APPENDIX K
Aquatic ecology

Evolution MINING

EMM creating opportunities

austral

research and consulting

CGO Open Pit Continuation Project: Aquatic Ecology Assessment

- Aquatic Ecology Assessment
- May 2023

a u s t r a l

research and consulting

CGO Open Pit Continuation Project: Aquatic Ecology Assessment

Austral Research and Consulting
ABN 73 007 840 779
23 Buntings Rd
Kirkstall Vic 3283 Australia
Web: www.austral.net.au

a u s t r a l

research and consulting

Document history and status

Revision	Date issued	Reviewed by	Approved by	Date approved	Revision type
Draft_V1	13/4/23	T. Robertson	T. Robertson	13/3/23	Draft
Draft_V2	14/4/23	D. Iervasi	D. Iervasi	17/4/23	Draft_revisions
Draft_V3	174/23	T. Robertson	T. Robertson	17/4/23	Draft_revisions
Draft_V4	18/4/23	D. Iervasi	D. Iervasi	18/4/23	Draft_revisions
Draft_V4	19/4/23	P.Freeman	P.Freeman	19/4/23	Draft_revisions
Final	26/04/2023	T. Robertson	T. Robertson	26/04/2023	Final
Final_V2	26/05/2023	T. Robertson	T. Robertson	26/05/2023	Final

Printed:	26 May 2023
Last saved:	26 May 2023 03:11 PM
File name:	
Author:	Thorin Robertson and Dion Iervasi
Project manager:	Dion Iervasi
Name of organisation:	EMM Consulting Pty Limited
Name of project:	CGO Open Cut Expansion: Aquatic Ecology Assessment
Name of document:	CGO Open Cut Expansion: Aquatic Ecology Assessment
Document version:	Final
Project number:	

Executive Summary

This Executive Summary summarises the results of all aquatic investigations undertaken in support of the proposed Cowal Gold Operations (CGO) Open Pit Continuation Project (the Project). The results of all investigations were used to identify and document potential impacts to aquatic values known to occur within the footprint of the proposed Project and includes Lake Cowal and the surrounding waterways.

A desktop assessment and comprehensive literature review was undertaken in late 2022 and early 2023 to identify potential listed species and associated habitat, and threatened ecological communities (TECs), and groundwater dependant ecosystems (GDEs) that may be impacted by the project. The results of the desktop assessment indicated that one TEC listed as Endangered under the Fisheries Management Act “the Lowland Lachlan River endangered ecological community (EEC)” occurs within, and around the Project footprint and has the potential to be impacted by the Project.

The results of the desktop assessment and literature review indicate that 10 threatened aquatic species or species comprising a threatened population, listed under the FM Act and/or the Environment Protection and Biodiversity Conservation (EPBC) Act, and the Platypus have the potential to occur in waterways associated with the Lachlan River catchment. Further review and assessment indicates that three fish species have the potential to occur within, immediately upstream, or downstream of Lake Cowal, and therefore have the potential to be impacted by the Project: Western population of Olive Perchlet (*Ambassis agassizii*), Southern Purple spotted Gudgeon (*Mogurnda adspersa*) and Flathead Galaxias (*Galaxias rostratus*).

Aquatic surveys were undertaken at a total of eight sites in November 2020. The study area included tributaries within Lake Cowal and Bland Creek within, upstream and downstream of the disturbance area.

Surveys included an assessment of Key Fish Habitat (KFH), water and sediment quality, aquatic flora (including algae), macroinvertebrates and aquatic vertebrates. Survey methods involved direct observation of KFH, laboratory analysis of water, sediments and algae, high level macroinvertebrate analysis, eDNA analysis of fish and electrofishing and netting for aquatic vertebrates.

A total of eight sites were assessed for KFH during the November 2020 aquatic surveys. All sites were classified as Type 1 highly sensitive key fish habitat and Class 1 major key fish habitat. Type 1 highly sensitive key fish habitat classifications for all sites were assigned due to the sites containing in-stream snags or native aquatic plants, and the potential for the waterway to provide habitat for threatened aquatic species.

Water quality analysis was undertaken at eight sites during the November 2020 surveys. A total of three sites were above the upper limit of the ANZECC and ARMCANZ (2000) guideline trigger for pH, all recorded in Lake Cowal. Electrical conductivity (EC) exceeded the ANZECC and ARMCANZ (2000) trigger values of 30 µS/cm at all sites. Concentrations of major ions were variable both within and between waterways. Dissolved Oxygen concentrations were well below the ANZECC & ARMCANZ lower trigger value of 90 percent across all sites. Turbidity exceeded the ANZECC & ARMCANZ maximum trigger value of 20 NTU at five sites within Lake Cowal. Turbidity levels in Bland Creek were recorded to be

well within the ANZECC & ARMCANZ guidelines. Nitrogen was recorded to be higher in Lake Cowal than Bland Creek, all sites were well within ANZECC & ARMCANZ guidelines. Concentrations of total phosphorus across all sites were within ANZECC & ARMCANZ guidelines. Concentrations of dissolved metals and trace elements were generally either below the analytical limit of reporting or within ANZECC & ARMCANZ guideline trigger values with the exception of copper.

Sediment quality analysis was undertaken at eight sites during the November 2020 surveys. Sediment pH was also comparable to surface water pH. Sediment salinity was considered high and the concentration of nitrogen and phosphorous was highest within Lake Cowal. The concentration of metals was variable across sites during the November 2020 field survey; however, six parameters were below the limit of analytical reporting at all sites. All metals that had an ANZECC and ARMCANZ (2000) ISQG trigger value were within their respective trigger value across all sites.

Phytoplankton and periphyton was assessed at eight sites. Taxa that have the potential to be toxic and/or bloom-forming and were recorded across all sites.

A total of four macrophytes from four families were recorded at six sites during the November 2020 survey. No macrophytes were recorded from Bland Creek.

