollar (Barrigan St) (Site No.62032). The Wilpinjong area experiences a temperate climate with an average annual rainfall of approximately 600 millimetres (mm) (BOM, 2015a). The data from Wollar indicates January is the wettest month, with an average rainfall of 66.7 mm and May is the driest month, with an average rainfall of 37.7 mm. The months of April to September are the driest with a consistent monthly mean of around 40 mm, with rain then increasing from October to January, then decreasing to April (BOM, 2015a).

3.3 Surface Water Quality

Water quality surveys indicate that the creeks within the Study Area commonly had elevated salinity and nutrient levels, reflecting the contribution of naturally saline groundwater contributions to base flow from the coal measures in the area (Section 3.1). The pH in creeks within the Study Area tends to be alkaline (Section 3.1).

WRM Water and Environment (2015) suggest that the downstream trend of increased salinity observed in Wilpinjong Creek is partly due to inflows from Cumbo Creek and naturally saline groundwater contributions to base flow. Average concentrations of sulphate in Wilpinjong Creek were below the ANZECC and ARMCANZ (2000) guideline value but above the lower bound guideline value in Cumbo Creek (WRM Water and Environment, 2015).

3.4 Groundwater Dependant Ecosystems

Groundwater Dependant Ecosystems (GDEs) are ecosystems that have species and natural ecological processes that are determined by groundwater (Department of Land and Water Conservation [DLWC], 2002). GDEs include base flow in streams, wetlands, terrestrial vegetation and aquifer and cave ecosystems (DLWC, 2002).

The *National Atlas of Groundwater Dependent Ecosystems* (BOM, 2015b), does not identify any potential GDEs in the study area or surrounds. However, Wilpinjong Creek is considered to be a GDE (i.e. the stream and associated riparian vegetation).

3.5 Aquatic Habitat and Biota

The majority of aquatic habitat within the Study Area occupies an altitude between 350 metres (m) and 400 m above Australian Height Datum. Waterways within the Study Area that are considered as “Key Fish Habitat” under DPI guidelines for aquatic habitats are Cumbo Creek, Wollar Creek and Wilpinjong Creek (Department of Primary Industries [DPI], 2015a).

No aquatic threatened or protected species, populations or communities were observed in the Study Area during past field surveys.

Vegetation on the banks and overbank areas of creeks within the Study Area was predominantly grass with occasional trees and little riparian vegetation (BIO-ANALYSIS, 2005). Riparian health is poor, mostly due to dominance by grasses, absence of a tree and shrub layer and presence of noxious weeds such as blackberry and prickly pear (Barnson, 2014).

There was little evidence of bed erosion, bed lowering, knickpoints and sediment deposition due to the creek channel being obscured by stream vegetation (Barnson, 2014).

Assemblages of aquatic plants were heavily infested in places by riparian and aquatic weeds, including *Juncus articulatus* (Jointed rush), *Cirsium vulgare* (Spear thistle), *Polypogon monospeliensis* (Annual Beardgrass), *Cynodon dactylon* (Common couch), *Aster subulatus* (Wild aster) and *Alternanthera caracasana* (Khaki weed) (BIO-ANALYSIS, 2005).

Assemblages of macroinvertebrates were generally dominated by pollution-tolerant taxa, particularly midge fly larvae (Family Chironomidae). Freshwater shrimp (Family Atyidae), water beetles (Families Hydrophilidae and Dytiscidae) and the introduced freshwater snail, Physidae, were also common (BIO-ANALYSIS, 2005; Landline Consulting, 2013).

A past study done within the Study Area found richness and abundance of fish in the Study Area to be poor with the alien species, Mosquito fish (*Gambusia holbrooki)* and Goldfish (*Carassius auratus*) dominating assemblages (BIO-ANALYSIS, 2005). Three native species were collected: Longfin eel (*Anguilla australis*), Striped gudgeon (*Gobiomorphus australis*) and Australian smelt (*Retropinna semoni*).

4.0 FIELD SAMPLING AND METHODS

After a review of existing literature relevant to the aquatic ecology of the Study Area and wider surrounds it was determined that additional field surveys were required to be done due to the time elapsed and the changes that may have occurred within this timeframe. In addition, the area required to be studied is larger than that examined for the original EIS. Accordingly, additional aquatic surveys were done to complement existing surveys and provide a baseline assessment of stream characteristics, aquatic biota and aquatic habitat within the Study area.

4.1 Aquatic Habitat Assessment

An aquatic habitat assessment was done in areas with limited existing data to assess the aquatic habitat within the Project area and surrounding watercourses (Figure 4). Specifically, field inspections were done at the following eight locations listed in Table 1.

Qualitative information was collected at each site, including the condition, quality and geomorphology of each creek as well as a description of the habitat and any anthropogenic disturbance. Photographs and a GPS fix were collected at each site. The aquatic habitat at each location was given one of three 'health' classifications based on the quality of water, sedimentation and erosion, exotic species and diversity and abundance of macrophytes, macroinvertebrates and fish. The classifications were:

***Good* –** no evidence of erosion, streambank degradation or excessive sedimentation; water quality excellent; riparian vegetation consists of native species; fish and macroinvertebrate habitat excellent (i.e. major, permanently or intermittently flowing waterway); no exotic weeds, macroinvertebrates or fish species; no artificial barriers to upstream migration.

Table 1: Aquatic ecology assessment sites sampled within the Study Area (May 2014)

Watercourse	Location	Site	Easting	Northing	Comment
Wilpinjong Creek	WIL-U	1	0767688	6422963	Upstream of the Project area – Stream Order 4
		2	0767728	6422930	
	WIL-D	1	0776743	6420796	Downstream of the Project area - Stream Order 5
		2	0776769	6420794	
Wollar Creek	WO-D	1	0777985	6420106	Downstream of confluence with Wilpinjong Creek. Stream Order 6
		2	0778115	6420191	
Unnamed Drainage Line -West of Slate Gully Road	SG-U	1	0775525	6418885	Upstream of culvert near Ulan-Wollar Road - Stream Order2
		2	0775550	6418618	
	SG-D	1	0775578	6420590	Downstream of culvert near Ulan-Wollar Road - Stream Order 2
		2	0775600	6420330	
Spring Creek	SC	1	0766625	6418048	Upstream reaches of the northern arm, approximately 600 m downstream of headwaters - Stream Order 2
		2	0767378	6418700	Upstream reaches, at a waterhole - Stream Order 2
Unnamed Tributary	UT	1	0767023	6417770	Intermittent watercourse - Stream Order 1
Weir	W		0768188	6422450	Situated ~ 700 m downstream of WIL-U. Sampled opportunistically for fish

Moderate – some evidence of erosion, streambank degradation and sedimentation; water quality good; riparian vegetation consists mostly of native species; fish and macroinvertebrate habitat good (i.e. permanent or intermittent stream, creek or waterway with clearly defined bed and banks and aquatic vegetation present); few exotic weeds, macroinvertebrates or fish species; no artificial barriers to upstream migration.

Poor - excessive erosion, streambank degradation and sedimentation; water quality poor; riparian vegetation consisting of weeds; poor fish and macroinvertebrate habitat (i.e. intermittent flow and potential refuge, breeding or feeding areas); dominated by exotic weeds, macroinvertebrates or fish species; major artificial barriers to upstream migration.

4.2 Quantitative Assessment

Within locations WIL-U, WIL-D, WO-D and SG-D, two randomly nested sites were sampled quantitatively for water quality, aquatic marcoinvertebrates (except location SG), macrophytes and fish (except location SG). Each site was separated by approximately 200 m. Information on stream characteristics, including a visual assessment of stream width and depth, riparian conditions, signs of disturbance and cover of the substratum by algae were recorded at each site. Photographs and a GPS fix were also collected at each site. Sampling was done on the 20th and 22nd of May 2014.

All collections of fish and macroinvertebrates were done in accordance with section 37 of the FM Act using Scientific Collection Permit Number P03/0032(B) and NSW Agriculture, Animal Research Authority Care and Ethics Certificate of Approval Number 03/2445.

4.2.1 Water Quality

Within each of the two sites at locations WIL-U, WIL-D WO-D and SG-D, three replicate measurements of physico-chemical water quality variables were collected. The variables included electrical conductivity (µS/cm), dissolved oxygen (% saturation and milligrams per litre [mg/L]), pH (pH units), temperature (degrees Celsius [^{o}C]), oxygen-reduction potential (millivolts [mV]), turbidity (Nephelometric Turbidity Units [NTU]) and alkalinity (mg/L calcium carbonate [$CaCO_3$]). Water quality was not sampled at location SG-U or at locations surveyed on Spring Creek (SC) and the Unnamed Tributary (UT) due to insufficient aquatic habitat.

4.2.2 Macrophytes

Within each of the two sites at locations WIL-U, WIL-D, WO-D and SG-D, an assessment of the in-stream and riparian aquatic vegetation was done by estimating the relative abundance or percentage cover of aquatic macrophytes within five haphazardly placed 0.25 square metre (m^2) quadrats, using a stratified sampling technique. The distribution of both in-stream and riparian macrophytes were also estimated along each section of the site by assigning a cover class to each species. The cover classes were: (+) one plant or small patch, (++) not common, growing in a few places, and (+++) widespread. Systematic assessment of macrophytes was not undertaken at locations SG-U, SC and UT due to insufficient aquatic habitat.

4.2.3 Macroinvertebrates

Aquatic macroinvertebrates were sampled using the Australian River Assessment System (AUSRIVAS) protocol (Turak et al., 2004) and quantitatively. Using the AUSRIVAS technique, samples of stream edge habitats and riffle habitats (where available) were collected at two sites (approximately 100 m long) within locations WIL-U, WIL-D, WO-D, over a total length of 10 m (usually in 1-2 m sections), using a 250 micrometre (µm) dip net. Aquatic macroinvertebrates were not sampled at locations SG-U, SG-D, SC and UT due to insufficient aquatic habitat.

The contents of each net sample were placed into a white sorting tray and animals collected for a minimum period of 30 minutes. Thereafter, removals were done in 10 minute periods, up to a total of one hour (Turak et al., 2004). If no new taxa were found within a 10 minute period, removals ceased (Turak et al., 2004). The animals collected were placed inside a labelled container, preserved with 70% alcohol and taken to the laboratory.

To sample quantitatively, three replicate macroinvertebrate samples were collected within each site using timed 1-minute sweeps of all habitats (edge, macrophytes, riffle, pools, etc.), using a 250 x 250 centimetres (cm) (250 µm) dip net. The contents of the net were placed into plastic trays filled with fresh water and the macroinvertebrates sorted and placed into pre-labelled plastic sample containers filled with 70% alcohol.

In the laboratory, samples were identified using an ISSCO M400 stereomicroscope. Taxa were identified to family level with the exception of Acarina (to order), Chironomidae (to sub-family), Nematoda (to phylum), Nemertea (to phylum), Oligochaeta (to class), Ostracoda (to subclass) and Polychaeta (to class). Some families of Anisoptera (dragonfly larvae) were identified to species, because they could have potentially included a threatened aquatic species (i.e. *Petalura gigantea*).

4.2.4 Fish

Within each of the two sites at locations WIL-U, WIL-D, WO-D, three replicate samples of the assemblage of fish were collected using a Smith-Root 15C Electrofisher backpack unit. The Electrofisher was used to stun the fish in open water and in the different edge habitats that were present (e.g. submerged and emergent aquatic vegetation, woody debris). Three minutes of electrofishing effort per replicate were used. All stunned fish were collected using a dip net and placed into plastic trays filled with water.

Where there were deeper pools, a combination of bait traps and fyke nets were used to sample the assemblage of fish. Traps were baited with a mixture of bran and bread soaked in tuna oil, chicken pellets and strips of mullet. Traps and/or fyke nets were set and left overnight.

All fish caught were placed into plastic trays filled with water. Fish were identified, counted and measured (fork length, nearest 0.5 cm) in the trays before being released back into the water once sampling at a site was completed. Incidental observations, e.g. evidence of disease such as lesions, were noted. Any alien species caught were euthanized and disposed of.

Fish were not sampled at locations SG-U, SG-D, SC and UT due to insufficient aquatic habitat.

4.2.5 Analyses

Both multivariate (PERMANOVA-PRIMER) and univariate (ANOVA – GMAV) statistical routines were used to analyse the quantitative data. Multivariate methods allow comparisons of two (or more) samples based on the degree to which these samples share particular species, at comparable levels of abundance. A non-metric multidimensional scaling (nMDS) ordination was used to graphically illustrate relationships between samples for each assemblage.

The significance of any apparent differences among sites and locations was determined using ANOSIM (analysis of similarities). A SIMPER (similarity of percentages) procedure was used to examine the contribution of taxa to the similarities (or dissimilarities) among locations and sites.

Analysis of variance (ANOVA) was used to test differences among locations and between sites for a range of derived variables. These analyses included the total number of species (species richness) and the number of individuals (abundance). Analyses would also be done on common taxa.

Data collected using the AUSRIVAS sampling protocol were analysed using the appropriate models developed for New South Wales. An AUSRIVAS assessment represents a comparison of the macroinvertebrates collected at a site (i.e. Observed) to those predicted to occur (Expected) if the site is in an undisturbed or ‘reference’ condition. The principal outputs of the AUSRIVAS model include the Observed to Expected ratio (OE50) and the BAND level for each site, which represents different levels of impairment.

5.0 RESULTS

A quantitative field survey of four locations was done on the 20th and 22nd May 2014.

