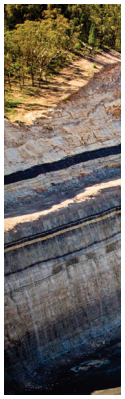
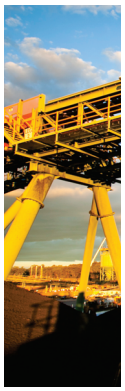








MOOLARBENCOAL

Moolarben Coal Complex
Open Cut Optimisation Modification

Environmental Assessment

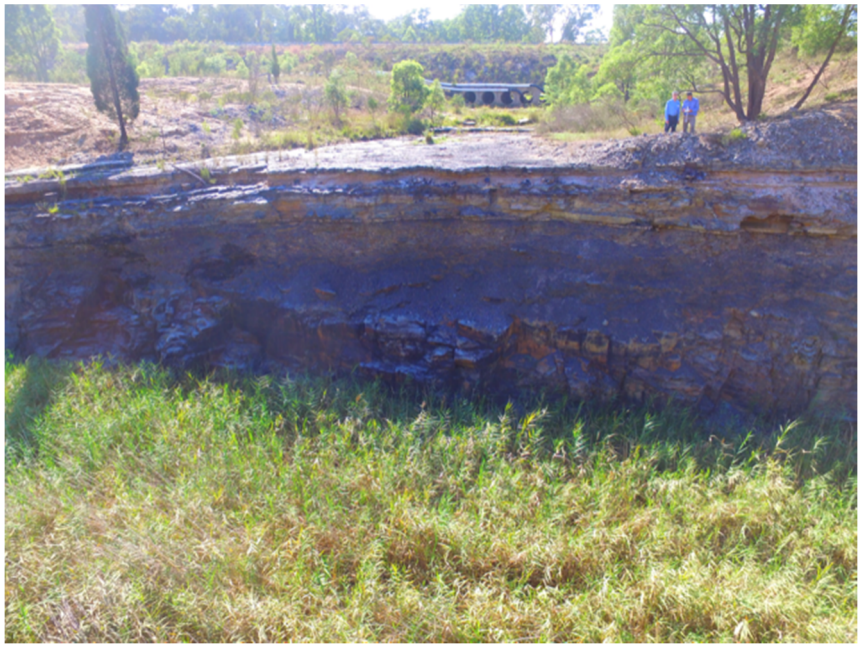
APPENDIX G

Aquatic Ecology Assessment

YANCOAL
兖煤澳大利亚有限公司

MOOLARBEN COAL COMPLEX OPEN CUT OPTIMISATION MODIFICATION

IMPACT ASSESSMENT FOR CONTROLLED MINE WATER RELEASE TO THE GOULBURN RIVER NSW: AQUATIC ECOLOGY ASSESSMENT



View of Bora Creek Discharge to the Goulburn River Diversion with Casillis Road Culvert in the background.

REPORT PREPARED FOR

MOOLARBEN COAL OPERATIONS PTY LIMITED

MARINE POLLUTION RESEARCH PTY LTD

October 2017

MARINE POLLUTION RESEARCH PTY LTD

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CLIENT & CONTACT:	MCO
MPR REPORT No:	MPR 1129
DRAFT REPORT FOR COMMENT:	Moolarben Coal Complex – Open Cut Optimisation Modification – Aquatic Ecology Assessment – Draft V2 Sent 8 August 2017
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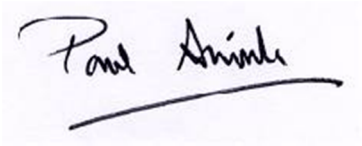
FINAL REPORT:	Moolarben Coal Complex – Open Cut Optimisation Modification – Aquatic Ecology Assessment – Final Sent 26 October 2017
MPR APPROVAL: PAUL ANINK	

TABLE OF CONTENTS **PAGE**

ANNEXURES

TABLES

FIGURES

AMMO	Avoidance, Minimisation, Mitigation &/or Offset Measures
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AUSRIVAS	Australian River Assessment System – an aquatic ecology assessment method
BC Act	Biodiversity Conservation Act 2016 (NSW)
BIS	Bobadeen Irrigation Scheme operated by UCM
EA	Environmental Assessment – generally relating to Part 3A of the EP&A Act
EC	Electrical Conductivity – a measure of water salinity
EPA	Environment Protection Authority (NSW)
EP&A Act	Environmental Planning & Assessment Act 1979 (NSW)
EPBC Act	Environment Protection & Biodiversity Conservation Act 1999 (Commonwealth)
EPL	Environment Protection Licence
FM Act	Fisheries Management Act 1994 (NSW)
kL/day	kilolitres per day
km	kilometres
KTP	Key Threatening Processes
m	metres
m/s	metres per second
MCO	Moolarben Coal Operations Pty Ltd
MCC	Moolarben Coal Complex – Stages 1 and 2 of the mine as assessed by EAs
mg/L	milligrams per litre
ML/day	Megalitres per day
NRPMP	National River Process and Management Program
NSW	New South Wales, Australia
NTU	Nephelometric Turbidity Units
OC	open cut mining area
OEH	NSW Office of Environment and Heritage
pH	A measure of the relative acidity of water
RCE	Riparian, Channel and Environmental Inventory – a riparian and aquatic site condition index
SIGNAL	Stream Invertebrate Grade Number Average Level – a pollution tolerance index
SWMP	Surface Water Management Plan
TDS	Total Dissolved Solids – roughly analogous to salinity
TSS	Total Suspended Solids – a measure of matter suspended in the water column
UG	underground mining area
UMC	Ulan Mine Complex
µS/cm	microSiemens per centimetre

1. INTRODUCTION

1.1 Background

The Moolarben Coal Complex (MCC) is located approximately 40 kilometers (km) north of Mudgee in the Western Coalfields of New South Wales (NSW) (**Figure 1**). The Ulan Mine Complex (UMC) is located to the north and west of the MCC and Wilpinjong Coal Mine is located to the south-east.

Moolarben Coal Operations Pty Ltd (MCO) is the operator of the MCC on behalf of the Moolarben Joint Venture (Moolarben Coal Mines Pty Ltd, Sojitz Moolarben Resources Pty Ltd and a consortium of Korean power companies). MCO is a wholly owned subsidiary of Yancoal Australia Limited .

The MCC comprises four approved open cut mining areas (OC1 to OC4), three approved underground mining areas (UG1, UG2 and UG4) and other mining related infrastructure (including coal processing and transport facilities).

Mining operations at the MCC are currently approved until 31 December 2038 in accordance with Project Approval (05_0117) (Moolarben Coal Project Stage 1) (as modified) and Project Approval (08_0135) (Moolarben Coal Project Stage 2) (as modified).

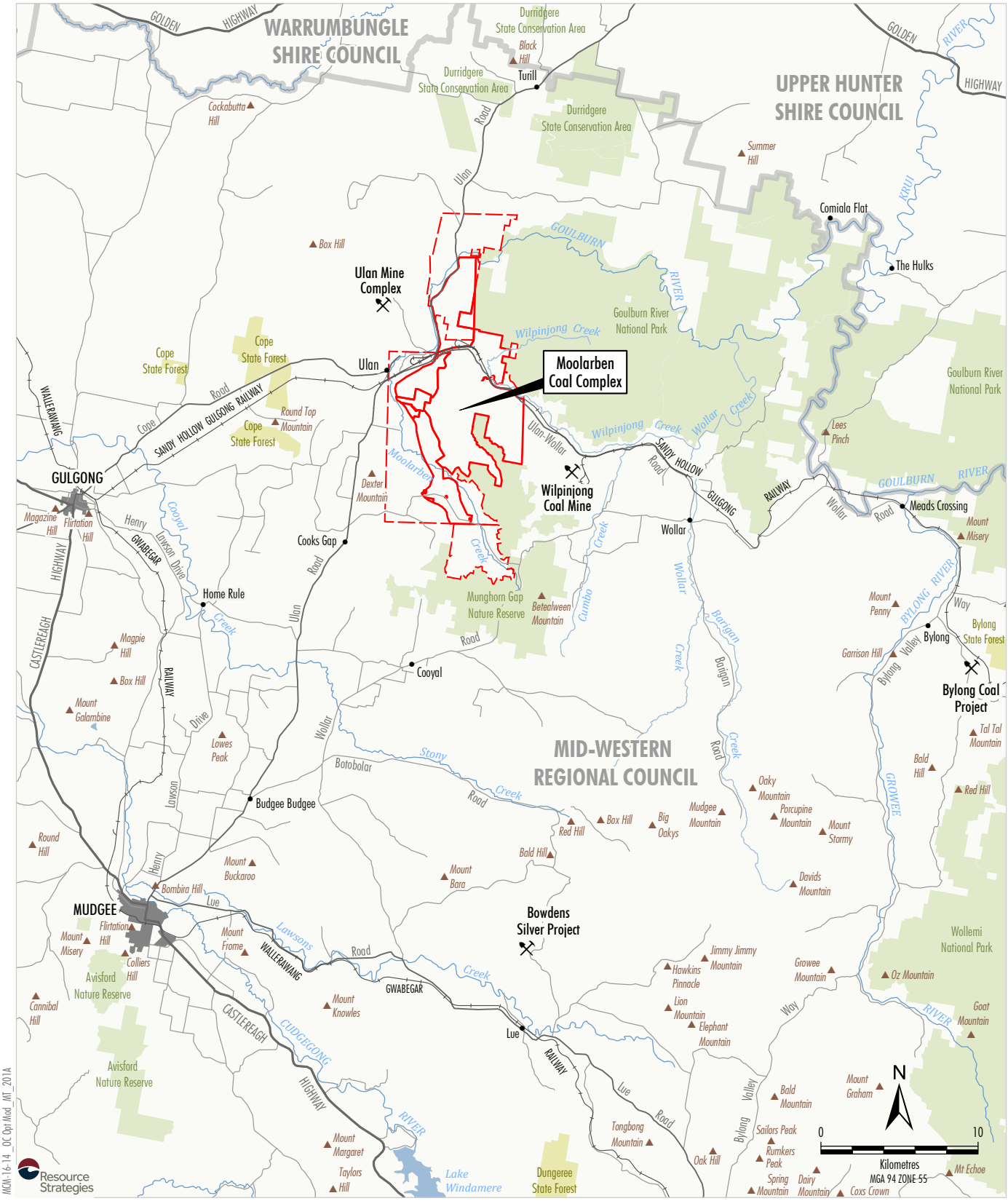
Since the commencement of coal mining operations in 2010, mining activities have occurred within OC1, OC2 and OC4. First workings for UG1 commenced in April 2016 and secondary workings (i.e. longwall extraction) commenced in October 2017.