A total of 80 taxa were identified from the aquatic invertebrate assemblage in the surface water at eight sites during the November 2020 field survey with diversity varying between sites.

Three aquatic vertebrate fauna taxa (three fish species) were recorded during the November 2020 field survey, including representatives from three families. Of the three fish taxa, two were exotic species; the Common Carp (*Cyprinus carpio*) and the Eastern Gambusia (*Gambusia holbrooki*). The third and only native species was Carp Gudgeon (*Hypseleotris* sp.) which comprises part of the fish assemblage that forms the Lowland Lachlan River EEC (Endangered under the FM Act). Given the lack of aquatic vertebrate fauna detected during the surveys the EIS draws on previous fish monitoring commissioned by Evolution.

A range of existing impacts to aquatic values are present in the Project area. These primarily include agricultural impacts, exotic species and stock access. A range of potential impacts were identified as part of this study and include loss of KFH associated with the Project, potential impacts to water quality resulting from the construction of the Lake Protection Bund (LPB) and the use of primary waste rock in the construction of the LPB. Minor impacts to geomorphic stability are likely within the mine foot print and minor impacts to the hydrology of Lake Cowal have been predicted. Impacts to GDEs are considered unlikely. There are potential impacts to water quality, aquatic fauna and the Lowland Lachlan River EEC. All impacts are considered minimal assuming management plans and mitigation measures are in place.

An indicative offsets approach has been proposed to offset the loss of KFH within Lake Cowal and detailed plans for a significant rehabilitation strategy for the Lake Foreshore have been prepared.

In summation, it is considered unlikely the Project poses a significant risk to aquatic values within Lake Cowal assuming all management plans and mitigation measures are in place.

Contents

1. Introduction 17

1.1. The Project 17

1.1.1. Background 17

1.1.2. Project Overview 17

1.2. Purpose of This Report 21

1.2.1. Assessment Guidelines and requirements 21

1.2.2. Other Relevant Reports 24

2. Legislative context 26

2.1. Fisheries Management Act 1994 26

2.2. Water Management Act 2000 27

2.3. Environmental Protection and Biodiversity Conservation Act 1999 27

3. Methods 30

3.1. Desktop Assessment 30

3.1.1. Database Searches 30

3.1.2. Literature Review 31

3.1.3. Likelihood of Occurrence Assessment 32

3.2. Field Survey Design 32

3.2.1. Key Fish Habitat 37

3.2.2. Water Quality 38

3.2.3. Sediment Quality 39

3.2.4. Algae and Macrophytes 40

I. Phytoplankton 40

II. Periphyton 40

III. Macrophytes 41

3.2.5. Aquatic Invertebrates 41

3.2.6. Aquatic vertebrates 41

3.3. Risk Assessment 43

3.4. Limitations 45

4. Results 47

4.1. Desktop Assessment Results 47

4.1.1. Biogeographical Context 47

4.1.2. Land Use 47

4.1.3. Climate 47

4.1.4. Geology and Topography 51

4.1.5. Catchment and Hydrology 53

4.1.6. Aquatic Habitats 56

4.1.6.1. Threatened communities and habitats 57

4.1.6.2. Key fish habitat 60

4.1.7. Water and Sediment Quality 63

4.1.8. Aquatic Flora 63
4.1.9. Aquatic Fauna 64
4.1.10. Threatened Aquatic Fauna 65
I. Western population of Olive Perchlet 69
II. Flathead Galaxias 69
III. Southern Purple-spotted Gudgeon 70
4.1.11. Groundwater Dependent Ecosystems 70

5. Field Survey Results 71

5.1. Key Fish Habitat and Habitat Characterisation 71

5.2. Water Quality 74

5.3. Sediment Quality 79

5.4. Algae and Macrophytes 82

5.4.1. Phytoplankton 82
5.4.2. Macrophytes 87

5.5. Aquatic Invertebrates 89

5.6. Aquatic Vertebrates 94

6. Ecological values 96

6.1. Aquatic Ecology 96

6.2. Environmental Receptors 97

7. Construction and Expansion Impacts 99

7.1. Lake Protection Bund (LPB) Construction 99

7.1.1. Existing Water Management and Lake Isolation System 99
7.1.2. Temporary Isolation Bund 99
7.1.3. Lake Protection Bund 100
7.1.4. Use of Primary Waste Rock in LPB 102
7.1.5. Chemicals and Fuel Spills 105
7.1.6. Water Quality 105
7.1.6.1. Historical Water Quality 105
7.1.7. Loss of KFH due to Expansion and New Bund Construction 111
7.1.8. Assessment of Geomorphic Stability of areas of KFH within the Development 114
7.1.9. Impacts to Hydrology 115
7.1.10. Impacts to GDEs 117
7.1.11. Fauna Passage During Bund Construction 118
7.1.12. Dewatering Impacts 118

8. Operation Impacts 120

9. Cumulative Impacts 121

10. Impact Assessment 122

10.1. Impacts to Aquatic Ecology 122

10.2. Risk Assessment for the Project 122

10.2.1. Direct 128

10.2.2. Indirect 129
10.3. Threatened Habitats, Ecological Communities, Species and Populations 129
10.3.1. FM Act 130
10.3.2. EPBC Act 132
11. Rehabilitation Strategy 134
12. Aquatic Offsets 136
13. Summary and Recommendations 137
13.1. Summary 137
13.2. Dewatering Management 138
13.3. Mitigation Measures 138
14. References 139
15. Appendix A – Database Search Summary 147
16. Appendix B - Literature Review Summary 149
17. Appendix C - Likelihood of Occurrence 159
18. Appendix D - Site Photographs, November 2020 165
19. Appendix E - DPI Fisheries Key Fish Habitat Assessment Proforma 170
20. Appendix F - In Situ Water Quality, November 2020 175
21. Appendix G - Electrofisher Settings, November 2020 177
22. Appendix H - FM Act Significant Impact Assessments 179
23. Appendix I - EPBC Act Significant Impact Assessments 195