5.1 Habitat Assessment

In general, the watercourses within the Study Area appear to have been degraded for a considerable period of time. Physical disturbances including land clearance, grazing by domestic stock and kangaroos and the activities of rabbits, pigs and wombats are the main contributors to observed degradation. Nutrients and sediments from erosion and runoff, invasions by riparian and aquatic weeds and alterations to natural stream flows have all exacerbated the problem. Notably, WCPL have implemented a number of control programmes to control large infestations of blackberry and other woody weeds (Landscape Constructions, 2014a and b).

i Wilpinjong Creek - Upstream (Stream Order 4)

Immediately north of the proposed open cut extension areas and north-west of current mining areas, Wilpinjong Creek consists of a moderately incised channel approximately 20 m wide and up to 0.3 m deep. During the survey, isolated pools up to 50 m in length and 12 m wide were observed (Plates 1 and 2). There was no flow and large sections of the creek bed were dry (Plates 1 and 2). The substratum of the channel was comprised of sandy gravel. Erosion was low to moderate and the area appeared to have had restricted grazing for some time.

Plate 1: Wilpinjong Creek (WIL-U) Site 1, looking upstream

Plate 2: Wilpinjong Creek (WIL-U) Site 1, looking downstream

The instream vegetation was dominated by *Phragmites australis, Typha domingensis Schoenoplectus validus*, *Paspalum distichum* (Water couch) and *Eleocharis sphacelata* (Appendix 2a). A few patches of *Isolepis cernua*, *Gahnia aspera*, *Juncus* spp. and the Charophyte, *Nitella* sp., were also present (Appendix 2a). Weeds included *Juncus articulatus* (Jointed rush), *Cirsium vulgare* (Spear thistle) and *Polypogon monospeliensis* (Annual Beardgrass) (Appendix 2a).

This section of the creek was given a moderate rating for aquatic habitat because water quality, fish and macroinvertebrate habitat was rated 'good' (e.g. no artificial barriers to upstream migration) and there were few exotic weeds, macroinvertebrates or fish (Mosquito fish) species but there was some evidence of erosion, streambank degradation and sedimentation (see Section 4.1).

ii Wilpinjong Creek - Downstream (Stream Order 5)

Situated north-east of proposed open cut extension areas and current mining areas, the channel in Wilpinjong Creek consisted of a moderately incised channel with relatively small (up to ~ 40 m in length and 8 m wide), shallow (up to 0.6 m in depth), isolated pools with intermittently running water (Figure 4, Plates 3 and 4). Erosion was moderate (Plate 4) although cattle were observed grazing the instream and bank vegetation. The creek bed consisted of sandy gravel.

Plate 3 Wilpinjong Creek (WIL-D) Site 1, looking upstream

Plate 4: Wilpinjong Creek (WIL-D) Site 1, looking downstream

Typha domingensis, Schoenoplectus pungens and *Schoenoplectus validus* were the most abundant instream plants (Appendix 2a). Other instream and riparian vegetation included *Eleocharis gracilis*, *Phragmites australis, Lythrum hyssopifolia*, *Isolepis cernua*, *Gahnia aspera*, *Juncus usitatus* and the tree, *Angophora* sp. (Appendix 2a). Weeds included *Cynodon dactylon* (Common couch)*, Juncus articulatus, Cirsium vulgare, Aster subulatus, Alternanthera caracasana* (Khaki weed), *Paspalum dilatatum* (Paspalum) (Appendix 2a). Small patches of the submerged macrophyte, *Potamogeton pectinatus*, were also present (Appendix 2a).

This section of the creek was given a poor rating for aquatic habitat because water visibility was poor, the riparian vegetation consisted of several species of weed, the assemblage of fish was numerically dominated by alien species (European Carp [*Cyprinus carpio*] and Mosquito fish) and there was evidence of erosion, streambank degradation and sedimentation in several places (see Section 4.1).

iii Wollar Creek (Stream Order 6)

North-east of the proposed open cut extension areas and current mining areas, Wilpinjong Creek joins Wollar Creek before it enters the Goulburn River National Park (Figure 4). Wollar Creek is heavily modified upstream of its confluence with Wilpinjong Creek (BIO-ANALYSIS, 2005). BIO-ANALYSIS (2005) noted that there was significant erosion and the creek banks were heavily infested with weeds including willows.

Approximately 0.5 km downstream of the confluence with Wilpinjong Creek, the creek consisted of a deeply incised channel (up to ~ 4 m) characterised by a series of pools up to 15 m wide to a depth of approximately 0.6 m (Plates 5 and 6). The flow channel was intact with a predominantly rock and cobble substrate. Flow was low-moderate and visibility of the water was relatively clear and free of sediment.

Plate 5: Wollar Creek (WO-D) Site 1, looking upstream

Plate 6: Wollar Creek (WO-D) Site 1, looking downstream

Dominant aquatic macrophytes included *Schoenoplectus pungens, Paspalum distichum* and *Typha domingensis* (Appendix 2a). Other plant species present included *Schoenoplectus validus*, *Isolepis cernua*, *Ranunculus undosus* (Appendix 2a). Introduced species included *Cynodon dactylon*, *Juncus articulatus*, *Aster subulatus*, *Hydrocotyle laxiflora* (Appendix 2a). Small patches of the floating-attached species, *Triglochin procerum*, and submerged plant species, *Potamogeton pectinatus, Potamogeton ochreatus, Myriophyllum verrucosum* and *Nitella* sp. were also present (Appendix 2a).

This section of the creek was given a moderate rating for aquatic habitat because water quality and fish and macroinvertebrate habitat was rated 'good' (e.g. no artificial barriers to upstream migration and beds of submerged native aquatic macrophytes were present). However, the alien species of fish, (Mosquito fish) was numerically abundant (Plate 16), exotic weeds were present and there was some evidence of erosion, streambank degradation (Plate 6) and sedimentation (see Section 4.1).

iv Unnamed Drainage Line West of Slate Gully Road (Stream Order 2)

An unnamed drainage line west of Slate Gully Road intermittently flows south to north through Pit 8 into Wilpinjong Creek (Figure 4). The majority of its catchment is pastoral and small rural holdings.

At the time of the field visit, the tributary was restricted to occasional small dams (Plate 8) where the shale shelf had forced water to the surface (Plate 9). Many reaches of the creek appeared to have been grazed recently.

Near the top of the catchment, *Paspalum dilatatum* and *Penucetum* sp. were abundant within the indistinct drainage channel (Plate 7). Plants growing at the edges of a small dam included *Persicaria* sp., *Juncus subsecundus* and *Cyperus difformis* (Plate 8).

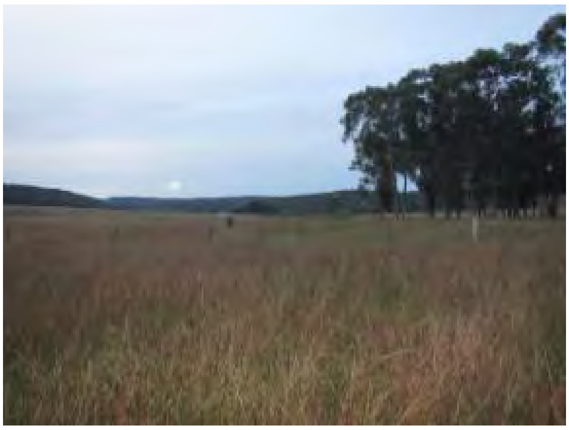


Plate 7: Unnamed Drainage Line West of Slate Gully Road (SG-U) upstream 'reaches'

Plate 8: Unnamed Drainage Line West of Slate Gully Road (SG-U) upstream 'reaches'

In the downstream reaches, small (up to ~ 8 m long and 2 m wide) dams comprised the only available aquatic habitat (Plates 7 and 8). *Eleocharis gracilis*, *Paspalum dilatatum* and *Cynodon dactylon* dominated plant assemblages within the channel, most likely where damp soil was still present, and the edges of the waterholes (Appendix 2a). Other species included *Juncus australis*, *Aster subulatus*, *Oxalis articulata*, *Trifolium subterraneum* (Clover) and the grasses *Setaria gracilis*, *Sporobolus caroli*, *Stipa setacea* (Spear grass) and *Themeda australis* (Kangaroo grass).

The unnamed drainage line west of Slate Gully Road was given a poor rating for aquatic habitat because the drainage channel was poorly defined (Plates 7 to 10)and there was no flow, little or no free standing water or pools and few semi-permanent aquatic macrophytes present. This tributary is unlikely to provide fish habitat (see Section 4.1).

Plate 9: Unnamed Drainage Line West of Slate Gully Road (SG-D) downstream reach looking upstream

Plate 10: Unnamed Drainage Line West of Slate Gully Road (SG-D) downstream reach looking downstream

v Spring Creek (Stream Order 2)

Spring Creek flows south-west to north-east through the proposed open cut extension areas (Figure 4). The creek is a semi-perennial, spring fed stream in its upper reaches near the Munghorn Gap Nature Reserve (Figure 4). The poorly defined ephemeral lower reaches have been intercepted by approved mining operations (Figure 2).

Aquatic habitat within the upper reaches of the creek was restricted to occasional dams (Plate 12). Aquatic macrophytes, including *Eleocharis gracilis, Schoenoplectus validus*, *Paspalum distichum*, *Paspalum dilatatum*, *Juncus subsecundus*, *Juncus usitatus*, *Myriophyllum latifolium*, *Elatine*, *Ottelia ovalifolia*, *Cyperus difformis*, *Plantago lanceolata*, and *Isolepis cernua* were abundant around the edges of dams (Plate 12).

**Plate 11: Spring Creek (SC)
upper reaches, looking upstream**

**Plate 12: Spring Creek (SC)
upper reaches at a dam**

Terrestrial plants (mostly native grasses and a large proportion [up to 80-90 %] of weeds) dominated the drainage line, which showed no signs of wetness and has been modified by grazing, rabbit and wombat burrows, among others (Plate 11). Native grasses included *Themeda australis* and *Microlaena stipoides*. Species of weeds included *Arctotheca calendula* (Capeweed), *Trifolium subterraneum*, *Aster subulatus, Xanthium spinosum* (Bathurst burr), *Malva parviflora, Cirsium vulgare, Verbena* sp. and *Echium plantagineum* (Paterson's curse).

Similar to the aquatic habitat assessment done in May 2004 (BIO-ANALYSIS, 2005), Spring Creek was given a poor rating for aquatic habitat because the drainage channel was poorly defined and there was no flow and little or no free standing water or pools (Plate 11). Aquatic macrophytes were restricted to the fringe of existing waterholes. This tributary is unlikely to provide fish habitat (see Section 4.1).

vi Unnamed Tributary

The Unnamed Tributary situated to the east of Spring Creek (see Table 1) had similar attributes to Spring Creek. The upper reaches of the Unnamed Tributary flow south-west to north-east through the proposed open cut extension areas. The creek is a semi-perennial, spring fed stream in its upper reaches near the Munghorn Gap Nature Reserve. The poorly defined ephemeral lower reaches have been intercepted by approved mining operations.

Similar to the upper reaches of Spring Creek, the drainage line had been colonised by terrestrial plants, mostly consisting of native grasses and a large proportion (up to 80-90 %) of weeds. The drainage line showed no signs of wetness and has been modified by grazing, rabbit and wombat burrows, among others. Native grasses included *Themeda australis* and *Microlaena stipoides*. Species of weeds included *Arctotheca calendula* (Capeweed), *Trifolium subterraneum, Aster subulatus, Xanthium spinosum* (Bathurst burr), *Malva parviflora, Cirsium vulgare, Verbena* sp. and *Echium plantagineum* (Paterson's curse). Notably, stands of the noxious tree, *Ailanthus altissima (*Tree-of-heaven) were also present (Plate 13).

Plate 13. Tree-of-heaven (*Ailanthus altissima*)
present in the upper reaches of the Unnamed Tributary

The Unnamed Tributary was given a poor rating for aquatic habitat because the drainage channel was poorly defined, there was no flow and little or no free standing water or pools. Few emergent species of aquatic macrophyte were present. This tributary is unlikely to provide fish habitat (see Section 4.1).

v Planters Creek

Planters Creek is situated to the north of Spring Creek (Figure 2). In May 2004, BIO-ANALYSIS (2005) described Planters Creek as an intermittent drainage line consisting of a series of five small dams, which have restricted the natural flow regime. Lack of flow and heavy grazing had reduced or eliminated semi-aquatic plants from the over-land flow path. For these reasons, Planters Creek was given a poor rating for aquatic habitat (see Section 4.1).

vi Narrow Creek

Narrow Creek lies to the south-east of Spring Creek (Figure 2) and has similar attributes to Planters Creek.

vii Bens Creek (Stream Order 1)

Bens Creek lies to the south-east of Narrow Creek (Figure 2) and has similar attributes to Planters Creek.

5.2 Quantitative Assessment

5.2.1 Water Quality

Physico-chemical water quality and alkalinity measurements are summarised in Table 2 with values highlighted in bold type indicating where mean values were outside the range recommended by the ANZECC and ARMCANZ (2000) guidelines. In general, mean water temperature within the four locations sampled ranged from 8.8 to 16.4 °C (Table 2), which is typical for the time of year the samples were collected. Mean pH (range = 8.1 – 9.4) was higher than the upper limit recommended by the ANZECC and ARMCANZ (2000) guidelines (i.e. pH 6.5-8.0) for upland rivers (i.e. systems at > 150 m altitude) at all of the sites sampled (Table 2). This is consistent with WRM Water and Environment (2015) who determined that the average pH within the local creeks has a high tendency towards slightly alkaline levels.

Mean conductivity values (range = 157.7 – 3549 µS/cm) were above the upper limit recommended by ANZECC and ARMCANZ (2000) at all sites except those sampled within the unnamed drainage line west of Slate Gully Road (Table 2). WRM Water and Environment (2015) proposed that the elevated conductivity levels in the local creeks were due to saline base-flow from the coal measures in the area.