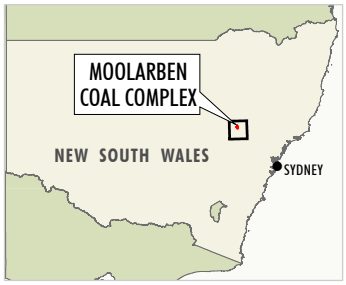
1.2 Modification Overview

MCO Environment Protection Licence (EPL) 12932 (version 26 May 2016) permits discharge of water from three existing discharge points (**Figure 2**), subject to stringent water quality concentration limits:

- EPL ID1– to Bora Creek from Cockies Dam – maximum 10 megalitres per day (ML/day);
- EPL ID2 – to Goulburn River from OC1 Sediment Dam 6 – maximum 10 ML/day; and
- EPL ID28 – to Moolarben Creek from OC2 Dam – maximum 1 kilolitre per day (kL/day).

The EPL also specifies that the maximum combined discharge from the discharge points must not exceed 10 ML/day.





LEGEND
- State Forest
- NSW National Parks and Wildlife Service
- Local Government Boundary
- Exploration Licence Boundary
- Mining Lease Boundary
- Mining Operation

Source: NSW Land & Property Information (2017); NSW Department of Industry (2017); Office of Environment and Heritage NSW (2017)

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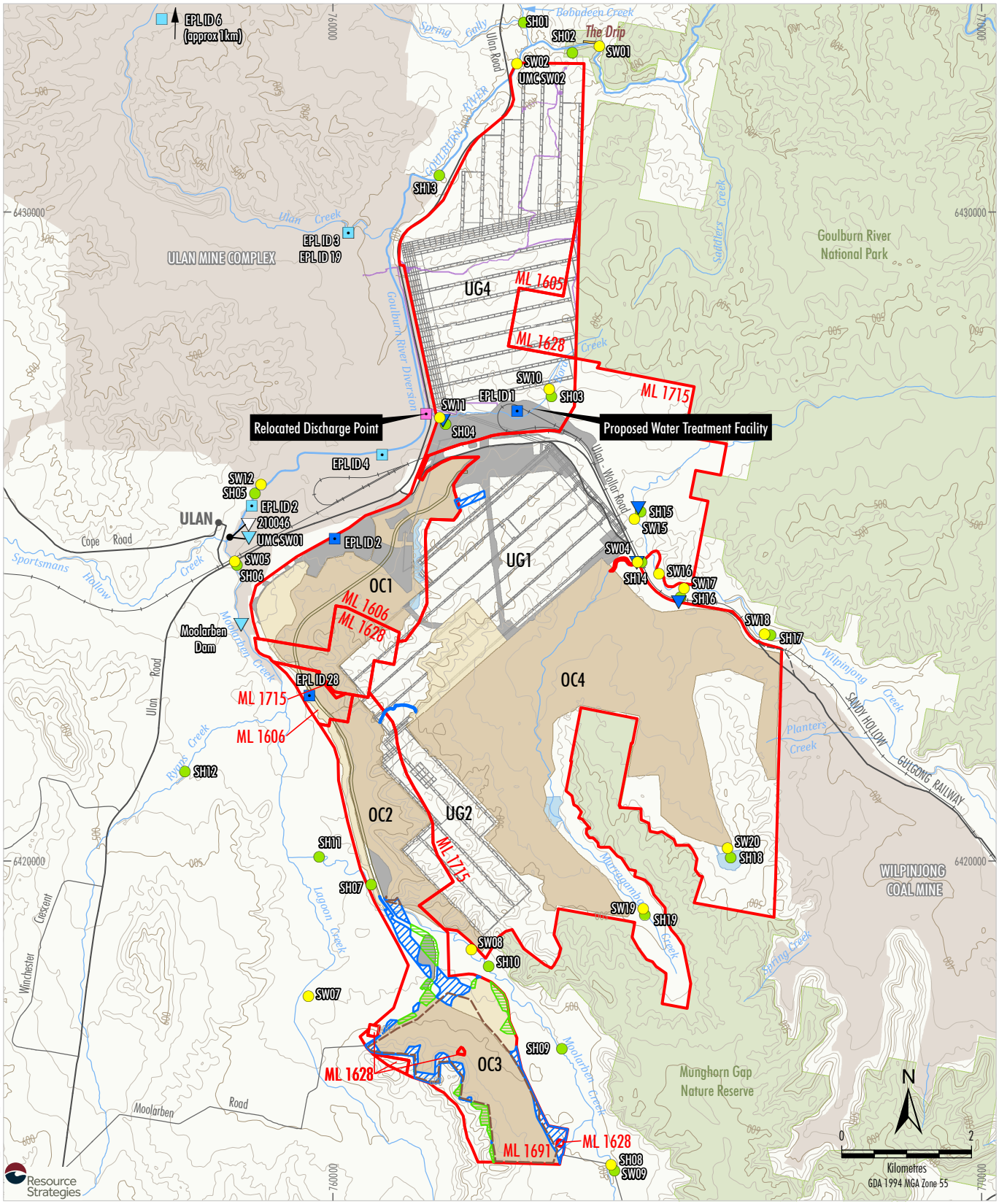
MOOLARBEN COAL COMPLEX

Regional Location

Figure 1



LEGEND

NSW National Parks and Wildlife Service

Mining Lease Boundary

Existing/Approved Development

- Open Cut Mining Area
- Out-of-pit Emplacement
- Surface Infrastructure Area
- Pipeline and Borefield Infrastructure
- Clean Water Diversion Infrastructure
- Underground Longwall Layout
- Haul Road
- Road Realignment (not yet constructed)

Open Cut Optimisation Modification

- Approximate Extent of Revised Open Cut Mining Area
- Approximate Extent of Additional Surface Development
- Approved Open Cut Mining Area, Out-of-pit Emplacement and Surface Infrastructure to be Relinquished

Surface Water Monitoring

- Moolarben Coal Complex Surface Water Monitoring Site
- Moolarben Coal Complex Stream Health Monitoring Site
- Moolarben Coal Complex Streamflow Gauge
- Ulan Mine Complex Streamflow Gauge
- Decommissioned Streamflow Gauge

Licensed Discharge Points

- Moolarben Coal Complex
- Ulan Mine Complex

Proposed Discharge Point

- Moolarben Coal Complex

Source: MCO (June 2017); NSW Dept of Industry (2017); NSW Land & Property Information (2017); Office of Environment and Heritage NSW (2017)

MOOLARBENCOAL

MOOLARBEN COAL COMPLEX

Discharge Locations and Stream Health Monitoring Sites

Figure 2

EPL 12932 also permits discharge of water from sediment dams following gravity settlement of sediment or periods of significant rainfall.

Recent revisions to the site water balance indicate the MCC will at times be a water surplus site and the ability to release additional water will be required. MCO therefore intends to seek approval for an increase in the combined volume of the controlled release of water from the site into the Goulburn River from 10 ML/day to 20 ML/day.

In addition, MCO proposes to relocate EPL ID1 from its current location at the MCC rail loop to the confluence of Bora Creek and the Goulburn River Diversion (**Figures 2 and 3**). Discharge water will be piped to the relocated discharge point, to reduce the potential for scour and erosion along Bora Creek. The proposed discharge limit from this relocated discharge point is a maximum of 20 ML/day.