Abbreviations

The following abbreviations have been used:

ANZG	the Australian and New Zealand Guidelines for Fresh & Marine Water Quality
Austral	Austral Research and Consulting
BC	Biodiversity Conservation
BC	Bland Creek
CE	Critically Endangered
CGO	Cowal Gold Operations
CEMP	Construction environment management plan
DA	Development Application
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DGV	Default guideline values
DMP	De-watering management plan
DO	Dissolved Oxygen
DPI	Department of Primary Industries
DPIE	Department of Planning, Industry and Environment, now Department of Planning and Environment
eDNA	Environmental deoxyribonucleic acid
E	Endangered
EC	Electrical conductivity
EEC	Endangered Ecological Community
EIS	Environmental Impact Statement
EP	Endangered population
EP&A	Environmental Planning and Assessment
EPBC	Environment Protection and Biodiversity Conservation
Evolution	Evolution Mining (Cowal) Pty Limited
FM	Fisheries Management

GL	Gigalitres
ha	Hectares
Hz	Hertz
ICDS	internal catchment drainage system
IBRA	Interim Biogeographic Regionalisation for Australia
IWL	Integrated waste landform
KFH	Key fish habitat
km	Kilometres
LC	Lake Cowal
LGO	low grade ore
LPB	Lake protection bund
LWD	Large Woody Debris
m	Metre
mg	Milligrams
mg/L	Milligrams per Litre
mL	Millilitres
mm	Millimetres
MNES	Matters of National Environmental Significance
Mt	Megatonnes
NAF	non-acid forming
NAG	net acid generation
NAPP	net acid production potential
NSW	New South Wales
ntu	Nephelometric Turbidity Units
PL	Provisional Management List.
PMST	Protected Matters Search Tool
SEAR	Secretary's Environmental Assessment Requirements
sp.	Species
SSD	State significant development

TEC	Threatened Ecological Community
TIB	Temporary Isolation Bund
UCDS	up-catchment diversion system
WM	Water Management
WRE	Waste rock emplacement
µm	Micrometers
$\mu S.cm^{-1}$	Microsiemens per centimeter
^{o}C	Degrees Celsius

Figures

- Figure 1-1: Project regional overview (Source: EMM Consulting Pty Limited);
- Figure 1-2: Project infrastructure layout (Source: EMM Consulting Pty Limited);
- Figure 3-1: Location of aquatic ecology sites assessed during the November 2020 field survey (Source: EMM Consulting Pty Limited);
- Figure 3-2: Strahler Stream order relevant to the Project (Source: EMM Consulting Pty Limited);
- Figure 4-1: IBRA regions and subregions relative to the Project (Source: EMM Consulting Pty Limited);
- Figure 4-2: Monthly rainfall compared to long-term mean monthly rainfall and mean minimum and mean maximum temperature (mean = 1999-2022);
- Figure 4-3: Annual rainfall compared to long-term mean annual rainfall (1999-2022);
- Figure 4-4: Catchment and sub catchment, relevant to the Project (Source: EMM Consulting Pty Limited);
- Figure 4-5: Waterways (3rd order and above) relative to the Project (Source: EMM Consulting Pty Limited);
- Figure 4-6: Lowland Lachlan River EEC relative to the Project (Source: EMM Consulting Pty Limited);
- Figure 4-7: key fish habitat distribution relevant to the Project (Source: EMM Consulting Pty Limited);
- Figure 4-8 Waterways, wetlands, reservoirs and springs relative to the Project (Source: EMM Consulting Pty Limited);
- Figure 4-9: Potential distribution of the Western population of Olive Perchlet, Flathead Galaxias, and Southern Purple-spotted Gudgeon relative to the Project area (Source: EMM Consulting Pty Limited);
- Figure 5-1: Inundated terrestrial grasses with occasional Eleocharis sp. typical at sites within Lake Cowal during the November 2020 field survey;
- Figure 5-2: Dam at site LC01 containing no fish passage into or out of Lake Cowal;
- Figure 7-1: LPB (groyne) design ;

- Figure 7-2: NAPP versus NAG pH for primary waste rock and other selected samples
- Figure 7-3: Values of pH and Mo in primary waste rock leachate compared to the range in Lake Cowal water quality and water quality objectives ;
- Figure 7-4: Comparison of average total nitrogen concentrations (1991-1995 and 2010-2023) (- = default trigger values for SE Australia Freshwater Lakes and Reservoirs);
- Figure 7-5: Comparison of average total phosphorous concentrations (1991-1995 and 2010-2023) (- = default trigger values for SE Australia Freshwater Lakes and Reservoirs);
- Figure 7-6: Comparison of average pH readings (1991-1995 and 2010-2023) (- = upper trigger value for SE Australia Freshwater Lakes and Reservoirs);
- Figure 7-7: Comparison of average conductivity readings (1991-1995 and 2010-2023) (- = default trigger values for SE Australia Freshwater Lakes and Reservoirs);
- Figure 7-8: Comparison of average conductivity readings (1991-1995 and 2010-2023) (- = default trigger values for slightly disturbed ecosystems – lakes);
- Figure 7-9: Comparison of average total arsenic concentrations (1991-1995 and 2010-2023) (- = 99% protection levels for aquatic ecosystems);
- Figure 7-10: Comparison of average total cadmium concentrations (1991-1995 and 2010-2023) (- = 99% protection levels for aquatic ecosystems);
- Figure 7-11: Comparison of average total copper concentrations (1991-1995 and 2010-2023) (- = 99% protection levels for aquatic ecosystems);
- Figure 7-12: Comparison of average total lead concentrations (1991-1995 and 2010-2023) (- = 99% protection levels for aquatic ecosystems);
- Figure 7-13: Comparison of average total mercury concentrations (1991-1995 and 2010-2023) (- = 99% protection levels for aquatic ecosystems);
- Figure 7-14: Comparison of average total zinc concentrations (1991-1995 and 2010-2023) (- = 99% protection levels for aquatic ecosystems);
- Figure 7-15: KFH impacted by the project;
- Figure 7 16: Lake Cowal when dry
- Figure 7-17: Modelled Lake Cowal Peak Flood Levels ;
- Figure 7-18: Geomorphic features within the development .