Mean dissolved oxygen (range = 60.1 – 86.1 % Saturation) was below the lower limit recommended by ANZECC and ARMCANZ (2000) at all of the sites sampled, particularly at the sites sampled in the upstream section of Wilpinjong Creek, where there was no flow (Table 2).

Mean turbidity (range = 2.8 – 328.1 NTU) was above the upper limit recommended by the ANZECC and ARMCANZ (2000) guidelines at the sites sampled in the downstream reaches of Wilpinjong Creek and at the unnamed drainage line west of Slate Gully Road (Table 2). Cattle were observed on this section, grazing the instream and bank vegetation. Mean oxidation-reduction potential ranged between 359.0 and 517.3 mV (Table 2). The raw water quality data are provided in Appendix 1.

Table 2: Mean (+ SE) measurements of water quality variables recorded at each site in May 2014

Location	Wilpinjong Creek Upstream (WIL-U)		Wilpinjong Creek Downstream (WIL-D)		Unnamed Drainage Line West of Slate Gully Road (SG-D)		Wollar Creek (WO-D)	
Site	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Temperature °C	11.7 (0.0)	11.7 (0.0)	16.4 (0.0)	15.1 (0.0)	8.8 (0.0)	9.0 (0.0)	13.0 (0.0)	10.3 (0.0)
pH	**8.2** (0.0)	**8.1** (0.0)	**8.7** (0.0)	**8.8** (0.0)	**8.5** (0.0)	**8.3** (0.0)	**9.2** (0.0)	**9.4** (0.0)
Conductivity (µS/cm)	**1830** (0)	**1809** (6)	**3548** (0)	**3549** (2)	157.7 (2)	176.7 (2)	**2998** (1)	**3003** (4)
Dissolved Oxygen (mg/L)	7.4 (0.0)	6.5 (0.1)	7.7 (0.0)	8.0 (0.1)	8.7 (0.1)	7.8 (0.0)	8.3 (0.0)	9.6 (0.1)
Dissolved Oxygen (% Saturation)	**68.4** (0.5)	**60.1** (1.0)	**79.9** (0.2)	**80.0** (0.9)	**75.2** (0.8)	**67.4** (0.3)	**79.3** (0.1)	**86.1** (0.6)
Turbidity (NTU)	25.5 (0.3)	19.6 (1.0)	**328.1** (2.3)	**114.6** (3.6)	**179.1** (0.4)	**321.9** (1.9)	2.8 (0.2)	15.8 (1.5)
Oxygen Reduction Potential (mV)	359.0 (2.1)	362.0 (3.1)	414.3 (0.3)	417.7 (0.3)	517.3 (0.3)	509.7 (0.3)	485.0 (0.6)	473.0 (0.0)
Alkalinity (mg/L $CaCO_3$)	35		35				35	

NB: Values in bold are outside the guideline values recommended by ANZECC and ARMCANZ (2000) (n = 3).Guideline values recommended by the ANZECC and ARMCANZ (2000) guidelines for slightly disturbed in south-east Australia NSW upland rivers: pH (6.5 – 8.0); Conductivity (30 – 350 µS/cm); Turbidity (2 – 25 NTU); Dissolved Oxygen (90–110 % Saturation). There are no ANZECC and ARMCANZ (2000) guideline values for Temperature, oxygen reduction potential or Alkalinity.

5.2.2 Aquatic Plants

A total of 25 plant taxa were recorded at the four locations sampled quantitatively (WIL-U: 9 species, WIL-D: 10 species, WO-D: 10 species, SG-D: 10 species), including 8 introduced species (Appendix 2b). Submerged species of macrophyte (*Myriophyllum verrucosum*, *Potamogeton ochreatus*, *Potamogeton pectinatus* and *Triglochin procerum*) were relatively abundant at WO-D while grasses dominated assemblages at SG-D (Appendix 2b).

Multivariate analyses found significant differences ($P < 0.01$) in the structure of the assemblages among locations (ANOSIM, Global R: 0.607). Pairwise tests found all locations differed significantly except WIL-D and WO-D. Differences were reflected by the nMDS ordination (Figure 5). In particular, the assemblage of plants found at the SG-D location was grouped separately from all other locations (Figure 5). The stress value (0.19) associated with the ordinations indicated that it was a reasonable 2-D picture (Clarke and Warwick, 1994).

The SIMPER procedure ranked *Phragmites australis* (Common reed) as the most important species that contributed to the structure of the macrophyte assemblage at WIL-U in May 2014 (Table 3). Other aquatic plants, including *Typha domingensis* (Cumbungi), *Schoenoplectus pungens* and *Schoenoplectus validus* (River clubrush), dominated assemblages of plants at WIL-D and WO-D while introduced grass species (*Cynoden dactylon* and *Paspalum dilatatum)* ranked highly at the location sampled within the lower reaches of the unnamed drainage line west of Slate Gully Road (Table 3).

Table 3: Macrophyte taxa ranked in order of importance according to the SIMPER procedure for each location (*n* = 10)

Taxa	Common Name	WIL-U	WIL-D	WO-D	SG-D
Phragmites australis	Common reed	1			
Typha domingensis	Cumbungi		1	2	
Schoenoplectus validus	River clubrush		2	4	
Schoenoplectus pungens	Common threesquare		3	1	
Paspalum distichum	Water couch			3	
*Cynoden dactylon**	Common couch				1
Eleocharis gracilis	Slender spikerush				2
*Paspalum dilatatum**	Paspalum				3

*Introduced species

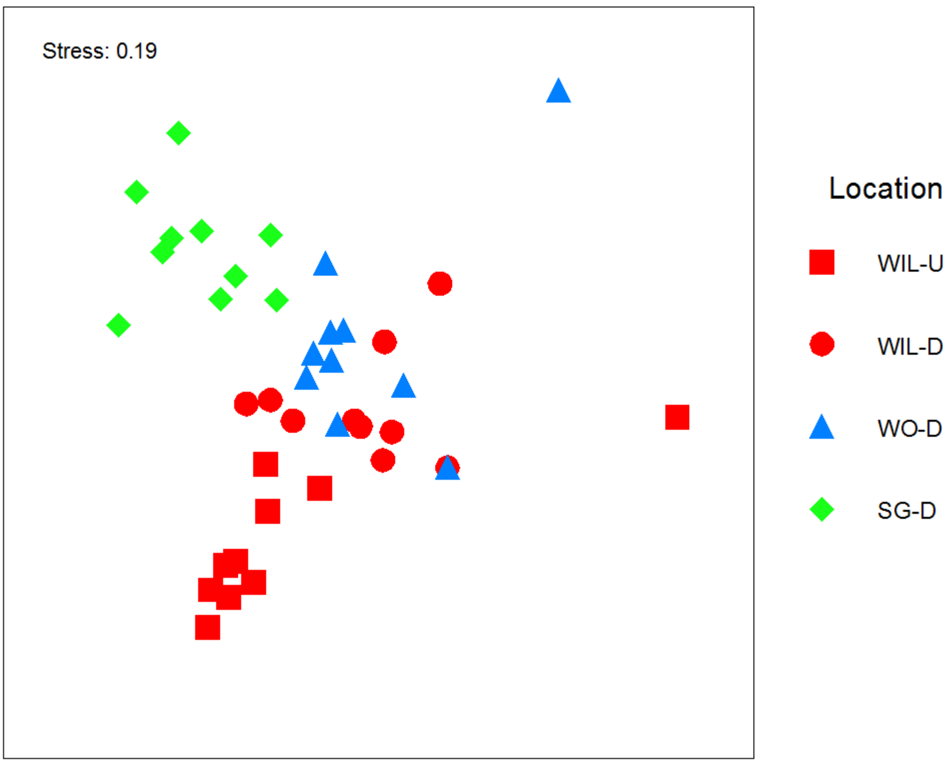


Figure 5. nMDS ordination for macrophytes at each location (May 2014).
NB: WIL-U – Wilpinjong Creek – Upstream, WIL-D – Wilpinjong Creek – Downstream, WO-D – Wollar Creek - Downstream, SG-D – the unnamed drainage line west of Slate Gully Road.

Analysis of variance found that the mean percentage cover of macrophytes differed significantly among locations (Table 4, Figure 6). Student-Newman-Keuls (or SNK) tests found that mean cover at WIL-U and SG-D were significantly greater than at WO-D and WIL-D (Figure 6). Diversity of macrophytes was smallest at WIL-U although the mean richness of macrophytes recorded in the 0.25 m^2 quadrats at any one location was generally low (<5 species) (Figure 6).

Table 4: Summary of a-ANOVAs for macrophyte variables sampled

Source		Richness		Abundance	
	df	**MS**	***F***	**MS**	***F***
Location	3	0.20	1.50 ns	1201.63	25.43 **
Site (Location)	4	0.13	0.76 ns	47.25	0.10 ns
Residual	32	0.18		457.60	
Total	39				
Cochran's Test		*C* = 0.31 ns		*C* = 0.31 ns	
Transformation		Ln(X+1)		None	

NB: ns = not significant (P > 0.05); * = significant (P < 0.05); ** = significant (P < 0.01).

Comments

- Similar to the assessment of aquatic habitat by BIO-ANALYSIS (2005), exotic species comprised a major proportion of assemblages at all of the locations sampled, particularly the unnamed drainage line west of Slate Gully Road. This most likely reflects past land-use activities, particularly cattle and sheep grazing with some intermittent cropping (fodder crops);
- Aquatic plants that were most abundant were similar to those recorded in studies done previously in Wilpinjong, Cumbo and Wollar Creeks (BIO-ANALYSIS, 2005); and
- The unnamed drainage line west of Slate Gully Road provided little habitat for aquatic plants because it was poorly defined, there was no flow and little or no free standing water or pools.

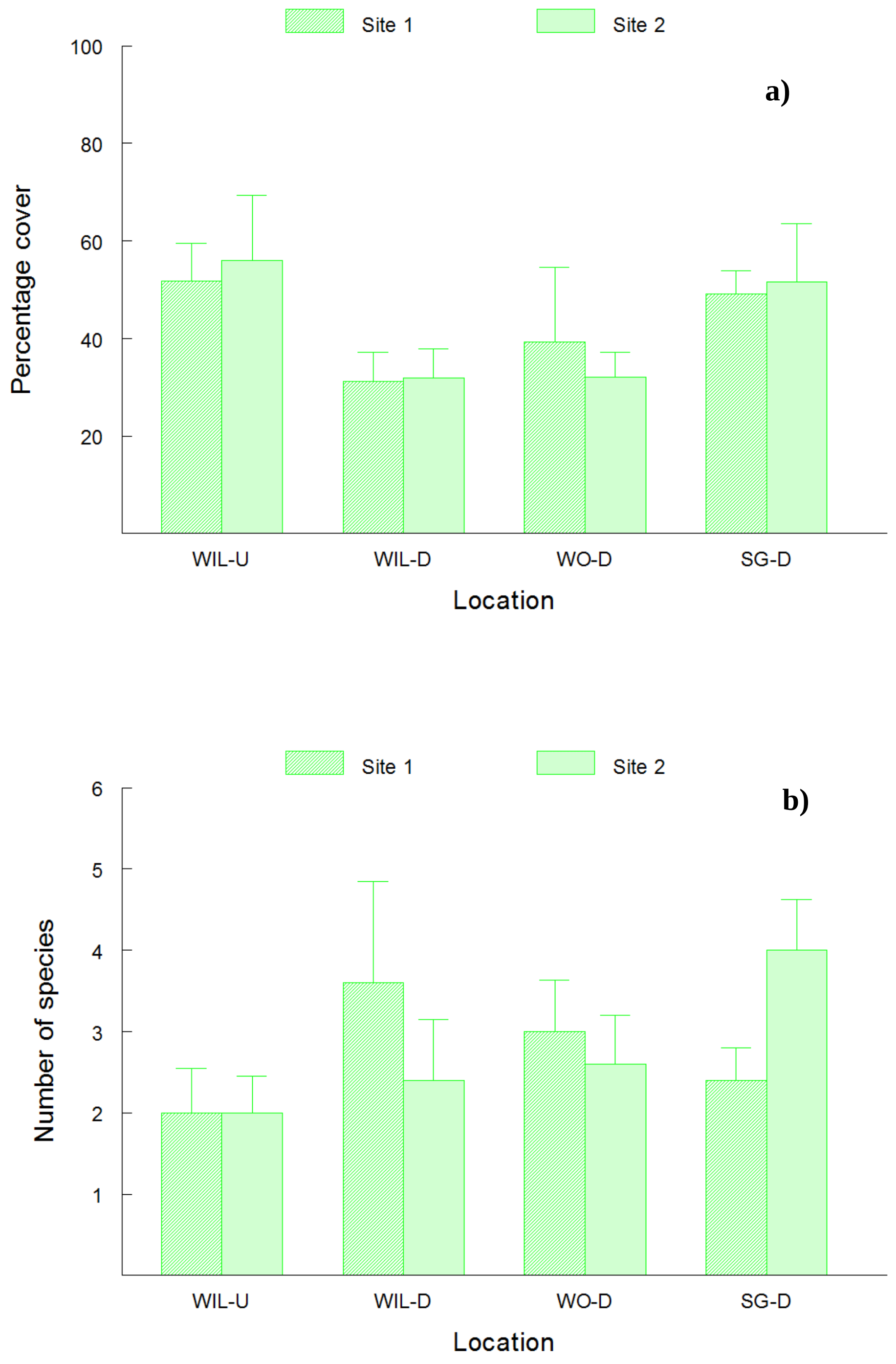


Figure 6. Mean (+SE) a) abundance and b) diversity of macrophytes at each location (May 2014).

NB: WIL-U – Wilpinjong Creek – Upstream, WIL-D – Wilpinjong Creek – Downstream, WO-D – Wollar Creek - Downstream, SG-D – the unnamed drainage line west of Slate Gully Road.