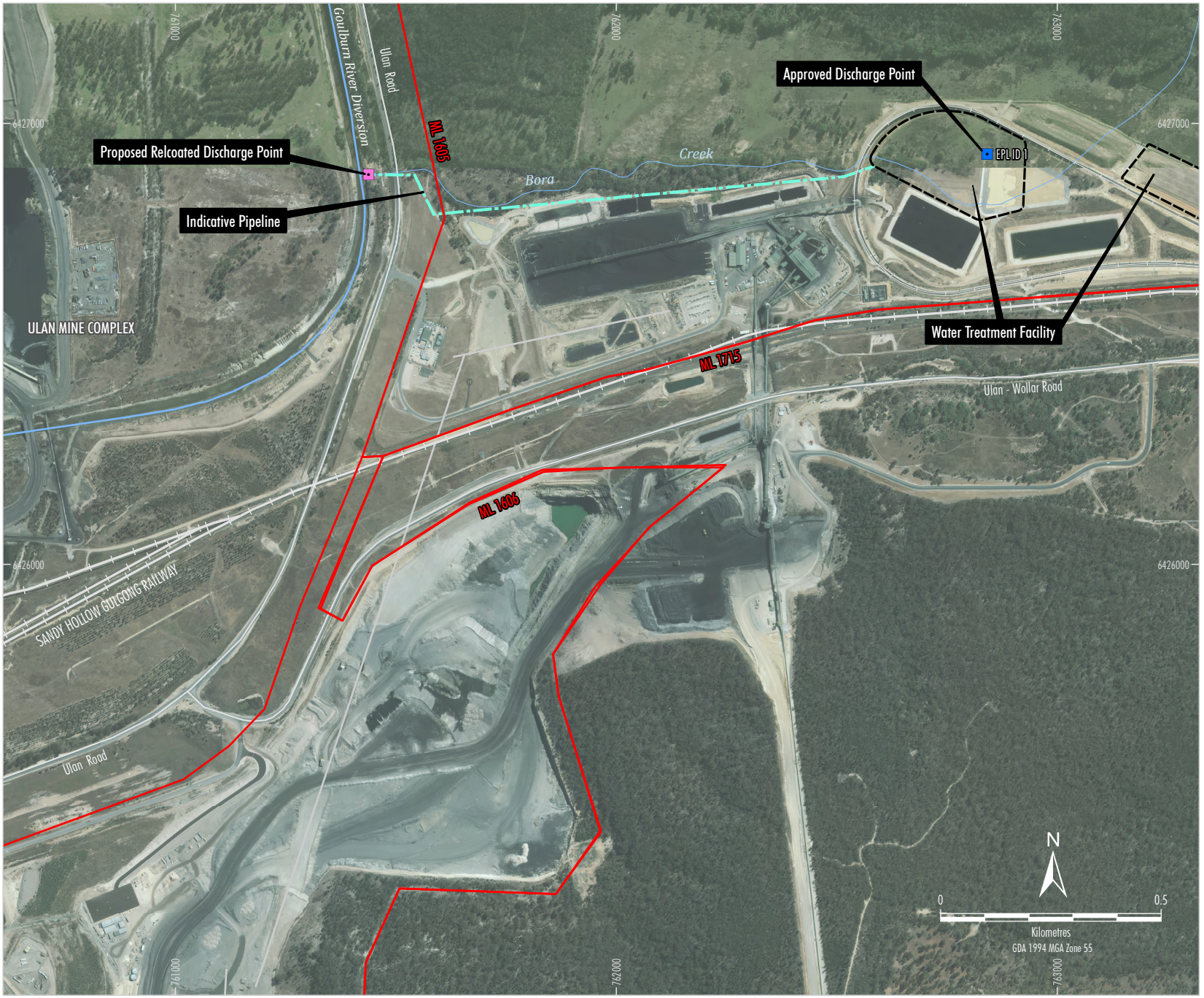
The proposed discharge water quality concentration limits would remain consistent with the current concentration limits as set out in EPL 12932. No change to the existing approved discharge quantities from EPL ID2 and EPL ID28 is proposed under the MCO Open Cut Optimisation Modification (the Modification), however, it is proposed the maximum discharge limit from the relocated EPL ID1, EPL ID2 and EPL ID28 would not exceed 20 ML/day, cumulatively. No change to the operation of sediment dams at the MCC (as permitted by EPL 12932) is proposed as part of this Modification.

The Modification also includes the operation of a new Water Treatment Plant and associated Water Storage Dams to be constructed adjacent to the MCC rail loop and supporting infrastructure, to treat site water prior to discharge (**Figure 3**). The treatment process is subject to final engineering design, however, it would likely include pre-treatment to control pH, iron and concentrations of dissolved metals, as well as salinity/conductivity via reverse osmosis.

1.3 Purpose and Assessment Methodology

The purpose of this Aquatic Ecology Assessment is to:

1. Assess the potential impacts of the Modification on the aquatic ecology of receiving waters by: considering whether there has been any material change in key stream-health indicators in the upper Goulburn River that could be attributed to alterations in river flow and quality over time from historic MCC and/or UMC licensed discharges; and



LEGEND
Mining Lease Boundary
Indicative Pipeline

Source: MCO (2017); NSW Dept of Industry (2017); NSW Land & Property Information (2017)
Orthophoto: MCO (April 2016 - May 2012))

MOOLARBENCOAL
MOOLARBEN COAL COMPLEX

Existing and Proposed Relocated Discharge Point

Figure 3

MCM-16-14 _OC Opt Mod_Aquatic_202A

- using the responses of the stream-health indicators to flow and quality changes over time as a basis for assessing potential impacts of the Modification, with consideration of the Controlled Water Release Impact Assessment prepared by Advisian (2017) for the Modification;

2. Develop *avoidance, minimisation, mitigation and/or offse*t (AMMO) measures to manage identified risks, where necessary; and
3. Provide suggested monitoring for assessing the success of any implemented AMMO measures.

2. EXISTING ENVIRONMENT

2.1 Regional and Local Hydrology

The MCC is located in the upper Goulburn River catchment, approximately 40 km north of Mudgee in the Western Coalfields of NSW. Stage 1 of the MCC is located in the Moolarben Creek/upper Goulburn River catchment, bounded by the Great Divide to the west. Stage 2 of the MCC is generally located in the Wilpinjong/Wollar Creek sub-catchment of the Goulburn River (**Figure 4**).

The Goulburn River commences at the confluence of Sportsman Hollow and Moolarben Creek sub-catchments and then drains in a north-easterly direction to the west and north of the MCC into the Goulburn River National Park, continuing east to join the Hunter River at Denman some 200 km downstream of the MCC. The Goulburn River was diverted as part of the development of the UMC in 1982. This diversion is known as the Goulburn River Diversion. Bora Creek is located immediately north of the MCC Coal Handling and Processing Plant area and flows to the Goulburn River Diversion.

"The Drip" is a feature located on the Goulburn River where it enters the Goulburn River National Park (**Figure 2**). Perched groundwater seeps through the rock gorge wall on the northern side of the Goulburn River. While the Drip is a groundwater-fed feature of interest, the groundwater seepage does not create aquatic ecology habitat on the rock face, and as such, the Drip is not unique from an aquatic ecology perspective in comparison to surrounding sections of the Goulburn River.

2.2 Goulburn River Flow and Water Quality

MCO undertakes stream flow monitoring and periodic water quality and aquatic ecology (stream-health) monitoring on the Goulburn River upstream and downstream of the MCC and UMC in accordance with the MCC Surface Water Management Plan (SWMP). The SWMP also describes water quality trigger values, which have been developed based on Australian and New Zealand Environment and Conservation Council (ANZECC) default triggers for 95% species protection, or site specific triggers based on 80th percentile baseline data (ANZECC/ARMCANZ 2000).

Advisian (2017) has analysed the available Goulburn River water quality at MCC and UMC sites. A summary of Advisian's (2017) findings is provided below.

For the monitoring site MCC SW08 on Moolarben Creek:

- pH is slightly alkaline, which is consistent with pH levels in the Goulburn River.

MCM-16-14_OC Opt Mod_Aquatic_001B

Source: NSW Environment Protection Authority (2017)

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MOOLARBEN COAL COMPLEX

Hunter River Catchment

Figure 4

- Electrical conductivity (EC) (lab) is very high with an average of 3,188 microSiemens per centimetre (µS/cm). This is much higher than the average EC in the Goulburn River, which ranges between 540 µS/cm and 734 µS/cm and has an adopted trigger level[1] of 900 µS/cm. As MCC SW08 is located upstream of all discharge points and mining operations, the high EC can be attributed to other sources in the catchment (e.g. sub-cropping coal seams).
- Total Suspended Solids (TSS) concentrations are low, which is consistent with TSS in Goulburn River.
- Average Total Dissolved Solids (TDS) concentrations mirror the variation in EC, as expected.
- Average Turbidity in Moolarben Creek is 48 Nephelometric Turbidity Units (NTU) which is above the trigger value for the Goulburn River of 25 NTU.

For the monitoring sites on Goulburn River upstream of the proposed discharge point (UMC SW01 and MCC SW12):

- pH is slightly alkaline with means in the range of 7.1 and 7.2, which is within the adopted trigger levels for the Goulburn River.
- Average EC (lab) varies between 540 µS/cm and 548 µS/cm, which is below the adopted trigger level for Goulburn River of 900 µS/cm.
- TSS concentrations are low reflecting the fact that TSS concentrations are closely related to flow rates.
- The average TDS concentration of 346 milligrams per litre (mg/L) mirrors the variation in EC, as expected.
- Turbidity at MCC SW12 has a mean of 35 NTU which is above the adopted trigger level for the Goulburn River of 25 NTU.

For the monitoring sites on the Goulburn River downstream of the proposed discharge point (UMC SW02, MCC SW02 and MCC SW01):

- pH is slightly alkaline with means in the range of 7.3 to 7.8, which is within the adopted trigger levels for the Goulburn River.
- Average EC (lab) varies between 711 µS/cm and 734 µS/cm, which is below the adopted trigger level for Goulburn River of 900 µS/cm.
- TSS concentrations are generally low reflecting the fact that TSS concentrations are closely related to flow rates.

[1] Adopted trigger level refers to the water quality trigger levels described in the Surface Water Management Plan (SWMP) (MCO, 2016). The SWMP was updated in 2016 and submitted for approval. Based on analysis of additional water quality data in the Goulburn River, revised triggers for pH and EC were proposed in the updated SWMP.