Tables

- Table 1-1: Aquatic ecology and groundwater-dependent ecosystems matters raised in the SEARs and associated attachments;
- Table 3-1: Likelihood of occurrence criteria;
- Table 3-2: Location of, and components sampled at, each aquatic ecology site during the November 2020 field survey;
- Table 3-3: Waterway type definitions for habitat sensitivity;
- Table 3-4: Waterway class definitions for fish passage;
- Table 3-5: Water quality parameters analysed from surface water during the November 2020 field survey;
- Table 3-6: Sediment quality parameters analysed during the November 2020 field survey;
- Table 3-7: Consequence Criteria adopted for the Risk Assessment;
- Table 3-8: Likelihood descriptors adopted for the Risk Assessment;
- Table 3-9: Risk matrix adopted for the Risk assessment;
- Table 4-1 Water Quality for Lake Cowal as published by Evolution Mining (2022);
- Table 4-2: Threatened species with the potential to occur within, or downstream of, Lake Cowal;
- Table 5-1: Habitat characteristics at each aquatic ecology site assessed during the November 2020 field survey.;
- Table 5-2: Water quality parameters recorded during the November 2020 field survey;
- Table 5-3: Sediment quality parameters recorded during the November 2020 field survey;
- Table 5-4: Phytoplankton taxa recorded during the November 2020 field survey;
- Table 5-5: Macrophyte taxa recorded during the November 2020 field survey;
- Table 5-6: Aquatic invertebrate taxa recorded during the November 2020 field survey.;

- Table 5-7: Aquatic vertebrate species presence/absence recorded during the November 2020 field survey;
- Table 6-1: Pathway for impacts and Aquatic Receptors Impacted. Note Project stage O = operation, C = Construction;
- Table 1-1: Key fish habitat offset requirements;
- Table 10-1: Risk matrix adopted for the Risk assessment for Construction Impacts;
-
- Table 10-2: Consequence Criteria adopted for the Risk assessment for the Construction Impacts;
- Table 10-3: Risk assessment for the Project Impacts;
- Table A-15-1: BioNet database search results (Lachlan River catchment);
- Table A-15-2: PMST database search results.

1. Introduction

1.1. The Project

1.1.1. Background

Evolution Mining (Cowal) Pty Limited (Evolution) is the owner and operator of the Cowal Gold Operations (CGO), an existing open pit and underground gold mine approximately 38 kilometres (km) north-east of West Wyalong, in the central west region of New South Wales (NSW).

CGO is located on the traditional lands of the Wiradjuri People and is immediately adjacent to the western foreshore of Lake Cowal, which is an ephemeral waterbody. The existing CGO mine is shown at a regional scale in Figure 1-1.

CGO was first approved in 1999, and open pit mining operations commenced in 2005. Underground mining operations were approved in 2021 and development works to enable underground mining are underway.

This Aquatic Ecology assessment report forms part of the EIS. It documents the assessment methods, results and the initiatives built into the Project design to avoid and minimise aquatic impacts, and the additional mitigation and management measures proposed to address residual impacts which cannot be avoided.

1.1.2. Project Overview

Evolution is seeking approval for further open pit mining operations at CGO through the Open Pit Continuation Project (the Project). The Project primarily seeks to continue the open pit operations by approximately 10 years to 2036 and extend the total mine life by approximately two years to 2042.

This will involve further development of the existing E42 Pit and the development of open pit mining in three new and adjacent orebodies, known as the 'E46', 'GR' and 'E41' pits. It is noted that the three new and adjacent ore bodies are within the existing mining lease (ML 1535). No change to the approved ore processing rate of 9.8 Mt per annum is proposed.

Other than the changes to existing approved activities as set out above, all activities that are currently approved under the existing Ministerial development consents are intended to continue. The existing activities approved under the consents are described in Chapter 3 of the EIS.

A detailed description of the Project is contained in Chapter 4 of the EIS and a conceptual Project layout is shown in Figure 1-2. The project comprises the following key components:

- the continued operation of activities as approved under DA14/98 and SSD 10367;

- development of three new satellite open pits (the 'E46', 'GR' and 'E41' pits) to the north and south of the existing open pit, within the current approved mining lease;
- extending the existing E42 open pit to the east and south via a 'cutback' within the current approved mine lease;
- extending open pit mining operations by approximately 10 years to 2036 and total mine life by approximately 2 years to 2042;
- expansion of the integrated waste landform (IWL) to accommodate life of mine tailings;
- extension of the lake protection bund (LPB) system to provide continued separation and mutual protection between Lake Cowal and the mine;
- backfilling of one of the new satellite open pits (E46) with waste rock and establishment of a new waste rock emplacement on the backfilled pit to minimise the additional area required for waste rock disposal;
- expansion of the footprint of the existing waste rock emplacement (WRE) areas to accommodate additional waste rock;
- development of additional topsoil and subsoil stockpiles to accommodate materials from pre-stripping, with materials to be reused during progressive mine rehabilitation;
- upgrades to existing surface water drainage system, to assist with on-site water management (WM) and maximise on-site water conservation;
- modification of internal site access and haul roads;
- development of new water storages and relocation of some components of the surface water drainage system; and
- modification and relocation of some existing ancillary mining infrastructure.

The Project will not change existing ore processing rates or methods, tailings disposal methods, main site access, water supply sources or hours of operation. The Project will also retain the existing open pit mining workforce.