5.2.3 Aquatic Macroinvertebrates

AUSRIVAS Protocol

A total of 411 individual macroinvertebrates from 25 taxa (an additional macroinvertebrate taxa was recorded, but not included in the sum of taxa for the survey period) were recorded from sites sampled using the AUSRIVAS protocol (Appendix 3). There was insufficient aquatic habitat to collect samples at sites SG-U and SG-D within the unnamed drainage line west of Slate Gully Road.

The OE50 scores ranged between 0.09 (WIL-U1) and 0.70 (WIL-U2 and WO-D1) (Table 5). Of the six sites sampled, all were grouped within Band B except WIL-U1, which was grouped in Band D (Table 5). Thus, fewer families of macroinvertebrates than expected were collected from all of the sites sampled, compared to reference sites selected by the AUSRIVAS model (Table 5).

Table 5: AUSRIVAS outputs for sites sampled at each location (May 2014)

System	Site Code	OE50	Band
Wilpinjong Creek	WIL-U1	0.09	D
	WIL-U2	0.70	B
	WIL-D1	0.52	B
	WIL-D2	0.52	B
Unnamed Drainage Line West of Slate Gully Road	SG-U	#	#
	SG-D	#	#
Wollar Creek	WO-D1	0.70	B
	WO-D2	0.52	B

Sample not collected due to insufficient aquatic habitat.

Taxon with > 0.85 probability of occurrence but not collected included the true fly sub-families, Tanypodinae, which was not collected at WIL-U1 or WIL-D2 and Chironominae, at WIL-U1. The mayfly family, Baetidae, was expected but not collected at WIL-U1, WIL-D1, WO-D1 and WO-D2 while Leptophlebiidae, another mayfly family were not collected at any of the sites sampled. The aquatic bug family, Notonectidae, was expected but not collected at WIL-U1 while the caddis fly family, Leptoceridae, was expected but not collected at WIL-U1 or WO-D2.

Quantitative Sampling

A total of 1,146 individuals from 30 macroinvertebrate taxon (an additional macroinvertebrate taxa was recorded, but not included in the sum of taxa for the survey period) were collected from sites using the quantitative sampling technique (Appendix 3b). The most abundant macroinvertebrate taxon was the Atyidae (264 individuals) and Corixidae (190 individuals) followed by the Chironomidae (188 individuals), Dytiscidae (101 individuals) and Notonectidae (65 individuals) (Appendix 4).

Fish fauna were also recorded opportunistically during macroinvertebrate sampling. A total of 326 individuals of Mosquito fish were recorded in Wilpinjong Creek (WIL-U: 165 individuals, WIL-D: 8 individuals) and Wollar Creek (153 individuals).

Multivariate analyses found significant differences ($P < 0.01$) in the structure of the assemblages among locations (ANOSIM, Global R: 0.785). Pairwise tests found all locations differed significantly from each other, which was reflected by the nMDS ordination, which clearly grouped each location separately (Figure 7).

The SIMPER procedure ranked the Chironomidae, Atyidae and Dytiscidae as the most important taxa that contributed to the structure of the assemblages of macroinvertebrates at location WIL-U, WIL-D and WO-D, respectively (Table 6). Chironomidae and Corixidae, which are considered to be relatively pollution tolerant taxa (Chessman, 1995) were ranked as important at all of the locations sampled (Table 6).

ANOVA showed that mean abundance and diversity of macroinvertebrates did not differ significantly among locations (Table 7, Figure 8). Overall mean abundance was greatest at WIL-U compared to the other locations sampled, mostly due to relatively large numbers of the freshwater shrimp family, Atyidae (Figure 8). Mean diversity of macroinvertebrates was greatest at WIL-U (Figure 8).

Table 6: Macroinvertebrate taxa ranked in order of importance according to the SIMPER procedure for each location (*n* = 6)

Taxa	Common Name	WIL-U	WIL-D	WO-D
Chironomidae	Non-biting midges	1	2	4
Corixidae	Water boatmen	2	3	2
Scirtidae	Marsh beetles	3		
Baetidae	Mayflies	4		
Libellulidae	Dragonflies	5		5
Atyidae	Freshwater shrimp		1	
Dytiscidae	Beetles			1
Caenidae	Mayflies			3

Table 7: Summary of a-ANOVAs for macroinvertebrate variables sampled

Source		Diversity		Abundance	
	df	MS	*F*	MS	*F*
Location	3	23.39	1.89 ns	544.33	0.60 ns
Site (Location)	4	3.42		588.92	
Residual	16	14.63		978.17	
Total	23				
Cochran's Test		*C* = 0.33 ns		*C* = 0.33 ns	
Transformation		None		None	

NB: (ns = not significant (P > 0.05); * = significant (P < 0.05); ** = significant (P < 0.01).

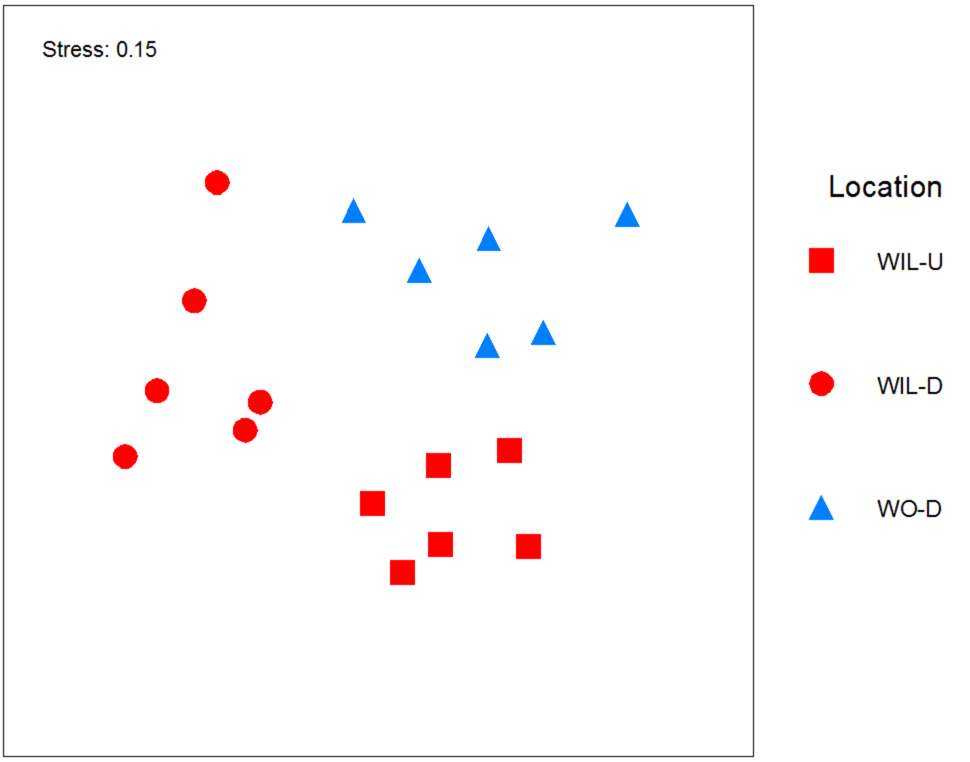
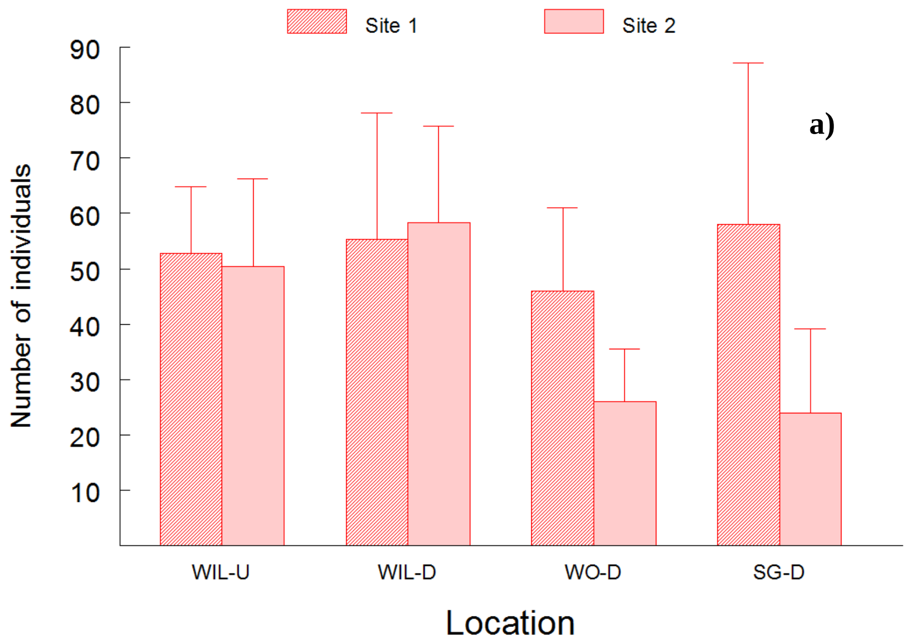


Figure 7. nMDS ordination for macroinvertebrates at each location (May 2014).
NB: WIL-U – Wilpinjong Creek – Upstream, WIL-D – Wilpinjong Creek – Downstream,
WO-D -– Wollar Creek –Downstream.



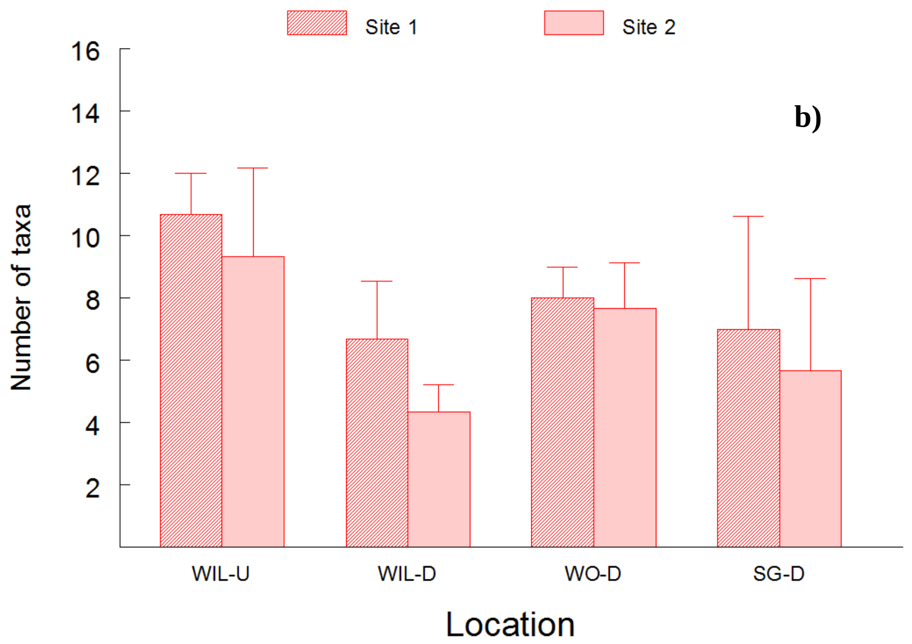


Figure 8. Mean (+SE) a) total abundance and b) diversity of macroinvertebrates at each location (May 2014).

NB: WIL-U – Wilpinjong Creek – Upstream, WIL-D – Wilpinjong Creek – Downstream, WO-D – Wollar Creek – Downstream.

Comments

- Macroinvertebrate families that were most abundant were similar to those recorded in studies done previously in Wilpinjong, Cumbo and Wollar Creeks (Roberts 2006, 2008, 2009; Landline Consulting 2013);
- Mosquito fish were collected at a number of the locations in this and in previous studies done by Roberts (2006, 2008, 2009) and Landline Consulting (2013); and
- Macroinvertebrate families that were most abundant are considered to be pollution tolerant (e.g. Chironomidae).

5.2.4 Fish

Four species of fish (including two introduced species) were recorded at locations WIL-U, WIL-D and WO-D (Table 8). Freshwater prawns (Family Palaemonidae) and shrimps (Atyidae) were also common, particularly at sites sampled in Wollar Creek (Table 8). The Eastern snake-necked turtle (*Chelodina longicollis*) was collected at each of WIL-U, WIL-D and WO-D (Table 8, Plate 14).

An additional two species, the alien species *Carassius auratus* (Goldfish) and *Gobiomorphus australis* (Striped gudgeon), were collected at a weir situated on Wilpinjong Creek within the Study Area, which was opportunistically sampled to provide additional information on fish within the area (Table 8, Plate 15).

Similar to the survey done in May 2004 (BIO-ANALYSIS, 2005), the introduced Mosquito fish (*Gambusia holbrooki*) was the most numerically abundant fish at the sites sampled in Wilpinjong Creek and Wollar Creek (Table 8, Plate 16). The Longfin eel (*Anguilla reinhardtii*) was also relatively common (Table 8).

Notably, nineteen individuals of the European Carp (*Cyprinus carpio)* were collected in the downstream section of Wilpinjong Creek (Table 8). The European Carp were not collected by the survey of the Study Area carried out in May 2004 (BIO-ANALYSIS, 2005).

No threatened species of fish listed under the NSW FM Act or the EPBC Act were recorded in the Study Area on this sampling occasion (Table 8) or in May 2004 (BIO-ANALYSIS, 2005).

Table 8: Species collected using electrofishing and/or fyke net techniques (May 2014)

Common Name	Family/Species Name	WIL-U	WIL-D	WO-D	Weir[1]
Longfin eel	*Anguilla reinhardtii*	22	9	4	4
Goldfish	*Carassius auratus**				1
European Carp	*Cyprinus carpio**		19	1	
Striped gudgeon	*Gobiomorphus australis*				1
Mosquito fish	*Gambusia holbrooki**	16	10s	1000s	6
Australian smelt	*Retropinna semoni*		5	2	
Freshwater prawns	Palaemonidae		3	2	
Freshwater shrimps	Atyidae		100s	1000s	
Eastern snake-necked turtle	*Chelodina longicollis*	1	1	1	

NB: WIL-U – Wilpinjong Creek – Upstream, WIL-D – Wilpinjong Creek – Downstream, WO-D – Wollar Creek.