- Average TDS concentrations range from 412 mg/L to 453 mg/L which, as expected, mirrors the variation in EC.
- Average Turbidity ranges from 7 NTU to 14 NTU, which is below the adopted trigger level for the Goulburn River of 25 NTU.

2.3 Previous Mining Activities

Operations at the MCC included three licensed discharge points. To date, discharges have included:

- Several uncontrolled discharge events to Bora Creek and Goulburn River that occurred during mine facility construction works between June 2009 and March 2012; and
- An approved controlled emergency discharge event from December 2010 to January 2011 following sustained heavy rainfall in November/December 2010 (**Figure 5**).

Figure 5 Moolarben Creek flooding on 1st December 2010; looking downstream from Moolarben Dam (photo Dennis Rayner).

The UMC, which is located on the western side of the Goulburn River Diversion, has a number of operational EPL licenced discharge points, including EPL (EPL Licence Number 394) ID3, ID6 and ID19 located on Ulan Creek, which discharge to Goulburn River just north (downstream) of the Goulburn River Diversion (**Figure 2**). Advisian (2017) has reviewed historical discharges from the UMC and notes:

- UMC has been discharging into Ulan Creek from EPL ID3 since April 2004, from EPL ID6 since June 2007, and from EPL ID19 since December 2011.

- Approved UMC discharge quantities have increased over time and that since May 2012, when a discharge limit of 30 ML/day was approved, an average volume of 10.7 ML/day has been discharged into Ulan Creek.
- The UMC EPL conditions for these combined discharges are similar, with respect to concentration limits, to the MCO EPL conditions.

UMC also operates the Bobadeen Irrigation Scheme (BIS), where surplus water is used to irrigate pastures within the Bobadeen Creek sub-catchment that also discharges to the Goulburn River downstream of the Ulan Creek discharge. The BIS has been in operation since 2003.

3. REVIEW OF EXISTING AQUATIC ECOLOGY DATA

3.1 MCO Aquatic Ecology Data

The MCO stream-health data can be used to evaluate whether the mine discharges described in **Section 2.3** have had any discernable impact on key stream-health aquatic macroinvertebrate indicators at downstream sites.

Stream-health aquatic ecology sampling of the upper Goulburn River above the Goulburn River National Park in relation to the MCC has been undertaken since the initial MCC Stage 1 Environmental Assessment (EA) investigations in 2004:

- Initial sampling was undertaken in Spring 2004, Autumn 2005, Spring 2005 and Summer 2006 for the approved Stage 1 EA. Results of these surveys are contained in Appendix 11 of the Stage 1 EA prepared by Wells Environmental Services (2006).
- Additional stream-health sampling was undertaken to the east of the Moolarben Creek/upper Goulburn River catchment in Autumn and Spring 2005, Summer 2006 and Spring 2007 for the approved MCC Stage 2 EA. Results of these surveys are contained as an Appendix to the Stage 2 EA prepared by Wells Environmental Services (2009).
- A stream-health monitoring program to meet the Minister's Conditions of Approval for Stage 1 was instigated in mid 2008 and additional pre-construction stream-health monitoring was undertaken in Spring 2008 and Autumn 2009.
- In mid 2009, MCO provided a new study design for stream-health monitoring for for four further seasons starting in Spring 2009. This program continued through to Autumn 2011. Sites for the monitoring program are shown in **Figure 2**.
- In mid 2011, MCO initiated a new stream-health monitoring program that has continued with Spring and Autumn sampling from Spring 2011 through to the present (Autumn 2017), with sampling continuing at the same sampling sites indicated in **Figure 2**.
- In mid 2014, MCO varied the stream-health monitoring design to include additional monitoring sites on the Wilpinjong Creek catchment for the Stage 2 operations.

Stream-health surveys have been undertaken using the National River Process and Management Program (NRPMP) River Bio-assessment Manual methods (NRPMP 1994) as adapted for the National River Health Program, now referred to as the Australian Rivers Assessment System (AUSRIVAS) method (Turak et. al 1999; Turak & Waddell 2001; Turak et. al 2004). Sampling and taxa identification for aquatic macroinvertebrates conforms to the AUSRIVAS methods for 'edge' sampling and data are analysed for site aquatic macroinvertebrate Diversity (number of taxa) and site Stream Invertebrate Grade Number Average Level (SIGNAL) index.

SIGNAL is a pollution tolerance index for stream macroinvertebrates. Each specified macroinvertebrate taxa (generally at Family level) has been assigned a SIGNAL score ranging from 10 (very pollution intolerant) to 1 (very pollution tolerant). The indices are derived by correlation analysis of macroinvertebrate occurrence against water chemical analysis (Chessman 1995). The water chemistry attributes generally used are temperature, turbidity, conductivity, alkalinity, pH, dissolved oxygen, total nitrogen and total phosphorus (Chessman 2003a).

As described in Marine Pollution and Research Pty Ltd (2008), SIGNAL indices may be regionally specific (e.g. SIGNAL HU-97 developed for the Hunter Valley Catchment [Chessman et. al 1997]), or applicable Australia wide (e.g. SIGNAL-2, Chessman 2003b) and the results from earlier (i.e. 2004 to 2008) MCO surveys were analysed against a mix of HU97 values plus SIGNAL-2 values for taxa that did not have a HU97 value. However, as MCO seasonal monitoring progressed, the number of taxa recorded in the study area for which there were no HU-97 values far exceeded the number of taxa with no SIGNAL-2 values, and accordingly, from Autumn 2009 onwards, site SIGNAL calculations used SIGNAL 2 family indices alone. This remained the case through to Spring 2016.

Once individual taxa SIGNAL scores have been applied, site SIGNAL indices are calculated as the mean of all site taxa SIGNAL scores. Site condition measurements have also been used to compile a stream condition index, based on the Riparian, Channel and Environmental (RCE) Inventory method for the Hunter River Catchment.

Analysis of the available stream-health data from MCO is presented in **Section 4**.

3.2 Other Relevant Aquatic Ecology Data

The original AUSRIVAS evaluation for NSW undertaken by the Environment Protection Authority (NSW) (EPA) included two reference sites on the Goulburn River, HUNT512 located downstream of the Cassilis Road Crossing which became the original MCO stream-health site GR3 (sampled in Summer 2006 and Autumn 2006) and HUNT588 located 22.5 km downstream of SH01 at Kerrabee. These sites were sampled in Autumn 1997 and Spring 1999. Site GR3 was not retained for long-term monitoring due to the proximity of the site to road runoff from the Cassilis Road bridge easement.

UMC has been undertaking aquatic stream-health sampling in the upper Goulburn River Catchment since at least 2007, with a number of Goulburn River stream-health sites at or close to MCO stream-health sites. UMC stream-health sampling included similar methods to the MCO sampling, with similar data analysis and stream-health indices.

3.3 Threatened Aquatic Species and Communities

Aquatic habitats, flora and fauna of conservation significance are protected under both State and Federal legislation. In NSW, threatened species, populations and ecological communities of terrestrial animals and plants, amphibians plus certain marine mammals and reptiles are protected under the NSW *Biodiversity Conservation Act 2016* (BC Act). Threatened species, populations and ecological communities of aquatic fauna including fish and marine vegetation are protected under the *Fisheries Management Act 1994* (FM Act). The BC Act and FM Act also list a number of key threatening processes that may threaten the survival of species, populations and ecological communities.

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) protects wetlands of international importance, Commonwealth Marine Areas, nationally threatened species and ecological communities and migratory species, nuclear actions and world and national heritage places.

The FM Act, BC Act and EPBC Act require that any proposed activity be assessed with respect to its potential impact on species or ecological communities listed as threatened under the Threatened Species Schedules of the Acts or listed as migratory species under the EPBC Act.

Both the MCC Stage 1 and Stage 2 EAs considered the possibility of listed threatened species and Endangered Ecological Communities and concluded that there were no aquatic species known from the locality and none were expected.

As these conclusions were made in 2006 through to 2008, searches of relevant threatened species databases and search tools have been updated for this present assessment. **Annexure A** provides the results of the EPBC Act database search and the relevant results of the BC Act and FM Act searches. The FM Act search is based on the most recent update of the FM Act threatened species assessment report (Department of Primary Industries 2016).

3.3.1 Threatened Fish

The updated searches confirmed that there are no EPBC Act or FM Act listed aquatic species or endangered populations or communities found in the upper Goulburn River upstream of the Goulburn River National Park and none are reported, known or expected from Goulburn River National Park downstream to the Wollar Creek confluence (**Figure 4**). Beyond the Wollar Creek confluence the Goulburn River provides habitat for one threatened fish species and one endangered fish population listed under the FM Act:

- Darling River Hardyhead *Craterocephalus amniculus* is listed as an Endangered Population (*Darling River Hardyhead Population in the Hunter River*). Its known and likely distribution includes the upper Hunter River catchment upstream of Denman plus the Goulburn River from the Munmurra River confluence (located 16 km downstream of the Wollar Creek confluence) downstream to the Hunter River confluence (**Figure 4**). The distribution includes all the Goulburn River north to south flowing sub-catchments located east from Turill Creek (near Casillis) and down to the Hunter confluence.
- The Purple Spotted Gudgeon *Mogurnda adspersa* is listed as an endangered species under the FM Act. The population west of the Great Divide is found in the elevated upper sub-catchments of most streams flowing west from the Great Divide to the Barwon/Bogan River. This includes the Cudgegong River immediately west of the Moolarben Creek sub-catchment of the Goulburn River. The eastern coastal population is found in northern coastal rivers from the Queensland boarder to the Hunter River. In the Goulburn River, it is confined to the reaches near and downstream of Baerami (i.e. downstream of the Widden Creek confluence) (**Figure 4**).