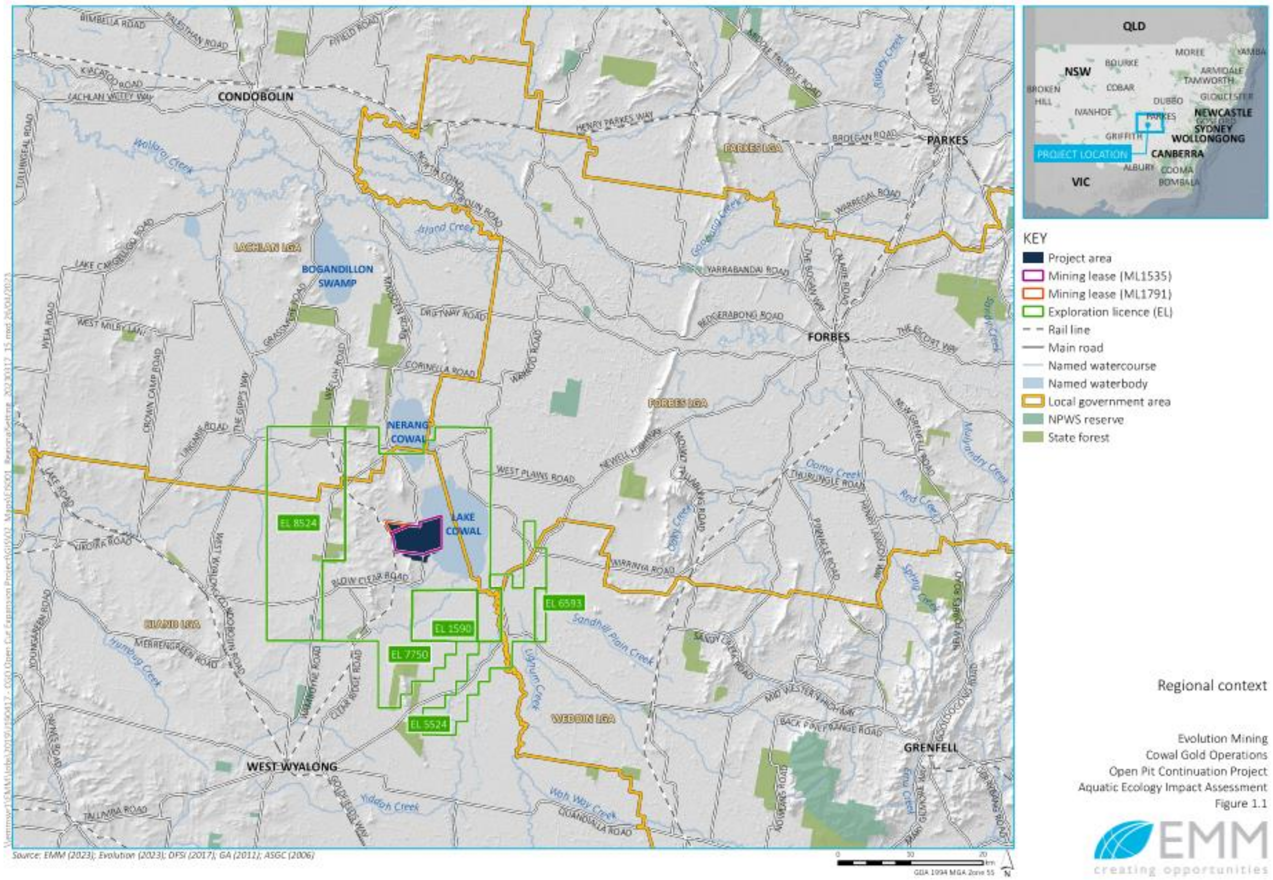

Figure 1-1: Project regional overview (Source: EMM Consulting Pty Limited)