*Non-native/Alien species

[1]Weir situated on Wilpinjong Creek, ~ 700 m downstream of WIL-U.

Plate 14. Turtle collected at the downstream location sampled in Wilpinjong Creek (WIL-D) in May 2014.

Plate 15. Weir situated on Wilpinjong Creek and sampled opportunistically for fish in May 2014.

Plate 16. Mosquito fish collected at the Wollar Creek location (WO-D) in May 2014.

Comments

- Alien species of fish were an abundant component of assemblages of fish at all locations;
- Mosquito fish were collected at all of the locations sampled, particularly at the location sampled within Wollar Creek;
- Striped gudgeon (*Gobiomorphus australis*) migrate upstream in spring/summer to breed; and
- With the exception of the European Carp, all of the species of fish collected here, including Striped gudgeon (*Gobiomorphus australis*), were recorded in the survey done by BIO-ANALYSIS (2005) in Wilpinjong, Cumbo and Wollar Creeks.

5.3 Threatened and Protected Species, Populations, Communities and Key Threatening Processes

No aquatic species of conservation significance listed under the EPBC Act, TSC Act or FM Act were recorded or were previously recorded within the Study Area (after Section 3.1).

Potentially relevant threatened species, populations and endangered ecological communities (EECs) that may occur within the area were identified by reviewing current listings on databases maintained by the Department of the Environment (DotE), DPI Fisheries and Office of Environment and Heritage (OEH).

5.3.1 Listings under the EPBC Act

The *Protected Matters Search Tool* (DotE, 2015) indicates that one threatened fish listed under the EPBC Act may occur in the vicinity of the Project, namely the Murray cod (*Maccullochella peelii*). The Murray cod is listed as Vulnerable under the EPBC Act.

Murray cod are generally found in the Murray-Darling Basin but overfishing and changes in the environment have drastically reduced its numbers (Morris et al., 2001). Murray cod have also been translocated into a number of river systems in NSW, Victoria and Western Australia, but has generally failed to establish in those areas. Murray cod uses a diverse range of habitats, from clear rocky streams to slow-flowing, turbid lowland rivers and billabongs (McDowall, 1996). They are frequently found in the main channels of rivers and larger tributaries and therefore are highly unlikely to be present in the Study Area.

5.3.2 Listings under the TSC Act

The Giant dragonfly (*Petalura gigantea*), which is listed as Endangered under Schedule 1 of the NSW *Threatened Species Conservation Act, 1995* (TSC Act), is not known from the locality but is predicted to occur in the locality (OEH, 2015a).

The Giant dragonfly is the third largest dragonfly in Australia and one of the largest dragonflies in the world. Potential habitats of the Giant dragonfly include permanent swamps and bogs containing some free water and open vegetation (NSW Scientific Committee, 2004). Females deposit eggs in moss or other soft vegetation (OEH, 2015b). The larval stage is unusually long, being from at least ten to 30 years but adults are short-lived, surviving for only one summer after emerging in late spring (NSW Scientific Committee, 2004). Larvae inhabit permanent, long-chambered burrows with terrestrial entrances, from which they emerge at night, and in wet weather, in search of insects and other arthropods to eat (NSW Scientific Committee, 2004). Interestingly, larvae are not known to swim and avoid open water (NSW Scientific Committee, 2004). Adult Giant dragonfly, which are also obligate carnivores, are thought to be poor flyers and do not readily disperse (NSW Scientific Committee, 2004).

The largest and most viable population of this species is believed to occur in sphagnum swamp areas within Wingecarribee Swamp, near Moss Vale (NSW Scientific Committee, 2004). This species is difficult to detect as the adult stage is short-lived and the larvae are highly cryptic. The species was not located in the Project area during the current studies. Important habitat requirements for the Giant dragonfly includes swamps or bogs or wetlands, which provide important breeding habitat. Foraging habitat includes vegetation within 500 m of breeding habitat. Potential key habitat includes Coastal Heath Swamps and Coastal Swamp Forests. Coastal Heath Swamp occurs within the Kerrabee sub-region but Coastal Swamp Forests do not.

Coastal Heath Swamps occur in poorly drained headwater valleys and dune swales with infertile sandy peats and humic sandy loams on coastal sand sheets and coastal plateau. Searches using the Department of Environment, Climate Change and Water Geographic Region Search tool indicate that Coastal Heath Swamp habitat occurs to the south-east of the Project area, mostly within the Wollemi National Park.

Threats to the Giant dragonfly include loss or modification of swamps, use of pesticides on or adjacent to swamps, decreasing water quality of swamps caused by pollution and siltation and changes to natural water flows (OEH, 2015b).

Key Threatening Processes

One key threatening process listed under Schedule 3 of the TSC Act is relevant to the Project:

- Alteration to the natural flow regime of rivers and streams and their floodplains and wetlands.

This process is assessed in Section 6 of this report.

5.3.3 Listings under the FM Act

The *Threatened and Protected Species Record Viewer* (DPI, 2015b) was also used to search for records of fish within the Hunter/Central Rivers Catchment Management Authority (CMA) (the CMA in which the Project is located). No threatened species were listed as occurring in the Hunter/Central Rivers CMA. The Murray cod listed under the EPBC Act (Section 5.3.1) is also listed under the FM Act.

There are no aquatic EECs listed under the FM Act within the Kerrabee sub-region of the Hunter/Central Rivers CMA Region.

Key Threatening Processes

Three key threatening processes listed under the FM Act are relevant to the Project:

- Degradation of Riparian Habitat;
- Removal of Large Woody Debris from NSW Rivers and Streams; and
- Instream Structures and other Mechanisms that Alter Natural Flow Regimes of Rivers and Streams.

These processes are assessed in Section 6 of this report.

6.0 ASSESSMENT OF POTENTIAL IMPACTS

This section provides an assessment of the potential impacts on aquatic ecology from the Project. The design of the Project, particularly those components related to water management (Section 1.2), address many of the potential impacts that might otherwise be associated with a project of this nature.

The potential impacts on aquatic ecology from the Project relate to:

- loss of on-site aquatic habitat (Section 6.1);
- surface water flow and aquatic biota (Section 6.2);
- surface water quality and aquatic biota (Section 6.3);
- barriers to fish movement (Section 6.4);
- groundwater and aquatic biota (Section 6.5); and
- cumulative impacts (Section 6.6).

6.1 Loss of On-Site Aquatic Habitat

The Wilpinjong Mine is approved to relocate Cumbo Creek and remove the lower reaches of Spring Creek, Narrow Creek and Bens Creek. Although the Project would involve further removal of these ephemeral creeks within the proposed open cut extensions area, Spring Creek and Planters Creek were assessed as providing poor aquatic habitat because their drainage channels were poorly defined and mostly colonised by pasture grasses, additionally there was no flow and little or no free standing water or pools (Section 5.1). These systems are not classified as “Key Fish Habitat” under DPI guidelines for aquatic habitats (DPI, 2015a). Narrow Creek and Bens Creek have similar attributes to Planters Creek (Section 5.1).

In addition to the above, the Project would involve the removal of unnamed drainage lines within the proposed open cut extensions areas, namely, the unnamed drainage line west of Slate Gully Road and the unnamed drainage line in the gully to the south of Spring Creek. These unnamed drainage lines were assessed as providing poor aquatic habitat because their drainage channels were poorly defined and mostly colonised by pasture grasses, there was no flow and little or no free standing water or pools (Section 5.1).

The Project would also involve removal of riparian vegetation (along ephemeral drainage lines) and large woody debris from within the proposed open cut extensions area. However, given that riparian health within the Project area was poor and that these systems are not classified as “Key Fish Habitat” under DPI NSW guidelines for aquatic habitats (see DPI, 2015a), it is considered unlikely that removal of riparian vegetation or large woody debris would have a negative effect on the aquatic ecology within the Study Area.

6.2 Surface Water Flow and Aquatic Biota

Alteration of the surface water flow in aquatic ecosystems can impact aquatic habitats and species. Changes to surface water flow can generally occur due to reductions in catchment areas, water releases and groundwater extraction.

During mining, flow reductions in Wilpinjong Creek associated with catchment excision and baseflow loss are offset to varying extents by the approved water discharges from the RO plant in accordance with EPL 12425. During dry periods these approved releases will typically result in an increase in flows downstream of the mine (WRM Water & Environment, 2015).

The Wilpinjong Coal Mine is estimated to result in more days with less than 0.1 ML/day flow relative to pre-mining conditions. However, the Wilpinjong Coal Mine results in negligible changes to the frequency of higher flows (e.g. greater than 1 ML/day) (WRM Water & Environment, 2015). The effects of the Wilpinjong Coal Mine on the frequency of flows less than 0.1 ML/day would be difficult to detect on a day to day basis. In practice this effect will typically result in an increase to the duration of natural no flow periods. At times, natural periods of very low flow could become no flow periods. The effects of the Wilpinjong Coal Mine (incorporating the Project) on aquatic ecology in the lower reaches of Wilpinjong Creek are unlikely to be significant due to high natural climatic variability.

The maximum incidence of days with less than 0.1 ML/day flow for the Wilpinjong Coal Mine (incorporating the Project) would be effectively unchanged from the impacts of the existing/approved Wilpinjong Coal Mine. The Project would therefore have no measurable incremental impact on flow in Wilpinjong Creek (WRM Water & Environment, 2015).

Based on the above, and in consideration of the poor habitat rating for Wilpinjong Creek downstream of the Wilpinjong Coal Mine (Section 5.1), there would be nil or negligible change to the aquatic ecology in Wilpinjong Creek as a result of changes to surface water flow. WCPL would continue stream health monitoring in Wilpinjong Creek.

6.3 Surface Water Quality and Aquatic Biota

Alteration of the surface water quality in aquatic ecosystems can impact aquatic habitats and species. Changes to surface water quality can generally occur due to soil disturbance (sedimentation and mobilisation of nutrients), nutrient leachates and pollution leaks.

The Project water management system would continue to maintain separation between runoff from areas undisturbed by mining and water generated within active mining areas. An objective of the on-site water management for the Wilpinjong Coal Mine is to operate such that there is no mine water storage overflow. The site water balance model results indicate that there would be no uncontrolled releases of mine water from the Project water management system (WRM Water & Environment, 2015).

As described in Section 1.2, final voids would remain at the cessation of mining for the Wilpinjong Coal Mine and for the Project. A water balance of the final voids indicates that none of the voids would spill to the receiving environment (WRM Water & Environment, 2015).

Overflows from sediment dams are possible during wet periods however, WRM Water & Environment (2015) predict that any overflows are unlikely to have a measurable impact on the receiving water quality.

Based on the above, there would be nil or negligible change to the aquatic ecology in Wilpinjong Creek due to surface water quality given the range of controls incorporated into the Project. WCPL would continue stream health monitoring in Wilpinjong Creek.

6.4 Barriers to Fish Movement

The Project would not involve construction of physical barriers within watercourses in the Study Area that might impede fish passage. Further, modelling by WRM Water & Environment (2015) indicates that the Project would not lower the water levels in Wilpinjong Creek to the point when physical barriers to movement by fishes within the creek or downstream environments would be created.

6.5 Groundwater and Aquatic Biota

The National Atlas of Groundwater Dependent Ecosystems (BOM, 2015a) does not identify any potential GDEs in the vicinity of the Project. However, Wilpinjong Creek is considered to be a GDE (i.e. the stream and associated riparian vegetation). Groundwater interaction between Wilpinjong Creek and the underlying alluvium varies with time. Wilpinjong Creek is generally a gaining stream, however, there have been occasions when in some sections there has been a brief reversal of gradient between the stream water level and the water table level (WRM Water & Environment, 2015).

The potential impacts of the Project on Wilpinjong Creek have been determined in accordance with the *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (NSW Office of Water [NOW], 2012) (GDE guideline). Wilpinjong Creek was given a poor to moderate rating for aquatic habitat due to exotic species, evidence of erosion and sedimentation. In accordance with the GDE guideline (NOW, 2012), Wilpinjong Creek is considered to be a low value GDE given:

- it is not reserved as a National Estate, listed wetland or a littoral rainforest (as in State Environmental Planning Policy 26;
- exotic species occur in large populations and multiple species; and
- it has undergone major changes in physical structure and species composition due to historical agriculture in the region.

Drawdown in the aquifers of the shallow alluvial groundwater system along Wilpinjong Creek would be minimal (approximately 1 m) (HydroSimulations, 2015).

Loss of groundwater discharge (or baseflow capture) to Wilpinjong Creek due to the Wilpinjong Coal Mine (incorporating the Project) would be minimal.

HydroSimulations (2015) predict that incremental baseflow impacts in Wilpinjong Creek due to the Project would be negligible. During mining, baseflow impacts would continue to be offset to varying extents by the approved water discharges from the water treatment facility in accordance with EPL 12425.

The Project is predicted to have negligible impact on water quality in Wilpinjong Creek (WRM Water & Environment, 2015; HydroSimulations, 2015).

On this basis, the Project would present a low risk to Wilpinjong Creek (as defined in the GDE guideline). WCPL would continue to conduct water quality and flow monitoring in Wilpinjong Creek.