Three threatened fish species (Flathead Galaxias, Murray Cod and Macquarie Perch) are listed under the EPBC Act, however these species are all confined to streams flowing west of the Great Divide toward the Murray-Darling River Basin. None of these species are known or expected in the Goulburn River catchment.

3.3.2 Other Aquatic Threatened Species

The EPBC Act search also indicated there may be habitat for the Booroolong Frog *Litoria booroolongensis* in the upper Goulburn River National Park catchment. This species is also listed as endangered under the BC Act. The presence of this species was considered for the Stage 1 and Stage 2 EAs and it was concluded that it was not located in this area and was unlikely to be found in the area. A NSW Wildlife Atlas search and updated NSW Office of Environment and Heritage (OEH) status report indicate the closest populations are located along the Turon River from Ben Bullen to Sofala with no sightings in the whole Goulburn River catchment. It is concluded that Booroolong Frog is not known or expected in the Goulburn River catchment.

The BC Act Bionet search also indicated a single sighting of a Giant Barred Frog *Mixophyes iteratus*, listed as endangered under the BC Act. The sighting was located at the southern boundary of the Goulburn River National Park on a tributary of Cumbo Creek. The OEH species profile does not include Goulburn River National Park in the known or predicted species range map (see **Annexure A**) and this species is not expected to occur along the upper Goulburn River adjacent to the MCC or through the Goulburn River National Park above the Wollar Creek confluence.

3.3.3 Threatened Species Summary

From the updated review of the threatened species, communities and population provisions under the BC Act, FM Act and EPBC provided above, it is concluded that there are no aquatic threatened species (fish, amphibians or aquatic invertebrates) in the locality around the MCO operations or in the upper Goulburn River catchment from its watershed on the Great Divide down to at least the Wollar Creek confluence. The lower Goulburn River catchment below the Wollar Creek confluence support two threatened fish species; the *Darling River Hardyhead Population in the Hunter River* is listed as Endangered Population and the *Purple Spotted Gudgeon* is listed as an Endangered Species.

On this basis, the following Key Threatening Processes (KTPs) listed under the FM Act should be considered for the section of the Goulburn River downstream of the Wollar Creek confluence:

- *Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams.* The Fisheries Scientific Committee recommendation (FR21) notes that alteration to the natural flow regimes of rivers and streams can contribute to a loss of biological diversity and ecological function in aquatic ecosystems.
- *Degradation of native riparian vegetation along New South Wales water courses* (FR19) may also be relevant in relation to the FR21 KTP if alterations to natural flows result in bank instability and, as a consequence, loss of riparian vegetation.

3.4 Summary of Existing Aquatic Ecology

The upper section of the Goulburn River, upstream of the Goulburn River National Park, has been modified by historic development, including clearing, grazing, sleeper cutting, cultivation, the construction of the Moolarben Dam (constructed in the 1960s) and the Goulburn River Diversion (constructed in the 1980s) (**Figure 2**).

Review of baseline aquatic ecology data shows that prior to the commencement of the MCC, aquatic ecology diversity and abundance was reflective of a disturbed environment, as evidenced by SIGNAL and Diversity scores. Threatened species database searches also show the upper Goulburn River catchment does not provide habitat for threatened aquatic ecology species.

4. REVIEW AND ANALYSIS OF MCO STREAM-HEALTH DATA

4.1 Data Considered

For the purposes of understanding the present and potential impacts of mine-sourced discharges to the Goulburn River over time, this review compares the MCO stream-health site aquatic macroinvertebrate data from sampling undertaken between Spring 2004 and Autumn 2011 with stream-health site aquatic macroinvertebrate data obtained from Spring 2011 to present.

A summary of seasonal stream-health Diversity, site SIGNAL index and site RCE index statistical data collected since the Spring 2004 survey is shown in **Annexure B.**

For the purposes of assessing any potential changes in aquatic ecology data since 2011, all the original MCO aquatic macroinvertebrate site data from 2004 through to Autumn 2011 were used to provide a base-line summary of site macroinvertebrate statistics in the form that were used to develop a mean ± one standard deviation statistic for site macroinvertebrate indices. Where it cannot be conclusively determined if mine related activities have affected the aquatic ecology sampling undertaken between 2004 and Autumn 2011 (e.g. during releases that occurred in June 2009 and December 2010 to January 2011 [**Section 2.3**]), data was excluded from this period.

Seasonal site macroinvertebrate statistics for stream-health samples from Spring 2011 through to Autumn 2017 have been compiled into the master macroinvertebrate database so that site statistics could be re-calculated. The period Spring 2011 to Autumn 2017 aligns with the period the UMC has been approved to discharge at 30 ML/day (**Section 2.3**).

4.2 Macroinvertebrate Indices Calculated for Analysis

For this review, data has been compared against the following indices:

- Diversity – score based on the number of taxa.
- SIGNAL-2 – a pollution tolerance index for macroinvertebrates based on correlation analysis of aquatic invertebrate survey information with water chemical analysis.
- EPT Taxa – a diversity index where only insect families from pollution sensitive Orders (Ephemeroptera, Plecoptera and Trichoptera) are counted (Lenat 1988).
- Salinity Index – similar to the SIGNAL index, but based on aquatic invertebrate relative sensitivity to increased water conductivity (Horrigan et. al 2005).

4.3 Monitoring Sites

Data have been analysed for the following sites, which are located both upstream and downstream of the locations of historic mine discharges to the Goulburn River (**Figure 2**).

Upstream Site

- **Site SH05** is upstream of the Bora Creek and Ulan Creek confluences and provides the stream-health response to inputs from the combined Moolarben Creek and Sportsman Hollow Creek discharges to the Goulburn River.

Downstream Sites

- **Site SH13** is located downstream of the Goulburn River Diversion and the Ulan Creek confluence and provides the initial stream-health response to inputs from the combined Goulburn River Diversion discharge and the Ulan Creek discharge (which includes Ulan Creek catchment discharge and UMC licensed discharges).
- **Site SH01** is indicated as being located in the lower Bobadeen Creek catchment upstream of the confluence with Goulburn River and was sampled at that location from Spring 2005 through to Autumn 2012. In Spring 2012 the site was relocated into the main stream confluence pool of Goulburn River. For the present Autumn 2017 sampling both SH01 locations were sampled and are designated SH01B for the Bobadeen Creek site and SH01G for the Goulburn River site. Accordingly assessment of data for SH01 has necessitated analysing data from the two sub-sites. Site SH01B allows for analysing stream-health response to the UMC BIS discharge.
- **SH02** is located in the Goulburn River downstream half-way between SH01G and "the Drip" and provides the stream-health response to inputs from the combined upper Goulburn River catchments including all MCC and UMC operations, at the point the Goulburn River flows into the National Park.

4.4 Adjustments Required During Data Compilation

Key adjustments made to the data during the compilation for this review include:

- Earlier data from sites that did not align with the sites used in the more recent monitoring program was necessarily excluded from the analysis.
- Earlier seasonal data that had been calculated (and reported) against the SIGNAL-HU97 database was re-calculated against the SIGNAL-2 database.

There were some minor residual differences between the recalculated results and the original SIGNAL-HU97 results. In order to minimise the effects of these differences, the present assessment re-calculated site presence/absence SIGNAL-2 scores, based on taxa common to the sites listed in **Section 4.3** over the full sampling period.

4.5 Data Analysis

Mean scores for Diversity, SIGNAL-2, EPT Taxa and Salinity Index have been calculated for the period from 2004 to Autumn 2011, along with standard deviations from the respective means.

Seasonal Site scores for the surveys undertaken between Spring 2011 and Autumn 2017 have also been calculated and compared to the means for data obtained between Spring 2004 and Autumn 2011. The terminology used for comparison is summarised in **Table 1**.

The analysis was conducted based on 75 taxa common to the majority of surveys. **Annexure C** provides the aquatic macroinvertebrate taxa comparisons.

Table 1 Terminology Used for Data Comparison

Term	Result	Conclusion
"OK"	Scores for data obtained from Spring 2011 to present are within the mean ± one standard deviation scores for data obtained from Spring 2004 to Autumn 2011.	No significant change is considered to have occurred during operations.
	Scores for data obtained from Spring 2011 to present are greater than the mean + one standard deviation scores for data obtained from Spring 2004 to Autumn 2011.	Conditions are considered to have improved during operations.
"Under"	Scores for data obtained from Spring 2011 to present are less than the mean minus one standard deviation scores for data obtained from Spring 2004 to Autumn 2011.	Trigger for further investigation of the data to confirm if the cause is mine related or climatic/other (i.e. where data is "Under" this does not necessary indicate an adverse impact due to mining operations has occurred).

4.6 Outcomes of Analysis

Table 2 provides a summary of the analysis of MCO site aquatic macroinvertebrate indices.