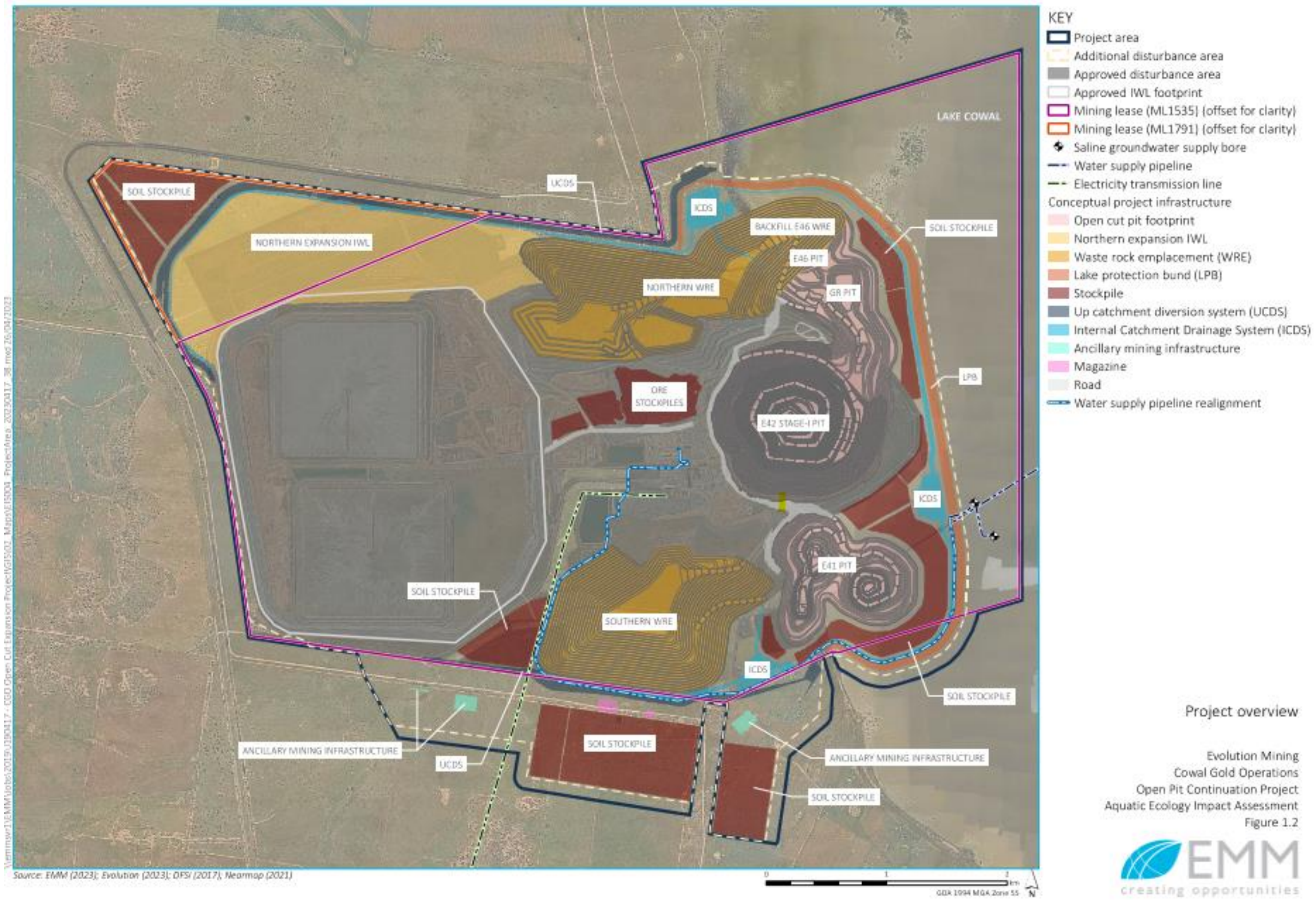

Figure 1-2: Project infrastructure layout (Source: EMM Consulting Pty Limited)

1.2. Purpose of This Report

This aquatic ecology assessment forms part of the EIS for the Project. It documents the aquatic assessment methods and results ("aquatic ecology assessment"), the initiatives built into the Project design to avoid and minimise associated impacts, and the mitigation and management measures, including offset requirements, proposed to address any unavoidable residual impacts.

The aim of the aquatic ecology assessment was to determine whether construction and operation of the Project is likely to have significant impacts on key fish habitat, listed habitat, threatened communities, populations or species. The specific objectives of this assessment were to:

- describe existing aquatic values and existing environment;
- identify and assess the potential for occurrence of aquatic biodiversity values relevant to the Project, including threatened species, populations and communities listed under the NSW *Fisheries Management Act 1994* (FM Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and associated polices and guidance material;
- identify direct, indirect and cumulative impacts with the potential to occur as a result of the Project;
- provide mitigation measures to reduce the impacts from the Project on aquatic values; and,
- consider appropriate compensatory measures (aquatic offsets), where impacts are unavoidable.

Austral has ensured that the aim and objectives of the aquatic ecology assessment have been addressed to a standard suitable for assessment by relevant regulators, following leading practice and in accordance with relevant legislation, policy and guidance material, summarised in Section 1.2.1.

1.2.1. Assessment Guidelines and requirements

This *Aquatic Ecology Assessment* report has been prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs) for the Project, issued on 10 June 2022, as well as relevant government assessment requirements, guidelines and policies, and in consultation with the relevant government agencies. To inform preparation of the SEARs, the Department of Planning, Industry and Environment (DPIE) invited relevant government agencies to advise on matters to be addressed in the EIS. These matters were taken into account by the Secretary for DPIE when preparing the SEARs. The SEARs must be addressed by the EIS and Table 1-1 lists the matters relevant to the Aquatic Ecology Assessment and where they are addressed in this report.

Table 1-1: Aquatic ecology and groundwater-dependent ecosystems matters raised in the SEARs and associated attachments

Department	Requirement or comment	Relevant Chapter/Section
SEARs	• an aquatic ecological assessment that addresses all direct and indirect impacts of the development on Key Fish Habitat and associated flora and fauna including threatened species, populations, and communities during construction and operation	This document
	• assessment of impacts of the development on the lake hydrology, geomorphic stability and water quality, and associated impacts on aquatic ecology of Lake Cowal	Sections 4 through 10.3.2; 22 and 23.
	• a strategy to offset any residual impacts of the development in accordance with the offset rules under the Biodiversity Offsets Scheme, including details of any potential biodiversity stewardship sites for retiring biodiversity credits, including consideration of inter-relationship between aquatic biodiversity offsets for loss of Key Fish Habitat	Section 12
Department of Primary Industries (DPI) (Fisheries)	• The Aquatic Ecological Assessment should cover the assessment requirements outlined in Chapter 3 of the Policy and Guidelines for Fish Habitat Conservation and Management (2013a) including: ○ Recent aerial photograph (preferably colour), map or GIS of the locality which details the Key Fish Habitat of the development site, all habitats impacted by the development, and waterway classification (CLASS) as defined in Tables 1 and 2 of the Policy and Guidelines for Fish Habitat Conservation and Management (2013a).	Figure 3-1
	○ Location details of all temporary and permanent infrastructure and construction activities, such as pits, dams, bunds, waste rock emplacement, pipelines etc.	Figure 1-2