6.6 Cumulative Impacts

Cumulative impacts include the effects from concurrent operations that are close enough to cause additive effect on the receiving environment. Relevant approved or proposed mining operations near the Project include:

- Moolarben Coal Complex, located adjacent to the Project to the west of the Wilpinjong Coal Mine;
- Ulan Mine Complex, located approximately 11 km to the north-west of the Wilpinjong Coal Mine;
- the proposed Bowdens Silver Project, located approximately 30 km to the south of the Wilpinjong Coal Mine; and
- the proposed Bylong Coal Project, located approximately 15 km east-southeast of the Wilpinjong Coal Mine.

WRM Water & Environment (2015) predict that the cumulative net impact on surface flow volumes would be too small to measure. The Project does not propose to discharge mine water directly to the receiving watercourses without appropriate treatment to meet the requirements of EPL 12425 and hence will not contribute to any localised or regional water quality impacts. The cumulative impacts on aquatic ecology are considered to be nil to negligible.

6.7 Threatened Species under the FM Act, TSC Act and EPBC Act

As stated in Section 5.3, no aquatic species of conservation significance listed under the EPBC Act, TSC Act or FM Act have been recorded within the Study Area.

Assessments of Significance in accordance with section 5A of the EP&A Act and the *Threatened Species Assessment Guidelines - the Assessment of Significance* (DECC, 2007) have been undertaken and it is concluded that the Project would not result in a significant impact to any listed threatened aquatic species or ecological communities (Appendix 4).

Similarly, an assessment of impacts on the threatened aquatic species listed under the EPBC Act has been undertaken and it is concluded that none would be significantly impacted (Appendix 4).

7.0 ENVIRONMENTAL MANAGEMENT AND MONITORING

There are a number of existing measures which would avoid and minimise impacts on aquatic ecology at the Wilpinjong Coal Mine. A summary of the existing measures is provided in Table 9. These existing measures would be continued for the Project.

Table 9: Existing impact avoidance and mitigation measures

Measure	Description	Further Information
Progressive Site Rehabilitation	• Surface development areas are progressively rehabilitated and revegetated. • Revegetation of rehabilitation areas will aim to result in a combination of woodland, pasture and mixed woodland/pasture areas. • The post mine drainage would be designed to integrate with the surrounding catchment and would include some permanent creek features formed within rehabilitation areas in locations similar to current creek lines. These reconstructed creek features would convey upslope runoff across the Project area to Wilpinjong Creek.	WCPL (2014a)
Creek Rehabilitation	• The banks of Wilpinjong and Cumbo Creeks in the rehabilitation areas and regeneration areas will be revegetated to increase the quantity of riparian vegetation along these creeks.	WCPL (2014a)
Feral Pest Control	• Regular property inspections are undertaken to assess the status of pest populations within WCPL-owned land. • Control of declared pests is undertaken (e.g. control feral pigs and rabbits).	WCPL (2014a and 2015)
Weed Control	• Regular inspections of WCPL-owned lands to identify areas requiring the implementation of weed management measures. • Control of noxious weeds identified on WCPL-owned land is undertaken considering the relevant control category. • WCPL implements a number of control programs to control large infestations of blackberry and other woody weeds along the Goulburn River (Landscape Constructions, 2014a and b).	WCPL (2014a and 2015)
Erosion Control	• Minimising surface disturbance and restricting access to undisturbed areas. • Construction of suitable erosion and sediment controls such as drains and sediment dams to control, contain and manage sediment laden surface runoff.	WCPL (2014b)
Mitigation of Potential Impacts to Downstream Water Flow	• Construction of up-slope control structures to divert water around active mine workings. • Discharge of treated water from the RO Plant in accordance with EPL 12425.	WRM Water & Environment (2015) EPL 12425
Mitigation of Potential Impacts to Downstream Water Quality	• Contained water storages are managed and operated for no release to downstream watercourses.	WRM Water & Environment (2015)
Erosion and Sediment Control	• Minimising surface disturbance and restricting access to undisturbed areas. • Construction of suitable erosion and sediment controls such as drains and sediment dams to control, contain and manage sediment laden surface runoff.	WCPL (2014b)

With the continued implementation of the mitigation measures in Table 9, an offset is not required to compensate for the impacts of the Project on aquatic ecology after consideration of the *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI, 2013).

8.0 CONCLUSION

The works and activities associated with the Project would take place against background ecological conditions that were found to be moderately degraded to poor and stressed, largely but not entirely due to past land uses.

The Wilpinjong Coal Mine is approved to remove ephemeral creek lines in the approved mine area and divert surface water flows. The mine is also approved to relocate and mine the lower reaches of Cumbo Creek. The Project would involve further removal of these ephemeral creeks but the impact on aquatic ecology would be minor as these ephemeral creeks provide poor aquatic habitat (due to location in catchment, poorly defined drainage channels that are mostly colonised by pasture grasses, and lack of consistent surface flows).

There would be nil or negligible change to the aquatic ecology in Wilpinjong Creek due to surface water flows given the Project would have no material impact on flows in the creek. Further, there would be nil or negligible change to the aquatic ecology in Wilpinjong Creek due to surface water quality given the range of controls incorporated into the Project.

Assessments of Significance in accordance with section 5A of the EP&A Act have been undertaken for potentially occurring threatened aquatic species and communities and concluded that the Project would not result in a significant impact to any listed threatened aquatic species or ecological communities listed under the TSC Act or FM Act. Similarly, an assessment of impacts on potentially occurring threatened aquatic species listed under the EPBC Act has been undertaken and it is concluded that none would be significantly impacted.

In conclusion, the direct impacts of the Project on aquatic ecology would likely be minimal and the potential indirect impacts on aquatic ecology downstream of the Project would be minimised with the continuation of a number of existing mitigation measures currently implemented at the Wilpinjong Coal Mine.

9.0 ACKNOWLEDGEMENTS

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11.0 APPENDICES

APPENDIX 1

WATER QUALITY

Appendix 1.
Water Quality Variables Measured at Stream Sites

	Wilpinjong Creek											
Taxa	**WILU1-1**	**WILU1-2**	**WILU1-3**	**WILU2-1**	**WILU2-2**	**WILU2-2**	**WILD1-1**	**WILD1-2**	**WILD1-3**	**WILD2-1**	**WILD2-2**	**WILD2-3**
Temperature (°C)	11.8	11.7	11.7	11.7	11.7	11.7	16.4	16.5	16.5	15.1	15.2	15.0
pH	8.22	8.18	8.16	8.17	8.12	8.04	8.71	8.71	8.72	8.81	8.79	8.78
Conductivity (µs/cm)	1830	1830	1830	1820	1803	1803	3549	3548	3548	3553	3548	3546
Dissolved Oxygen (mg/L)	7.5	7.4	7.4	6.7	6.4	6.4	7.7	7.7	7.8	8.1	7.9	7.9
Dissolved Oxygen (%Sat)	69.4	67.7	68.1	62.0	59.2	59.1	80.0	79.5	80.3	81.7	79.4	78.8
Turbidity (NTU)	25.6	24.9	25.9	21.3	19.7	17.8	323.5	329.8	331.1	121.9	111.2	110.8
REDOX (mv)	363	358	356	368	360	358	415	414	414	417	418	418

	Wollar Creek						Slate Gully Tributary					
Taxa	**WOD1-1**	**WOD1-2**	**WOD1-3**	**WOD2-1**	**WOD2-2**	**WOD2-3**	**SGD1-1**	**SGD1-2**	**SGD1-3**	**SGD2-1**	**SGD2-2**	**SGD2-3**
Temperature (°C)	13.0	13.1	13.0	10.3	10.3	10.4	8.7	8.8	8.8	9.0	9.0	8.9
pH	9.15	9.17	9.18	9.35	9.37	9.37	8.5	8.44	8.42	8.35	8.34	8.33
Conductivity (µs/cm)	2997	2999	2999	3010	3003	2995	161	156	156	175	180	175
Dissolved Oxygen (mg/L)	8.3	8.3	8.3	9.7	9.6	9.5	8.9	8.7	8.6	7.9	7.8	7.8
Dissolved Oxygen (%Sat)	79.4	79.3	79.1	87.2	86.1	85.0	76.7	75.0	74.0	67.9	67.4	67.0
Turbidity (NTU)	2.4	2.8	3.2	18.5	15.4	13.4	179.5	178.3	179.5	320.0	319.9	325.7
REDOX (mv)	486	485	484	473	473	473	518	517	517	510	510	509

Site Codes: WILU1-1 = Wilpinjong Creek Upstream, Site 1, Replicate 1, etc

APPENDIX 2

AQUATIC MACROPHYTES

Appendix 2a. Estimated Cover of Aquatic Macrophyte Species at Stream Sites

Species	WILU1	WILU2	WILD1	WILD2	WOD1	WOD2	SGD1	SGD2
*Alternanthera caracasana**	0	0	1	0	0	0	0	0
*Aster subulatus**	0	0	1	0	0	1	1	1
Aster squamatus	0	0	0	0	1	0	0	0
Schoenoplectus pungens	0	0	3	2	3	3	0	0
*Cirsium vulgare**	1	1	1	0	0	0	1	0
Cyperus ?gymnocaulos	0	0	0	0	0	0	1	0
*Cynodon dactylon**	0	0	2	0	0	1	3	3
Eleocharis gracilis	0	0	2	0	0	0	3	2
Eleocharis sphacelata	1	0	1	0	0	0	0	0
Gahnia aspera	1	0	0	0	0	0	0	0
Gratiola pedunculata	1	0	0	0	0	0	0	0
Hemarthria uncinata	0	0	0	0	1	0	0	0
*Hydrocotyle ?laxiflora**	0	0	0	0	0	1	0	0
Isolepis ?cernua	1	1	1	1	2	2	0	0
Juncus ?australis	1	1	0	0	0	0	1	1
*Juncus articulatus**	1	1	1	0	0	1	0	0
Juncus planifolius	0	0	0	0	0	0	0	1
Juncus usitatus	0	0	0	2	0	0	0	0
Lythrum hyssopifolia	0	0	1	0	0	0	0	0
Myriophyllum verrucosum	0	0	0	0	2	2	0	0
Nitella sp.	0	1	0	0	0	1	0	0
*Oxalis articulata**	0	0	0	0	0	0	0	1
*Paspalum dilatatum**	0	0	0	1	0	0	3	3
Paspalum distichum	1	0	0	0	3	2	0	0
Polypogon monospeliensis	1	0	0	0	0	0	0	0
Potamogeton ochreatus	0	0	0	0	0	1	0	0
Potamogeton pectinatus	0	0	0	1	1	2	0	0
Phragmites australis	3	3	2	1	0	0	0	0
Ranunculus undosus	0	0	0	0	2	1	0	0
Samolus valerandi	0	0	0	0	1	1	0	0
Schoenoplectus validus	1	1	2	3	2	2	0	0
*Setaria ?gracilis**	0	0	0	0	0	0	0	3
Sporobolus ?caroli	0	0	0	0	0	0	0	1
Stipa ?setacea	0	0	0	0	0	0	0	1
Stuckenia pectinata	0	0	0	1	0	3	0	0
Themeda australis	0	0	0	0	0	0	0	1
Triglochin procerum	0	0	0	0	0	1	0	0
*Trifolium subterraneum**	0	0	0	0	0	0	0	1
Typha domingensis	1	0	3	3	0	3	0	0

Site Codes: WILU1 = Wilpinjong Creek - Upstream, Site 1, etc

Appendix 2b. Percentage Cover of Aquatic Macrophyte Species at Stream Sites

	Wilpinjong Creek									
Species	**WILU1-1**	**WILU1-2**	**WILU1-3**	**WILU1-4**	**WILU1-5**	**WILU2-1**	**WILU2-2**	**WILU2-3**	**WILU2-4**	**WILU2-5**
*Aster subulatus**	0	0	0	0	0	0	0	0	0	0
Schoenoplectus pungens	0	0	0	0	0	0	0	0	0	0
*Cirsium vulgare**	0	0	0	0	0	0	0	10	0	0
*Cynodon dactylon**	0	0	0	0	0	0	0	0	0	0
Eleocharis gracilis	0	0	0	0	0	0	0	0	0	0
Eleocharis sphacelata	0	0	0	0	0	0	0	0	0	0
Isolepis ?cernua	0	0	15	0	0	0	0	0	0	3
Juncus ?australis	0	0	1	0	0	0	0	0	2	0
*Juncus articulatus**	0	0	0	0	0	0	0	0	0	5
Juncus usitatus	0	0	0	0	0	0	0	0	0	0
Myriophyllum verrucosum	0	0	0	0	0	0	0	0	0	0
Nitella sp.	0	0	0	0	0	0	100	0	0	0
*Oxalis articulata**	0	0	0	0	0	0	0	0	0	0
*Paspalum dilatatum**	0	0	0	0	0	0	0	0	0	0
Paspalum distichum	0	0	0	0	0	0	0	0	0	0
Polypogon monospeliensis	0	0	1	0	0	0	0	0	0	0
Potamogeton pectinatus	0	0	0	0	0	0	0	0	0	0
Phragmites australis	60	15	20	60	70	50	0	40	15	45
Ranunculus undosus	0	0	0	0	0	0	0	0	0	0
Schoenoplectus validus	2	0	0	0	0	0	0	0	0	0
*Setaria ?gracilis**	0	0	0	0	0	0	0	0	0	0
Sporobolus ?caroli	0	0	0	0	0	0	0	0	0	0
Themeda australis	0	0	0	0	0	0	0	0	0	0
*Trifolium subterraneum**	0	0	0	0	0	0	0	0	0	0
Typha domingensis	0	15	0	0	0	0	0	0	0	0