As noted in **Section 4.3**, Site SH01 was relocated to the Goulburn River in Spring 2012. Notwithstanding, as the new site is located in the actual confluence pool of Bobadeen Creek/Goulburn River it is likely that the aquatic macroinvertebrate assemblage at this site would include a mix of Bobadeen and Goulburn River taxa. Accordingly, the seasonal statistics from

Spring 2011 onwards for site SH01G were tested against the original SH01B data.
The analysis provided in **Table 2** indicates:

- SIGNAL-2 and Salinity scores at downstream sites SH13, SH01 and SH02 indicate no adverse effects due to mining.
- Diversity and EPT Taxa scores that were “Under” at downstream sites generally occurred at the same time as “Under” results at upstream site SH05, which is unaffected by mine discharges. The Autumn 2017 monitoring data for Diversity and EPT Taxa shows that scores return to the pre-Autumn 2011 levels or better at all sites with the exception of SH01B.
- Whilst the SH01G site data Diversity scores followed a similar pattern to SHO2, the confounding effect of comparing the site diversity to that of the original Bobadeen Creek site cannot be totally discounted.

Table 2 Seasonal Operational Aquatic Macroinvertebrate Indices (post Autumn 2011) tested against pre-Spring 2011 Data

	Statistic	Mean	Standard Deviation	Spring 2011	Autumn 2012	Spring 2012	Autumn 2013	Spring 2013	Autumn 2014	Spring 2014	Autumn 2015	Spring 2015	Autumn 2016	Spring 2016	Autumn 2017
		Spring 2004 - Autumn 2011													
Upstream Site	**Goulburn River**	**SH05**	**SH05**	**SH05**	**SH05**	**SH05**	**SH05**	**SH05**	**SH05**	**SH05**	**SH05**	**SH05**	**SH05**	**SH05**	**SH05**
	Diversity	22.20	2.28	**OK**	Under	**OK**	**OK**	**OK**	Under	Under	Under	Under	Under	**OK**	**OK**
	SIG-2 Score:	3.43	0.37	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**
	EPT Taxa	3.60	1.34	**OK**	**OK**	**OK**	**OK**	**OK**	Under	Under	**OK**	Under	**OK**	**OK**	**OK**
	Salinity Score	5.02	0.50	**OK**	Under	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	Under	**OK**	**OK**	**OK**
Downstream Sites	**Goulburn River**	**SH13**	**SH13**	**SH13**	**SH13**	**SH13**	**SH13**	**SH13**	**SH13**	**SH13**	**SH13**	**SH13**	**SH13**	**SH13**	**SH13**
	Diversity	24.78	4.21	**OK**	Under	**OK**	**OK**	**OK**	**OK**	**OK**	Under	Under	Under	Under	**OK**
	SIG-2 Score:	3.77	0.22	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**
	EPT Taxa	6.11	1.62	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**
	Salinity Score	5.37	0.21	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**
	Bobadeen Creek	**SH01B**	**SH01B**	**SH01B**	**SH01B**										**SH01B**
	Diversity	26.33	2.18	**OK**	Under										Under
	SIG-2 Score:	3.69	0.17	**OK**	**OK**										**OK**
	EPT Taxa	6.00	1.12	**OK**	**OK**										**OK**
	Salinity Score	5.28	0.33	**OK**	**OK**										**OK**
	Goulburn River	**SH01B**	**SH01B**			**SH01G**	**SH01G**	**SH01G**	**SH01G**	**SH01G**	**SH01G**	**SH01G**	**SH01G**	**SH01G**	**SH01G**
	Diversity	26.33	2.18			Under	**OK**	**OK**	Under	Under	Under	Under	Under	Under	Under
	SIG-2 Score:	3.69	0.17			**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**
	EPT Taxa	6.00	1.12			**OK**	**OK**	**OK**	**OK**	**OK**	Under	**OK**	Under	**OK**	**OK**
	Salinity Score	5.28	0.33			**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**
	Goulburn River	**SH02**	**SH02**	**SH02**	**SH02**	**SH02**	**SH02**	**SH02**	**SH02**	**SH02**	**SH02**	**SH02**	**SH02**	**SH02**	**SH02**
	Diversity	29.89	6.05	**OK**	Under	Under	**OK**	**OK**	Under	Under	Under	Under	Under	Under	**OK**
	SIG-2 Score:	3.82	0.37	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**
	EPT Taxa	7.33	2.24	Under	Under	**OK**	**OK**	Under	Under	Under	Under	**OK**	Under	**OK**	**OK**
	Salinity Score	5.55	0.34	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**

4.7 Further Investigation of Diversity and EPT Taxa Scores

Based on the findings in **Table 2**, further investigation of consistently lower Diversity and EPT Taxa scores at downstream sites is provided below:

Site SH13:

- Diversity scores are "under" for the Autumn 2012 survey and from Autumn 2015 to Spring 2016.
- However, these results also occurred at upstream site SH05 (i.e. indicating these results may be due to factors other than mine discharges), with the exception of Spring 2016.
- It is noted that following the Spring 2016 survey, the diversity score returned to the pre-Spring 2011 levels.

Site SH01 (SH01B/SH01G):

- Diversity scores are "under" for the Autumn and Spring 2012 surveys and from Autumn 2014 to Autumn 2017.
- These results also occurred at upstream site SH05 (i.e. indicating these results may be due to factors other than mine discharges), with the exception of Spring 2012, Spring 2016 and Autumn 2017.
- For Spring 2012 and Autumn 2017, diversity scores were not "under" at SH13 (i.e. the monitoring location closer to the source of discharges from the UCM).
- EPT Taxa score was "under" for two surveys, and this result was not recorded at SH13 during the same survey periods.

Site SH02:

- Diversity scores are "under" for the Autumn and Spring 2012 surveys and from Autumn 2014 to Spring 2016.
- These results also occurred at upstream site SH05 (i.e. indicating these results may be due to factors other than mine discharges), with the exception of Spring 2012 and Spring 2016.
- For Spring 2012, the diversity score was not "under" at SH13 (i.e. the monitoring location closer to the source of discharges from the UCM).
- It is noted that following the Spring 2016 survey, the diversity score returned to the pre-Spring 2011 levels.
- EPT Taxa scores are "under" for Spring 2011, Autumn 2012, Spring 2013 to Autumn 2015 and Autumn 2016.

- EPT Taxa results were not “under” at sites SH13 or SH01 (with the exception of Autumn 2015 and Autumn 2016 at SH01) (i.e. monitoring locations closer to the source of discharges from the UCM).
- For Autumn 2014 and Spring 2014, EPT Taxa results were also “under” at upstream site SH05.

As noted in **Section 4.6**, the confounding effect of comparing the SH01G river site diversity to that of the original Bobadeen Creek site SH01B cannot be totally discounted, particularly given that the pre- 2011 Bobadeen Creek diversity only varied by ± 2 taxa per season, whereas river diversity as measured at site SH02 varied by ± 6 taxa per season.

In addition to the above, it is likely that some differences in diversity and EPT Taxa scores are associated with differences in the sorting and identification of macroinvertebrate taxa for the two periods rather than a ‘real’ diversity reduction so quickly after the survey methodology changed in Spring 2011. This likely effect was noted in the SWMP.

4.8 Conclusions

It is concluded that for the purposes of comparing the seasonal post-Autumn 2011 site statistics against the pre-Autumn 2011 value for each Stream-health statistic, using the common 75 taxa set of data (**Table 2**), provides a good indication of change over time, and on this basis the following conclusions may be made:

- Aquatic ecology monitoring data indicates discharges from UMC during 2011 to 2017 have not resulted in an adverse impact to aquatic macroinvertebrate SIGNAL or Salinity Index sensitivity downstream, and generally indicate no adverse impact to EPT Taxa scores at the site immediately downstream of the UMC discharge.
- While there appears to have been an overall decrease in individual site Diversity and EPT Taxa scores over time, the diversity differences between the Spring 04 to Spring 11 data set and the Autumn 11 to Spring 16 data set are methodological rather than operational.
- This conclusion was confirmed when total and EPT Taxa diversities increased back to pre-Autumn 2011 values in Autumn 2017 - where sampling, sorting and taxa identification protocols of the pre-Autumn 2011 studies were used. This indicates that the observed Diversity differences are based on sampling methodology rather than any impact from discharges.

5. IMPACT ASSESSMENT

MCO is seeking approval for an increase in the volume of water permitted to be released from EPL ID1 into the Goulburn River from 10 ML/day to 20 ML/day at the existing concentration limits set out in the EPL 12932.

The proposal would involve the relocation of the existing discharge point on Bora Creek (EPL ID1) to the Goulburn River Diversion in order to mitigate scour potential. EPL ID2 and EPL ID28 would not change location, release rate or quality.

The Modification would also involve the construction and operation of a new Water Treatment Plant and associated water storage dam(s), which would be constructed adjacent to the rail loop area.

The following potential impacts to aquatic ecology which are relevant to the proposed increase in discharges have been considered:

- Potential physical impacts of discharge at the discharge point.
- Potential impacts of increased flows downstream of the discharge point.
- Potential impacts of altered water quality downstream of the discharge point, including potential increased pollutant loads.
- Potential impact to threatened species.

5.1 Potential Physical Impacts of Discharge at the Discharge Point

The relocated discharge location would reduce the physical impact of discharge (when compared to the approved discharge point EPL ID1) by avoiding the length of Bora Creek.

There is evidence of existing physical impact of rainwater discharges from Bora Creek to the Goulburn River Diversion Channel. Bora Creek is isolated from the Goulburn River Diversion channel by the vertical edge of the diversion. A plunge pool has developed at the base of the diversion wall where Bora Creek discharges, and has subsequently in-filled and overgrown with reeds over subsequent low rainfall periods. The net result of this plunge pool formation and in-filling is that there is a build-up of sediment alongside the eastern bank of the diversion channel that extends approximately 45 metres (m) downstream.