	○ Details of the location of all waterway structures and a timetable for construction of the proposal with details of various phases of construction.	Addressed in EMM Consulting Pty Limited (2023)
	○ Mapping of the full aerial extent of Key Fish Habitat types that will be impacted either directly or indirectly by the development and subsequent operation of the Cowal Gold Operations Open Pit Project, with impacted habitats clearly identified on recent aerial photographs, maps or GIS.	Figure 3-1
	○ Description, quantification, and mapping of all aquatic and riparian vegetation communities potentially impacted by the development. This should include an assessment of the extent and condition of aquatic and riparian vegetation and the presence of significant habitat features (e.g. gravel beds, snags, reed beds, rock bars, etc).	Sections 5.1 and 7.1.7
	○ Quantification of the extent of aquatic and riparian habitat removal, modification or inundation (whether temporary or permanent) that will result from the proposed continuation of the project, particularly within Lake Cowal.	Section 12
	○ Detailed maps that outline and assess the geomorphic stability of areas of Key Fish Habitat within the development.	Section 0 and Figure 7-18
	○ Detailed maps that quantify and outline compensatory habitats and significant habitat features that may need to be created to offset any loss of aquatic and riparian habitat.	Detailed in EMM Consulting Pty Limited (2023a)
	○ Development of mitigation measures during construction (e.g. Environmental Management Plans) and operation (e.g. Operational Management Plan) including monitoring of proposed mitigation measures and plans to confirm their effectiveness.	Section 12.3

Guidance material relevant to aquatic ecology and groundwater-dependent ecosystems (GDEs) considered in this report includes:

- *Policy and guidelines for fish habitat conservation and management* (Department of Primary Industries, 2013)
- *Survey guidelines for Australia's threatened fish: Guidelines for detecting fish listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999* (Department of Sustainability, Environment, Water, Population and Communities, 2011);
- *NSW Biodiversity Offsets Policy for Major Projects. Factsheet: Aquatic biodiversity* (Department of Primary Industries, 2014);
- *NSW Aquifer Interference Policy* (Department of Primary Industries, 2012);
- *The NSW State Groundwater Dependent Ecosystems Policy* (Department of Land and Water Conservation, 2002);
- *Risk assessment guidelines for groundwater dependent ecosystems: Volume 1 – The conceptual framework* (Department of Primary Industries, 2012), as well as associated guidelines in this series (where applicable);
- *Guidelines for controlled activities on waterfront land: Riparian corridors* (Department of Industry, 2018); and
- *Matters of National Environmental Significance Significant impact guidelines 1.1* (EPBC Act) (Department of the Environment, 2013).

1.2.2. Other Relevant Reports

This Aquatic Ecology Assessment report has been prepared with reference to other technical reports prepared for the Project, listed below:

- *Cowal Gold Operations Open Pit Continuation Environmental Impact Statement Surface Water Assessment* (ATC Williams, 2023);
- *Cowal Gold Operations Open Pit Continuation Project Biodiversity Development Assessment Report* (EMM Consulting Pty Limited, 2023a);
- *Cowal Gold Operation - Open Pit Continuation Project: Groundwater Impact Assessment* (EMM Consulting Pty Limited, 2023b);
- *CGO Open Cut Expansion Project: Lake Protection Bund Waste Rock Management* (EMM Consulting Pty Limited, 2023c); and,

- *Mine Closure and Rehabilitation Strategy: Cowal Gold Operations Open Pit Continuation Project* (EMM Consulting Pty Limited, 2023d).

2. Legislative context

This section provides a brief outline of the key legislation and government policy considered in this assessment.

2.1. Fisheries Management Act 1994

The FM Act, administered by the Department of Primary Industries (DPI) Fisheries, provides for the sustainable management of fish and fish habitats, and outlines approval processes for activities that may impact on threatened fish species and habitats. It also contains provisions for the conservation of fish stocks, key fish habitat, biodiversity, and threatened aquatic species, populations and ecological communities. It regulates the conservation of fish, aquatic vegetation and some aquatic macroinvertebrates, and the development and sharing of the fishery resources of NSW for present and future generations. The FM Act lists threatened aquatic species, populations and ecological communities, key threatening processes and declared critical habitat. Assessment guidelines to determine whether a significant impact is expected are detailed in s 220ZZ and s 220ZZA of the FM Act.

A key objective of the FM Act is to conserve key fish habitat. These are defined as aquatic habitats that are important to the sustainability of recreational and commercial fishing industries, the maintenance of fish populations generally, and the survival and recovery of threatened aquatic species. Key fish habitat is defined in Section 3.2.1 and Section 3.2.2 of the Policy and guidelines for fish conservation and management (Department of Primary Industries, 2013), and is ranked based on a combination of habitat sensitivity (waterway type) and water classification (waterway class). These habitats include rivers, creeks, lakes, lagoons, billabongs, weir pools and impoundments up to the top of the bank, but do not include small ephemeral headwater creeks and gullies (ie 1st and 2nd order streams (Strahler, 1952) or farm dams constructed on these (Department of Primary Industries, 2013). Generally, 3rd order tributaries and above (Strahler, 1952) are considered key fish habitat that require conservation and management, although threatened species still have the potential to inhabit waterways of a 1st or 2nd order when inundated. In alignment with the FM Act's primary objective to 'conserve key fish habitats', permanent and semi-permanent freshwater habitats must be assessed if they intersect areas of impact related to a project.

To inform aquatic offsets, the assessment of impacts on aquatic biodiversity must be undertaken in accordance with NSW Biodiversity Offsets Policy for Major Projects Fact sheet: Aquatic biodiversity (Department of Primary Industries, 2014). The policy notes that "*Offset sites can include the same or a similar habitat in the same catchment that is more threatened than the habitat being impacted on*".

As the Project has been declared as SSD, permits under the following sections of the FM Act are not required (s 4.41 of the EP&A Act); however, where applicable, consideration has been given to these issues within this report:

- s 201 Circumstances in which a person (other than a public or local government authority) may carry out dredging or reclamation;

- s 205 Marine vegetation—regulation of harm; and
- s 219 Passage of fish not to be blocked.