* Denotes an introduced species

Site Codes: WILU1-1 = Wilpinjong Creek - Upstream, Site 1, Replicate 1, etc

Appendix 2b. Percentage Cover of Aquatic Macrophyte Species at Stream Sites

	Wilpinjong Creek									
Species	**WILD1-1**	**WILD1-2**	**WILD1-3**	**WILD1-4**	**WILD1-5**	**WILD2-1**	**WILD2-2**	**WILD2-3**	**WILD2-4**	**WILD2-5**
*Aster subulatus**	0	0	0	0	0	0	0	0	0	0
Schoenoplectus pungens	10	10	0	0	0	0	0	5	0	0
*Cirsium vulgare**	0	0	0	0	0	0	0	0	0	0
*Cynodon dactylon**	0	0	2	0	0	0	0	0	0	0
Eleocharis gracilis	0	0	0	0	0	0	0	0	0	0
Eleocharis sphacelata	0	0	7	0	0	0	0	0	0	0
Isolepis ?cernua	0	0	0	0	0	0	0	2	5	0
Juncus ?australis	0	0	0	0	0	0	0	0	0	0
*Juncus articulatus**	0	0	0	0	0	0	0	0	0	0
Juncus usitatus	5	0	5	0	0	0	0	0	0	0
Myriophyllum verrucosum	0	0	0	0	0	0	0	0	0	0
Nitella sp.	0	0	0	0	0	0	0	0	0	0
*Oxalis articulata**	0	0	0	0	0	0	0	0	0	0
*Paspalum dilatatum**	0	0	0	0	0	0	0	2	0	0
Paspalum distichum	0	0	0	0	0	0	0	0	0	0
Polypogon monospeliensis	0	0	0	0	0	0	0	0	0	0
Potamogeton pectinatus	0	0	0	0	0	0	35	0	0	0
Phragmites australis	0	1	5	0	0	0	0	5	0	0
Ranunculus undosus	0	0	0	0	0	0	0	0	0	0
Schoenoplectus validus	2	10	0	0	0	30	15	10	20	0
*Setaria ?gracilis**	0	0	0	0	0	0	0	0	0	0
Sporobolus ?caroli	0	0	0	0	0	0	0	0	0	0
Themeda australis	0	0	0	0	0	0	0	0	0	0
*Trifolium subterraneum**	0	0	0	0	0	0	0	0	0	0
Typha domingensis	10	0	5	20	50	0	0	0	15	15

* Denotes an introduced species

Site Codes: WILU1-1 = Wilpinjong Creek - Upstream, Site 1, Replicate 1, etc

Appendix 2b. Percentage Cover of Aquatic Macrophyte Species at Stream Sites

	Wollar Creek									
Species	**WOD1-1**	**WOD1-2**	**WOD1-3**	**WOD1-4**	**WOD1-5**	**WOD2-1**	**WOD2-2**	**WOD2-3**	**WOD2-4**	**WOD2-5**
*Aster subulatus**	0	0	0	0	0	0	0	0	0	0
Schoenoplectus pungens	15	10	0	15	25	0	0	20	0	0
*Cirsium vulgare**	0	0	0	0	0	0	0	0	0	0
*Cynodon dactylon**	0	0	0	0	0	0	5	0	0	0
Eleocharis gracilis	0	0	0	0	0	0	0	0	0	0
Eleocharis sphacelata	0	0	0	0	0	0	0	0	0	0
Isolepis ?cernua	10	0	0	2	0	0	0	0	0	0
Juncus ?australis	0	0	0	0	0	0	0	0	0	0
*Juncus articulatus**	0	0	0	0	0	0	25	0	0	0
Juncus usitatus	0	0	0	0	0	0	0	0	0	0
Myriophyllum verrucosum	0	0	0	3	0	2	0	0	0	0
Nitella sp.	0	0	0	0	0	0	0	0	0	0
*Oxalis articulata**	0	0	0	0	0	0	0	0	0	0
*Paspalum dilatatum**	0	0	0	0	0	0	0	0	0	0
Paspalum distichum	2	2	0	0	2	2	0	5	0	0
Polypogon monospeliensis	0	0	0	0	0	0	0	0	0	0
Potamogeton pectinatus	0	0	100	0	0	2	2	0	0	0
Phragmites australis	0	0	0	0	0	0	0	0	0	0
Ranunculus undosus	2	2	0	1	0	0	0	0	0	0
Schoenoplectus validus	0	5	0	0	0	0	2	0	10	0
*Setaria ?gracilis**	0	0	0	0	0	0	0	0	0	0
Sporobolus ?caroli	0	0	0	0	0	0	0	0	0	0
Themeda australis	0	0	0	0	0	0	0	0	0	0
*Trifolium subterraneum**	0	0	0	0	0	0	0	0	0	0
Typha domingensis	0	0	0	0	0	25	0	0	10	50

* Denotes an introduced species

Site Codes: WILU1-1 = Wilpinjong Creek - Upstream, Site 1, Replicate 1, etc

Appendix 2b. Percentage Cover of Aquatic Macrophyte Species at Stream Sites

	Slate Gully									
Species	**SGD1-1**	**SGD1-2**	**SGD1-3**	**SGD1-4**	**SGD1-5**	**SGD2-1**	**SGD2-2**	**SGD2-3**	**SGD2-4**	**SGD2-5**
*Aster subulatus**	0	1	0	0	0	0	0	0	2	0
Schoenoplectus pungens	0	0	0	0	0	0	0	0	0	0
*Cirsium vulgare**	0	0	0	0	0	0	0	0	0	0
*Cynodon dactylon**	30	20	0	25	30	50	0	0	2	25
Eleocharis gracilis	10	10	55	10	25	20	15	0	0	0
Eleocharis sphacelata	0	0	0	0	0	0	0	0	0	0
Isolepis ?cernua	0	0	0	0	0	0	0	0	0	0
Juncus ?australis	0	0	0	0	0	0	0	0	0	0
*Juncus articulatus**	0	0	0	20	0	0	0	0	0	0
Juncus usitatus	0	0	0	0	0	0	0	0	0	0
Myriophyllum verrucosum	0	0	0	0	0	0	0	0	0	0
Nitella sp.	0	0	0	0	0	0	0	0	0	0
*Oxalis articulata**	0	0	0	0	0	0	0	1	0	0
*Paspalum dilatatum**	10	0	0	0	0	10	15	10	10	50
Paspalum distichum	0	0	0	0	0	0	0	0	0	0
Polypogon monospeliensis	0	0	0	0	0	0	0	0	0	0
Potamogeton pectinatus	0	0	0	0	0	0	0	0	0	0
Phragmites australis	0	0	0	0	0	0	0	0	0	0
Ranunculus undosus	0	0	0	0	0	0	0	0	0	0
Schoenoplectus validus	0	0	0	0	0	0	0	0	0	0
*Setaria ?gracilis**	0	0	0	0	0	0	5	0	20	5
Sporobolus ?caroli	0	0	0	0	0	0	0	2	0	0
Themeda australis	0	0	0	0	0	0	0	5	0	0
*Trifolium subterraneum**	0	0	0	0	0	0	0	0	1	0
Typha domingensis	0	0	0	0	0	0	0	0	0	0

* Denotes an introduced species

Site Codes: WILU1-1 = Wilpinjong Creek - Upstream, Site 1, Replicate 1, etc

APPENDIX 3

AQUATIC MACROINVERTEBRATES

Appendix 3a. May 2014
AUSRIVAS Sampling of Stream Sites - Macroinvertebrate Taxa and Abundance

Taxa	WILU1	WILU2	WILD1	WILD2	WOD1	WOD2
Aeshnidae	0	3	7	0	0	0
Araneae	5	0	0	0	0	0
Atyidae	0	0	3	76	47	24
Baetidae	0	4	0	1	0	0
Caenidae	0	0	0	0	5	0
Ceinidae	0	0	0	0	1	0
Chironomidae - Chironominae	0	25	33	7	7	4
Chironomidae - Tanypodinae	0	2	2	0	2	2
Coenagrionidae	0	3	1	7	0	1
Collembola	0	0	1	0	0	0
Corixidae	1	9	17	6	1	4
Dytiscidae	0	1	0	0	1	5
Gerridae	0	1	0	0	0	0
Gyrinidae	0	0	0	0	1	0
Hydraenidae	0	1	0	1	0	0
Hydroptilidae	0	0	0	0	0	2
Leptoceridae	0	2	3	1	1	0
Libellulidae	6	1	0	0	4	4
Notonectidae	0	2	3	3	1	1
Ostracoda	0	0	5	0	0	0
Physidae	0	2	13	2	3	0
Pyralidae	0	0	0	1	0	0
Scirtidae	1	19	0	2	0	0
Staphylinidae	0	1	1	0	0	0
Tabanidae	1	0	0	0	0	1
Adult Hemiptera	1	2	0	0	0	0
Total Macroinvertebrates	**15**	**78**	**89**	**107**	**74**	**48**
Gambusia	34	29	0	5	71	29

Not included in the sum of the 'Total Number of Taxa' for the survey period

Site Codes: WILU1 = Wilpinjong Creek - Upstream, Site 1, etc

Wilpinjong Macroinvertebrate Data (May 2014)

WILU = Wilpinjong Creek - Upstream; WILD = Wilpinjong Creek - Downstream; WOD = Wollar Creek; SGD = Slate Gully - Downstream

Taxa	WILU1-1	WILU1-2	WILU1-3	WILU2-1	WILU2-2	WILU2-3	WILD1-1	WILD1-2	WILD1-3	WILD2-1	WILD2-2	WILD2-3	WOD1-1	WOD1-2	WOD1-3	WOD2-1	WOD2-2	WOD2-3	SGD1-1	SGD1-2	SGD1-3	SGD2-1	SGD2-2	SGD2-3
Aeshnidae	0	3	3	0	2	3	1	0	0	0	0	0	0	0	0	0	0	0	13	4	0	2	0	0
Aranea	1	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Atyidae	0	0	0	0	0	0	7	68	51	32	20	76	1	0	0	2	5	2	0	0	0	0	0	0
Baetidae	6	1	1	4	0	4	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Bachrdae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	1	0	1	0	0
Caenidae	0	0	0	0	0	0	0	0	0	0	0	0	1	36	23	0	2	2	0	0	0	0	0	0
Chironomidae	4	34	15	1	12	47	0	5	6	7	4	14	3	3	10	3	0	2	1	7	0	10	0	0
Coenagrionidae	0	2	5	0	1	6	0	2	1	1	0	0	3	3	0	0	1	0	3	0	0	1	1	0
Collembola	0	0	0	0	0	1	0	1	0	0	0	0	1	0	1	2	0	0	0	0	0	0	0	0
Corixidae	8	12	4	13	6	8	2	2	12	10	2	0	1	0	3	25	4	4	40	24	0	8	2	0
Culicidae	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dytiscidae	3	2	1	0	1	0	0	1	1	0	0	0	5	20	10	9	0	2	12	22	0	8	4	0
Elmidae	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gerridae	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydraenidae	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	6	2	0	4	0	0
Hydrometridae	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrophilidae	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	4	3	0	1	1	0
Hydroptilidae	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Leptoceridae	2	0	0	0	0	2	0	0	1	1	0	1	0	0	0	0	0	0	1	2	0	0	0	0
Leptophlebiidae	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Lestidae	15	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Libellulidae	3	3	0	1	3	1	0	0	0	0	0	0	2	4	1	1	3	1	3	8	0	3	2	0
Notonectidae	1	0	1	0	0	1	1	1	1	1	6	0	0	0	0	0	0	1	14	13	0	15	9	0
Ostracoda	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Parastacidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Physidae	1	0	0	0	0	1	0	0	0	0	0	0	0	3	0	2	0	2	0	0	0	0	0	0
Scirtidae	0	4	3	14	11	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Staphylinidae	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Synthemistidae	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Veliidae	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Dipteran pupae	0	4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
Total Macroinvertebrates	**48**	**80**	**38**	**34**	**37**	**86**	**11**	**81**	**75**	**52**	**32**	**91**	**18**	**69**	**51**	**45**	**15**	**18**	**105**	**86**	**0**	**54**	**20**	**0**
Total Species	**13**	**13**	**10**	**6**	**8**	**17**	**4**	**8**	**9**	**6**	**4**	**3**	**9**	**6**	**8**	**8**	**5**	**9**	**13**	**10**	**0**	**11**	**7**	**0**
Gambusia	16	2	11	15	10	48	3	0	0	0	0	0	13	7	9	15	3	6	0	0	0	0	0	0

Site Codes: WILU1-1 = Wilpinjong Creek - Upstream, Site 1, Replicate 1, etc

APPENDIX 4

THREATENED SPECIES ASSESSMENTS

Environment Protection and Biodiversity Conversation Act 1999 Impact Assessment

The *Protected Matters Search Tool* (Department of the Environment [DotE], 2015) indicates that one threatened fish listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) Act may occur in the vicinity of the Wilpinjong Extension Project (the Project), namely the Murray cod (*Maccullochella peelii*). It is noted the Project is located outside the Murray-Darling Basin, however, the potential impact of the Project on Murray cod has been assessed in accordance with the Significant Impact Criteria outlined in the Matters of National Significance Significant Impact Guidelines 1.1 (DotE, 2013).

Murray Cod

The impact of the Project on Murray cod, which is listed as Vulnerable under both the EPBC Act and the *Fisheries Management Act 1994* (FM Act) has been assessed below.

No cod were recorded by the field survey nor are there any formal records of it occurring within the Study Area. Although considered a 'main channel specialist' because it frequents main river channels, larger tributaries and anabranches, the Murray cod is found in a diverse range of habitats from clear rocky streams to slow-flowing, turbid lowland rivers and billabongs (McDowall, 1996).

Wilpinjong Creek is ephemeral and does not have flow for approximately 6 percent (%) of the time. Between 2011 and 2014, median daily flow upstream of inputs from the Reverse Osmosis Plant was approximately 0.2 megalitres per day (WRM Water & Environment, 2015). Low flows may restrict migration of adult Murray cod (National Murray Cod Recovery Team [NMCRT], 2010).