In order to not exacerbate the existing effects of Bora Creek rainwater discharge on the Goulburn River Diversion, the proposed piped discharge would be fitted with a flat spreader/diffuser structure to spread the discharge over the width of the Bora Creek outfall platform so as to prevent further development of a discharge plunge pool in the Goulburn River Diversion Channel.

5.2 Potential Impacts of Increased River Flow

Advisian (2017) has modelled the impacts of the proposed discharge from the MCC on Goulburn River water levels and flow rates and concluded:

- During low river flow conditions, when the MCO proposed discharge would constitute the majority of flow in the Goulburn River, increased flow rates due to discharge are not predicted to result in channel erosion or scour.
- Similarly, during high flow conditions (i.e. 16 ML/day at the confluence with Bora Creek and 30 ML/day downstream of Ulan Creek), the changes in maximum depth and average velocity are not expected to result in any increase in erosion of the Goulburn River.

Modelling undertaken by Advisian (2017) indicates the key potential change associated with the proposed discharges is decreases in low to very low flow periods.

These low to very low flow periods generally result in adverse water quality conditions in the Goulburn River during prolonged drought periods, due to the increased relative contribution of groundwater base-flow from Moolarben Creek, which has high salinity, and the development of shallow and isolated stagnating ponded water with consequent evapo-concentration effects (low dissolved oxygen concentrations, elevated dissolved metal and nutrient concentrations) which are all detrimental for aquatic macroinvertebrate and fish assemblages.

The analysis of existing aquatic ecology data presented in **Section 4** indicates that historic discharges from the UMC, which have reduced low and no-flows in the Goulburn River, have not resulted in adverse impacts to aquatic ecology in the Goulburn River.

Accordingly, the loss of prolonged periods of low flow is considered a beneficial impact that offsets the loss of low-flow variation. As a result, the changes to the low flow regime are considered neutral on balance to aquatic ecology in the Goulburn River.

The Modification would have a minor effect on the Goulburn River's response to storm events (i.e. the contribution of up to 20 ML/d from the MCC would be minor in comparison to total Goulburn River flows during storm events), and this is considered negligible in terms of overall aquatic ecology of the upper Goulburn River.

5.3 Potential Impacts Due to Changes in Water Quality

Analysis undertaken by Advisian (2017) indicates that downstream water quality would continue to comply with the water quality adopted trigger levels specified in the MCC Water Management Plan for pH, EC and turbidity, including under a 'Low flow' scenario where 20 ML/day discharge constitutes the majority of total flow.

The water discharged from the relocated discharge point would be treated, as required, to meet EPL concentration limits. The water treatment process would have the effect of removing any elevated concentrations of metals in the water to be discharged. It is understood that design specification for the water treatment process would be for concentrations of key metals in the treated water to be below ANZECC trigger levels (i.e. 95% species protection trigger levels, or site-specific trigger levels based on 80th percentile concentrations, where baseline conditions exceed 95% species protection trigger levels) (ANZECC/ARMCANZ 2000).

Advisian (2017) has considered the Geochemistry Review (RGS Environmental 2017) prepared for the Modification, existing water quality data in the Goulburn River and the expected quality of water to be discharged, and concludes that metal concentrations in the Goulburn River are likely to remain below ANCECC trigger levels (i.e. 95% species protection trigger levels, or site-specific trigger levels based on 80th percentile concentrations [ANZECC/ARMCANZ 2000]) given metal concentrations would be controlled at the point of discharge via the water treatment process.

Relocating the primary discharge point from Bora Creek to the Goulburn River Diversion would avoid the potential for increased erosion along Bora Creek. In addition, the Water Treatment Plant would reduce TSS from the discharge water (as evidenced by low TSS levels downstream of the UCM discharges). On this basis, Advisian (2017) considers the discharges are likely to reduce TSS in the Goulburn River (when compared to the approved EPL ID1 discharge location).

The analysis of existing aquatic ecology data presented in **Section 4** indicates previous discharges from UMC (at concentration limits similar to those for the proposed discharges) have not resulted in adverse impacts to aquatic ecology in the Goulburn River, as supported by no observed decrease in pollution tolerance scores (SIGNAL and Salinity Index).

On the basis of the review of existing discharge effects (**Section 4**) and Advisian's water quality findings, it is concluded the proposed discharges at 20 ML/day would have negligible impacts on the aquatic ecology of the Goulburn River. That is, the monitoring indices for the aquatic ecology of downstream monitoring sites (e.g. SH02) are expected to continue to meet the baseline trigger values established from sampling undertaken prior to Autumn 2011.

Further downstream, including within the Goulburn River National Park, potential impacts would be lower than those at SH02, as the proportion of the proposed discharges to total flow would reduce as the catchment of the Goulburn River increases and other tributaries contribute to total flow.

5.4 Threatened Species

As described in **Section 3.3**, there are no EPBC Act or FM Act listed aquatic species or endangered populations or communities found in the upper Goulburn River upstream of the Goulburn River National Park and none are reported, known or expected from Goulburn River National Park downstream to the Wollar Creek confluence.

The closest threatened species to the MCC are identified as (**Section 3.3**):

- Darling River Hardyhead, not known or expected above Munmurra River (**Figure 4**).
- Purpose Spotted Gudgeon, not known or expected above Baerami (i.e. downstream of the Widden Creek confluence) (**Figure 4**).

The following KTPs listed under the FM Act have been considered for the section of the Goulburn River downstream of the Wollar Creek confluence:

- KTP 1 – Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams.
- KTP 2 – Degradation of native riparian vegetation along NSW water courses if alterations to natural flows results in bank instability and, as a consequence, loss of riparian vegetation.

5.4.1 KTP 1 - Alteration of Natural Flow Regimes of Rivers and Streams

An analysis of potential impacts to the flow regime of the Goulburn River (at SH02) is presented in Advisian (2017) and summarised in **Section 5.1**.

Advisian (2017) has also assessed the potential change in stream flow downstream of the SH02 based on stream flow gauge data at the closest downstream station at Coggan. Advisian (2017) indicates the contribution of the Modification to changes in flow at Coggan is unlikely to be significant.

Therefore, the proposed increase in discharges is unlikely to be of any significance to the aquatic ecology in the range of closest threatened species habitat (downstream of the Munmurra River), except during severe and prolonged drought periods when the discharges would likely be beneficial.

5.4.2 KTP 2 – Riparian Vegetation

Advisian (2017) describes that the discharge location at the Goulburn River Diversion is a stable and well vegetated channel, and a discharge of 20 ML/day is well within the carrying capacity of the Diversion and is not expected to have a significant effect on water levels or velocities during high flow events (**Section 5.2**).

Downstream of the Goulburn River Diversion (i.e. some 2.5 km downstream of the relocated discharge point), the proportion of the proposed discharges to total flows decreases due to the contribution of other tributaries (e.g. Ulan Creek) and the increasing catchment of the Goulburn River.

During low flows, when the proportion of the proposed discharges to total flow is greatest, the 20 ML/day release would increase depth of river by 0.05 m (and 0.02 m when compared to approved 10 ML/day releases) at the Goulburn River National Park (SH02), and average velocity would increase by 0.3 metres per second (m/s) (and <0.1 m/s compared to 10 ML/day release) (Advisian 2017).

The minor changes in river conditions are not predicted to result in any significant additional scour. In addition, the predicted total velocity and river height inclusive of the 20 ML/day release during low flows is within existing velocity and river height levels for high flow (Advisian 2017).

Based on the above, the Modification is not expected to adversely impact on channel stability at SH02, or downstream. On this basis, impacts to native riparian vegetation due to bank instability would be negligible.

6. MANAGEMENT, MITIGATION AND MONITORING

The following management, mitigation and monitoring measures are recommended for the Modification:

- Construction impacts on existing aquatic ecosystems are to be managed by siting all infrastructure within existing/approved disturbance areas (e.g. storage dams and Water Treatment Plant located adjacent to the existing rail loop) and the implementation of appropriate erosion and sediment controls in the approved Water Management Plan.
- Minimisation of potential physical impacts of Water Treatment Plant Discharge on the Goulburn River Diversion through utilisation of a flat spreader/diffuser structure.
- Continued monitoring and implementation of trigger action response plans (as defined in the Water Management Plan) in the event that monitoring indicates an exceedance of downstream water quality trigger levels.
- Continued seasonal aquatic ecology monitoring and implementation of trigger action response plans (as defined in the Water Management Plan) in the event that monitoring indicates a reduction in any of the following aquatic ecology criteria:
    - Diversity;
    - SIGNAL-2 Score;
    - EPT Taxa; and
    - Salinity Score.
- The Water Management Plan should be reviewed and updated as follows:
    - Review of the trigger levels in the SWMP to reflect the latest available data and analysis.
    - Update the trigger action response plans in the SWMP to include the Salinity and EPT Taxa indices described in **Section 4** of this report.
    - Update the stream-health monitoring methodology to incorporate consideration of monthly water quality data, daily stream-flow and rainfall data in the interpretation of stream-health monitoring results.

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ANNEXURE A

Indicative Distribution in
Hunter River Region NSW

Darling River Hardyhead

(*Craterocephalus amniculus*)

Indicative Distribution

Distribution based on survey records, predicted occurrence (MaxEnt 3.3.3) and expert opinion. Output restricted to named streams with a modelled average daily flow of more than 5 megalitres. 2015.

0 10 20 30 40

Kilometres

 Fish illustration: Jill Ruse.

NSW GOVERNMENT Department of Primary Industries

Indicative Distribution in NSW

Purple Spotted Gudgeon

(*Mogurnda adspersa*)

Indicative Distribution

Distribution based on survey records, predicted occurrence (MaxEnt 3.3.3) and expert opinion. 2015.

0 50 100 150 200

Kilometres

 Fish photo: Gunther Schmida.

NSW GOVERNMENT Department of Primary Industries

ANNEXURE B

ANNEXURE B - SUMMARY STATISTICAL DATA FOR GOULBURN RIVER SITES SHO5, SH13, SHO1 AND SHO2 Spring 2004 TO Autumn 2017

SEASON	Sp04	Au05	Sp05	Sp08	Au09	Sp09	Au10	Sp10	Au11	Sp11	Au12	Sp12	Au13	Sp13	Au14	Sp14	Au15	Sp15	Au16	Sp16	Au17
Site					SH05	SH05	SH05	SH05	SH05	SH05	SH05	SH05	SH05	SH05	SH05	SH05	SH05	SH05	SH05	SH05	SH05
Diversity					22	20	22	26	21	13	24	28	27	22	19	15	13	18	7	20	24
SIG-2					3.00	3.63	3.05	3.75	3.71	3.54	3.39	4.14	3.70	3.59	3.89	3.80	3.58	3.82	3.33	3.78	4.41
EPT Taxa					2	3	3	5	5	3	4	6	5	5	3	2	2	4	2	5	8
Salinity					4.27	4.80	5.14	5.42	5.47	5.67	4.00	5.42	4.89	4.89	4.77	4.86	5.88	6.21	4.40	5.53	5.56
Site	SH13	SH13	SH13	SH13	SH13	SH13	SH13	SH13	SH13	SH13	SH13	SH13	SH13	SH13	SH13	SH13	SH13	SH13	SH13	SH13	SH13
Diversity	25	22	26	17	22	26	32	25	28	19	21	20	26	22	23	25	15	13	11	11	23
SIG-2	3.71	3.33	3.88	3.65	3.90	3.62	3.87	3.84	4.11	3.84	4.48	4.25	4.85	4.27	4.65	4.52	4.57	5.00	5.60	4.80	4.29
EPT Taxa	5	4	6	5	7	5	8	6	9	6	8	8	10	8	8	8	5	6	5	5	7
Salinity	5.18	5.53	5.20	5.20	5.47	5.20	5.35	5.37	5.81	5.50	6.47	6.06	6.37	6.53	6.13	6.24	5.70	6.67	6.88	8.00	5.81
Site	SH01B	SH01B	SH01B	SH01B	SH01B	SH01B	SH01B	SH01B	SH01B	SH01B	SH01B										SH01B
Diversity	28	26	24	26	24	25	27	31	26	17	14										22
SIG-2	3.70	3.54	3.75	3.69	3.61	4.04	3.63	3.81	3.46	3.65	3.92										4.33
EPT Taxa	6	5	5	7	6	7	7	7	4	5	6										7
Salinity	5.38	6.00	5.18	4.94	4.88	5.44	5.17	5.35	5.16	5.50	6.00										5.81
Site												SH01G	SH01G	SH01G	SH01G	SH01G	SH01G	SH01G	SH01G	SH01G	SH01G
Diversity												27	31	24	16	21	9	10	9	13	27
SIG-2												4.63	4.48	4.50	4.13	3.95	4.63	4.33	4.50	4.50	4.62
EPT Taxa												9	8	9	6	6	4	5	4	5	9
Salinity												5.89	5.78	5.94	5.92	5.75	6.83	8.13	5.86	6.78	6.44
Site	SH02	SH02	SH02	SH02	SH02	SH02	SH02	SH02	SH02	SH02	SH02	SH02	SH02	SH02	SH02	SH02	SH02	SH02	SH02	SH02	SH02
Diversity	28	16	30	29	34	29	37	35	31	14	12	24	27	24	21	19	12	11	17	15	25
SIG-2	3.96	3.00	3.75	4.32	3.88	3.90	3.58	4.03	3.94	3.93	4.36	4.33	4.26	4.38	4.33	4.26	5.55	4.40	4.38	4.57	4.46
EPT Taxa	8	3	6	9	9	6	6	9	10	4	4	8	8	7	5	4	5	5	6	5	8
Salinity	5.95	6.10	5.41	5.81	5.36	5.41	5.04	5.37	5.52	5.92	7.22	6.22	5.62	5.86	5.75	5.44	6.57	7.14	6.62	6.82	5.24

ANNEXURE C

Annexure C Macroinvertebrate Taxa common to both pre and post Au 11 surveys						
Order	**Sub-Order**	**Family**	**Sub-Family**	**Common Name**	**No of Occurrences**	
					MPR	**ELA**
Coleoptera		Dytiscidae		Diving Beetles	88	106
Coleoptera		Elmidae		Riffle Beetles	7	8
Coleoptera		Gyrinidae		Whirligig Beetles	33	25
Coleoptera		Haliplidae		Crawling Water Beetles	20	20
Coleoptera		Hydraenidae		Minute Rove Beetles	29	26
Coleoptera		Hydrochidae		Scavenger Water Beetles	10	11
Coleoptera		Hydrophilidae		Scavenger Water Beetles	60	49
Coleoptera		Scirtidae		Marsh Beetles	42	38
Diptera		Ceratopogonidae		Biting Midges	45	60
Diptera		Chaoboridae		Phantom Midges	2	3
Diptera		Chironomidae	Chironominae	Bloodworms	88	110
Diptera		Chironomidae	Orthocladiinae	Bloodworms	33	39
Diptera		Chironomidae	Tanypodinae	Bloodworms	65	66
Diptera		Culicidae		Mosquitoes	26	19
Diptera		Dixidae		Meniscus Midges	12	14
Diptera		Ephydridae		Fly Larva	1	2
Diptera		Muscidae?		Muscids	3	0
Diptera		Psychodidae		Moth Flies	1	2
Diptera		Sciomyzidae			1	2
Diptera		Simuliidae		Black Flies	33	32
Diptera		Stratiomyidae		Soldier Flies	6	12
Diptera		Tabanidae		March Flies	6	10
Diptera		Tipulidae		Crane Flies	9	21
Ephemoptera		Baetidae		Mayflies	79	86
Ephemoptera		Caenidae		Mayflies	46	38
Ephemoptera		Leptophlebiidae		Mayflies	58	61
Hemiptera		Corixidae		Lesser Water Boatmen	73	77
Hemiptera		Gelastocoridae		Toad Bugs	0	3
Hemiptera		Gerridae		Water Striders	19	7
Hemiptera		Hydrometridae		Water Measurers	10	12
Hemiptera		Naucoridae		Creeping Water Bugs	4	4
Hemiptera		Nepidae		Water Scorpions/ Needle Bugs	10	4
Hemiptera		Notonectidae		Backswimmers	66	55
Hemiptera		Pleidae		Pygmy Backswimmers	2	4
Hemiptera		Veliidae		Small Water Striders	29	21
Odonata		Aeshnidae		Dragonflies	42	51
Odonata		Gomphidae		Dragonflies	43	41
Odonata		Hemicorduliidae		Dragonflies	55	68
Odonata		Libellulidae		Dragonflies	37	40
Odonata		Synthemistidae		Dragonflies	3	4

Annexure C Macroinvertebrate Taxa common to both pre and post Au 11 surveys (continued)						
Order	**Sub-Order**	**Family**	**Sub-Family**	**Common Name**	**No of Occurrences**	
					MPR	**ELA**
Odonata		Telephlebiidae		Dragonflies	14	19
Odonata		Coenagrionidae		Damselflies	55	83
Odonata		Lestidae		Damselflies	21	6
Odonata		Megapodagrionidae		Damselflies	12	16
Odonata		Protoneuridae		Damselflies	2	3
Odonata		Synlestidae		Damselflies	2	7
Plecoptera		Gripopterygidae		Stone Flies	10	12
Tricoptera		Calamoceratidae		Caddis Flies	35	32
Tricoptera		Ecnomidae		Caddis Flies	16	21
Tricoptera		Hydrobiosidae		Caddis Flies	9	13
Tricoptera		Hydropsychidae		Caddis Flies	20	16
Tricoptera		Hydroptilidae		Caddis Flies	51	55
Tricoptera		Leptoceridae		Caddis Flies	68	52
Tricoptera		Philopotamidae			3	4
Tricoptera		Philorheithridae		Caddis Flies	9	14
Trichoptera		Polycentropodidae			3	12
Arachnida	Hydracarina			Freshwater Mites	44	29
Collembola				Springtails	10	15
Crustacea	Cladocera			Water Fleas	23	17
Crustacea		Centropagidae		Copepods	10	12
Crustacea		Cyclopidae		Copepods	40	52
Crustacea		Atyidae		Freshwater Shrimp	52	62
Crustacea		Palaemonidae		Freshwater Prawns	3	10
Crustacea		Parastacidae		Yabbies	5	8
Hirudinea		Erpobdellidae		Leeches	3	3
Hirudinea		Glossiphoniidae		Leeches	14	8
Hirudinea		Richardsoniadidae		Leeches	4	10
Oligochaeta				Freshwater Worms	67	63
Bivalvia		Sphaeriidae		Pea Shells	35	31
Gastropoda		Ancylidae		Freshwater Limpets	9	10
Gastropoda		Lymnaeidae		Freshwater Snails	20	28
Gastropoda		Physidae		Freshwater Snails	77	78
Gastropoda		Planorbidae		Freshwater Snails	14	9
Nematoda				Round Worms	4	5
Turbellaria		Dugesiidae		Flatworms	41	43