Average electrical conductivity (a measure of salinity) was elevated in all streams in relation to ANZECC and ARMCANZ (2000) guideline vales. Increased salinity is a major problem causing degradation in some areas in the region. Adult Murray cod have a degree of tolerance to increased salinity but juveniles are more sensitive (NMCRT, 2010).

As such, the Study Area is considered unlikely to support a viable population of Murray cod.

Is the action likely to lead to a long-term decrease in the size of an important population of a species?

Murray cod are generally found in the Murray-Darling Basin but overfishing and changes in the environment (including pollution, barriers to passage, altered flow regimes, removal of large woody debris, predation and competition by alien species) have drastically reduced its numbers (Morris et al., 2001).

Murray cod are frequently found in the main channels of rivers and larger tributaries. Between late spring and early summer adult cod commonly migrate upstream for distances of up to 80 – 120 kilometres (km) to spawn following seasonal floods or high flows (Koehn, 1997). Following spawning, the species moves back downstream, returning to the same territory occupied before the spawning migration (Koehn, 1997).

No cod were recorded by the field survey nor are there any formal records of it occurring within the Study Area. All sightings within the region were from watercourses that occur within catchments which lie to the south-west of the Study Area. The Project is unlikely to cause a long term decrease in the size of local populations as local populations are unlikely to occur and regional populations occur in separate catchments.

Would the action reduce the area of occupancy of an important population?
Murray cod is considered a ‘main channel specialist’ because it frequents complex habitat in the main river channels, larger tributaries and anabranches (Humphries *et al*., 2002). Wilpinjong Creek is ephemeral and does not have flow for approximately 6% of the time.

There are no formal records of Murray cod from the Study Area. Populations considered important for the long-term survival and recovery of Murray cod do not occur within waterways within the Study Area or in downstream reaches (NMCRT, 2010).

The Study Area is considered unlikely to support a viable population of Murray cod.

Would the action fragment an existing important population into two or more populations?
There is no evidence of an existing population within the Study Area or downstream environments and hence the Project is unlikely to cause the fragmentation of an existing population.

Would the action adversely affect habitat critical to the survival of a species?
No critical habitat has been identified for the Murray cod in the vicinity of the Study Area.

Would the action disrupt the breeding cycle of a population?
Murray cod spawning occurs when water temperatures exceed 15 ºC (Humphries, 2005; Koehn and Harrington, 2005). Spawning also appears to be correlated with day length, typically occurring in spring over a 4-5 week period (Humphries, 2005; Koehn and Harrington, 2005). Although spawning doesn’t appear to require flooding, recruitment success appears to be strongly linked to river flow (Kearney and Kildea, 2001), with good year classes in some rivers coinciding with a rise in water level or flooding soon after spawning (Rowland, 1998; NMCRT, 2010).

The Study Area is considered unlikely to support a viable population of Murray cod and therefore the Project would not disrupt the breeding cycle of the species.

Would the action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?
The Project would not substantially alter flows or other cues that affect spawning or recruitment success. Consequently, it is highly unlikely that habitat quality and/or availability would be changed to such an extent that the species (if present) would decline.

Would the action result in invasive species that are harmful to an endangered species becoming established in the endangered species' habitat?
Goldfish (*Carassius auratus*), European Carp (*Cyprinus carpio*) and Mosquito fish (*Gambusia holbrooki*) were collected within the Study Area. It is highly unlikely that additional invasive species would become established as a result of construction and operation or the water management regime of the Project.

Would the action introduce disease that may cause the species to decline?
The Project does not include any mechanisms that would introduce disease.

Would the action interfere substantially with the recovery of the species?
There are no formal records of Murray cod from the Study Area. Populations considered important for the long-term survival and recovery of Murray cod do not occur within waterways within the Study Area or in downstream reaches (NMCRT, 2010).

Conclusion
The assessment of significance found that the Project would be unlikely to significantly affect Murray cod.

Threatened Species Conservation Act 1995 Impact Assessment

No aquatic species listed as threatened under the *Threatened Species Conservation Act 1995* (TSC Act) were identified in the Study Area, although one aquatic species has the potential to occur, namely, the Giant dragonfly (*Petalura gigantea*). Potential impacts on this species are assessed below in accordance with section 5A of the *Environmental Planning and Assessment Act 1999* (EP&A Act) and the *Threatened Species Assessment Guidelines - the Assessment of Significance* (Department of Environment and Climate Change [DECC], 2007).

Giant dragonfly

The Giant dragonfly is the third largest dragonfly in Australia and one of the largest dragonflies in the world. Potential habitats of the Giant dragonfly include permanent swamps and bogs containing some free water and open vegetation (New South Wales [NSW] Scientific Committee, 2004). Females deposit eggs in moss or other soft vegetation (Ofice of Environment and Heritage [OEH], 2015b). The larval stage is unusually long, being from at least ten to 30 years but adults are short-lived, surviving for only one summer after emerging in late spring (NSW Scientific Committee, 2004). Larvae inhabit permanent, long-chambered burrows with terrestrial entrances, from which they emerge at night, and in wet weather, in search of insects and other arthropods to eat (NSW Scientific Committee, 2004). Interestingly, larvae are not known to swim and avoid open water (NSW Scientific Committee, 2004). Adult Giant dragonfly, which are also obligate carnivores, are thought to be poor flyers and do not readily disperse (NSW Scientific Committee, 2004).

Threats to the Giant dragonfly include loss or modification of swamps, use of pesticides on or adjacent to swamps, decreasing water quality of swamps caused by pollution and siltation and changes to natural water flows (OEH, 2015b).

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the lifecycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The lifecycle of the Giant dragonfly could be adversely affected if activities associated with the Project cause the surface hydrological conditions in swamps (if present) to change. Excision of the proposed open cut extension area and drawdown of ground-water over the mine life could potentially influence the drainage flow regimes of swamps. Lower levels of moisture in the soil could cause swamps to be more vulnerable to fire and flood and couild cause extensive erosion (Young, 1982; Krogh, 2004; 2007). Other threats to the Giant dragonfly include the use of pesticides on or adjacent to swamps and decreasing water quality of swamps caused by pollution and siltation (OEH, 2015b).

The Giant dragonfly has not been recorded within the Study Area or within the Kerrabee sub-region of the Hunter/Central Rivers Catchment Management Authority. Potential key habitat (i.e. Coastal Heath Swamps) for this species has been mapped as occurring within the Kerrabee sub-region, approximately 40 km south-east of the Project area, within the Wollemi National Park. Coastal Heath Swamps occur in poorly drained headwater valleys and dune swales with infertile sandy peats and humic sandy loams on coastal sand sheets and coastal plateau.

Streams that flow through the Project area are semi-perennial, spring-fed streams in their upper reaches near the Munghorn Gap Nature Reserve, changing to relatively wide, ill-defined ephemeral drainages. At the time of the field surveys, these tributaries and unnamed drainage lines were given a poor rating for aquatic habitat because their drainage channels were poorly defined and there was no flow, little or no free standing water or pools and few semi-permanent aquatic macrophytes present. These waterways are unlikely to provide habitat for the Giant dragonfly.

It is therefore considered unlikely that the Project would result in a reduction in the availability of habitat and resources such that the lifecycle of the Giant dragonfly would be significantly adversely affected.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the lifecycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

An endangered population is a population listed under Part 2 of Schedule 1 of the TSC Act and is defined as a population that, in the opinion of the NSW Scientific Committee, is facing a very high risk of extinction in NSW in the near future. A population is not eligible to be listed in Schedule 1 or 1A (i.e. already listed as an Endangered or Critically Endangered species).

To date, there are no Endangered Populations listed for the Giant dragonfly.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or*
- *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.*

Not applicable to threatened species.

In relation to the habitat of a threatened species, population or ecological community:

- *(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed;*
- *(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and*
- *(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.*

Direct loss of habitat for this species can occur as a result of vegetation clearance. Loss of habitat for the Giant dragonfly within the Project area could also occur if changes in hydrology result in swamps partially or fully drying out. Lower levels of moisture in the swamp soil could cause swamps to be more vulnerable to fire and flood and could cause extensive erosion (Young, 1982; Krogh, 2004; 2007). A significant increase in the frequency of fires could lead to habitat loss for the Giant dragonfly.

Potential habitats of the Giant dragonfly include permanent swamps and bogs containing some free water and open vegetation (NSW Scientific Committee, 2004). Specifically, microhabitats including seepage creeklets, groundwater-fed creeks and soaks, burrows in moist organic/peaty soil and swamp vegetation are important for this species.

It is not considered likely that potential breeding, larval development and/or foraging habitat for the Giant dragonfly is present within the Study Area. It is therefore unlikely that the Project would result in significant adverse effects on the quality or availability of habitat for the Giant dragonfly.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).
No critical habitat is present within the Project area according to any databases or registers.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.
There are no recovery plans for the Giant dragonfly.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
Freshwater habitat within the Study Area ranged from moderately to significantly degraded due to some evidence of streambank degradation and sedimentation, moderate water quality, the presence of alien species of fish and the presence of weeds amongst the riparian and instream vegetation. Water quality in the catchment is typical of aquatic ecosystems that have been disturbed by agricultural practices and salinity levels commonly exceeded the ANZECC & ARMCANZ (2000) guideline value.
The Project is not likely to affect current disturbance regimes relevant to the Giant dragonfly.

Conclusion

It is not considered likely that potential breeding, larval development and/or foraging habitat for the Giant dragonfly is present within the Study Area. It is therefore unlikely that the Project would result in significant adverse effects on the Giant dragonfly.

Fisheries Management Act 1994 Impact Assessment

The Department of Primary Industries (DPI) Fisheries *Threatened and Protected Species Record Viewer* (DPI, 2015b) indicated one species of fish, Murray cod, may occur within the Mid-Western Regional Local Government Area. It is noted the Project is located outside of the Murray-Darling Basin, however, potential impacts on the Murray cod are assessed below in accordance with section 5A of the EP&A Act and the *Threatened Species Assessment Guidelines - the Assessment of Significance* (DECC, 2007).

Murray cod

How is the Project likely to affect the lifecycle of a threatened species, population or ecological community?

Murray cod spawning occurs when water temperatures exceed 15 ºC (Humphries, 2005; Koehn and Harrington, 2006). Spawning also appears to be correlated with day length, typically occurring in spring over a 4-5 week period (Humphries, 2005; Koehn and Harrington, 2006). Although spawning doesn't appear to require flooding, recruitment success appears to be strongly linked to river flow (Kearney and Kildea, 2001), with good year classes in some rivers coinciding with a rise in water level or flooding soon after spawning (Rowland, 1998, NMCRT, 2010).

Between late spring and early summer adult cod commonly migrate upstream for distances of up to 80 – 120 km to spawn (Koehn, 1997). Murray cod form breeding pairs prior to spawning. A female of up to 3 kg would deposit approximately 10,000 eggs, usually in a sunken log in lowland rivers, or a submerged rock in upland streams. Murray cod have also been recorded excavating and laying eggs in depressions in clay banks. Incubation time takes 3-13 days depending on temperature (Humphries, 2005; Lintermans, 2007). Larvae then leave the nest to drift downstream (Humphries, 2005;

Koehn and Harrington, 2006). Following spawning, adults moves back downstream, returning to the same territory occupied before the spawning migration (Koehn, 1997).

The typical adult diet consists of spiny crayfish, yabbies and shrimps (NMCRT, 2010). It also feeds on fish, water birds, frogs, turtles, ducks and terrestrial animals such as mice and snakes (Koehn and O'Connor, 1990).

There are no formal records of Murray cod in the Upper Goulburn River catchment. Furthermore, it is unlikely that the Project would have adverse effects on the lifecycle of the Murray cod given mitigation measures to address water management and erosion and sediment control.

How is the Project likely to affect the habitat of a threatened species, population or ecological community?

Murray cod use a diverse range of habitats, from clear rocky streams to slow-flowing, turbid lowland rivers and billabongs (McDowall, 1996). They are frequently found in the main channels of rivers and larger tributaries. Micro-habitat consists of complex structural features such as large rocks, snags (large submerged woody debris), overhanging stream banks and vegetation (Morris *et al*., 2001).

There are no formal records of Murray cod within the Study Area or downstream environments within the Goulburn River Catchment. As such, aquatic habitat within the Study Area is not critical to the long-term survival of this species.

Does the Project affect any threatened species or populations that are at the limit of its known distribution?

The Murray cod are historically distributed throughout the Murray-Darling Basin. The distribution of the Murray cod occurs in the following bioregions according to the Interim Biogeographic Regionalisation for Australia (IBRA7) (Department of Sustainability, Environment, Water, Population and Communities, 2012): Murray-Darling Depression, Riverina, NSW South Western Slopes, South Eastern Highlands, Cobar Peneplain, Darling Riverine Plains, Brigalow Belt South and Nandewar (NMCRT, 2010). As such, the Project Area/Study Area is a considerable distance from the distribution limits of this species.

How is the Project likely to affect current disturbance regimes?
Freshwater habitat within the Study Area ranged from moderately to significantly degraded due to some evidence of streambank degradation and sedimentation, moderate water quality, the presence of alien species of fish and the presence of weeds amongst the riparian and instream vegetation. Water quality in the catchment is typical of aquatic ecosystems that have been disturbed by agricultural practices and salinity levels commonly exceeded the ANZECC & ARMCANZ (2000) guideline value.

The Project is not likely to affect current disturbance regimes relevant to the Murray cod.

How is the Project likely to affect habitat connectivity?
The Project is not likely to affect habitat connectivity.

How is the Project likely to affect critical habitat?
There are no critical habitats listed for Murray cod listed under the FM Act.

Conclusion
It is unlikely that the Project would impact on a local or regional population of Murray cod.