2.2. Water Management Act 2000

The WM Act, administered by the NSW Department of Planning and Environment (DPIE) Water, governs the sustainable and integrated management of NSW's water for the benefit of both present and future generations. In the context of aquatic ecology, the WM Act provides the physical definition of a waterway, and other waterbodies, pertinent to this assessment:

'watercourse means a river, creek or other natural stream of water (whether modified or not) flowing in a defined channel, or between banks, notwithstanding that the flow may be intermittent or seasonal or the banks not clearly or sharply defined, and includes:

(a) a dam that collects water flowing in any such stream; and

(b) a lake through which water flows; and

(c) a channel into which the water of any such stream has been diverted; and

(d) part of any such stream; and

(e) the floodplain of any such stream –…'

The WM Act also provides guidance on controlled actions undertaken within the riparian zone of a waterway, with assessment of the potential impact of any controlled activity to be undertaken to ensure that minimal impacts will occur to "waterfront land". However, as the Project has been declared as SSD, so approvals under Sections 89, 90 and 91 the WM Act are not required (s 4.41 of the EP&A Act).

Division 6 of the WM Act requires consideration of aquifer interference activities. The NSW Aquifer Interference Policy (Department of Primary Industries, 2012) requires an assessment of potential impacts on water dependent assets, including groundwater-dependent ecosystems (GDEs). In addition, specific guidance relating to the assessment of GDEs is provided within The NSW State Groundwater Dependent Ecosystems Policy (Department of Land and Water Conservation, 2002) and Risk assessment guidelines for groundwater dependent ecosystems: Volume 1 – The conceptual framework (Department of Primary Industries, 2012).

2.3. Environmental Protection and Biodiversity Conservation Act 1999

The EPBC Act, administered by the Department of Climate Change, Energy, the Environment and Water (DCCEEW), is the primary Commonwealth legislation relevant to the assessment of aquatic ecology, providing a framework for the protection of the Australian environment, including its biodiversity and its natural and culturally significant places. The EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities, heritage places and water resources which are defined as Matters of National Environmental Significance (MNES) under the EPBC Act. These are:

- world heritage properties;
- places listed on the National Heritage Register;
- Ramsar wetlands of international significance;
- threatened flora and fauna species and ecological communities;
- migratory species;
- Commonwealth marine areas;
- the Great Barrier Reef Marine Park;
- nuclear actions (including uranium mining); and
- water resources, in relation to coal seam gas or large coal mining development.

The EPBC Act also facilitates a more streamlined national environmental assessment and approvals process between the Commonwealth, and the States and Territories.

Under the EPBC Act, an action that may have a significant impact on a MNES is deemed to be a ‘controlled action’ and can only proceed with the approval of the Commonwealth Minister for the Environment. An action that may potentially have a significant impact on a MNES is to be referred to DCCEEW for determination as to whether or not it is a controlled action. If deemed a controlled action the Project is assessed under the EPBC Act and a decision made as to whether or not to grant approval.

A referral under the EPBC Act was made to the Commonwealth Minister for the Environment (EPBC Ref:2022/09223) and the Project has been deemed a controlled action. Specifically, it was deemed that the Project was likely to have a significant impact on:

- listed threatened species and communities (sections 18 & 18A); and,
- listed migratory species (section 20 & section 20A).

In addition to the above, the DCCEEW released a provisional list of animal species identified as requiring urgent management intervention following the 2019/2020 bushfire season in southern and eastern Australia (24 March 2020) (Department of Climate Change, Energy, the Environment and Water, 2020). Most of the species have potentially had at least 30% of their range burnt. The list includes a number of bird, mammal, reptile, frog, invertebrate, crayfish and fish species. The priority animals were identified based on the extent to which their range has potentially been burnt, their conservation status prior to the fires, and the physical, behavioural and ecological traits which influence their vulnerability to fire. While the list primarily comprises species already listed under the EPBC Act, it also includes species which are not currently listed as threatened under the FM Act or EPBC Act but have more than 30% of their range within burnt areas.

3. Methods

The following tasks were completed to address the aim and objectives of the aquatic ecology assessment:

- database searches and a literature review;
- an aquatic ecology field survey, including:
  - assessment of key fish habitat (KFH) using a combination of habitat sensitivity (waterway type) and water classification (waterway class) to determine if Lake Cowal meets the definition of 'key fish habitat';
  - cataloguing of photographs at each site assessed within Lake Cowal and associated waterways;
  - assessment of the suitability of identified habitats to support threatened aquatic species, communities or populations; and
  - collection of abiotic and biotic samples to aid in determining existing environmental values and documenting identified threatened communities, populations and species.
- preparation of an aquatic ecology assessment report to:
  - summarise the above information and outline the environmental receptors;
  - present assessments of significance for aquatic species listed under the FM Act and the EPBC Act;
  - assess the potential for occurrence of direct, indirect and cumulative impacts to the aquatic ecology of Lake Cowal as a result of the construction and operation of the Project;
  - provide information on an indicative aquatic offsets approach; and
  - provide management and monitoring recommendations as appropriate.

3.1. Desktop Assessment

3.1.1. Database Searches

Database search results are provided in Appendix A.

As a part of the desktop assessment, the following databases and datasets were reviewed:

- Freshwater threatened species distribution maps (DPI Fisheries; September 2022);
- Threatened species lists (DPI Fisheries; September 2022);
- Key Fish Habitat maps (DPI Fisheries; September 2022);
- Fish stocking (DPI Fisheries; September 2022);
- Fisheries NSW Spatial Data Portal (DPI Fisheries; February 2023);
- BioNet Atlas (DPIE; August 2022);
- Australian Museum (September 2022);
- Protected Matters Search Tool (PMST) (DCCEEW; February 2023);
- Provisional list of animals requiring urgent management intervention (DCCEEW; September 2022);
- Australian Ramsar Wetlands: Internationally Important Wetlands (DCCEEW; September 2022);
- Directory of Important Wetlands: Nationally Important Wetlands (DCCEEW; September 2022);
- NSW Fish Passage Database (DPI Fisheries; September 2022);
- WaterNSW Continuous water monitoring network data; and,
- Climate data online (BoM; September 2022).

3.1.2. Literature Review

A review of publicly available literature relating to aquatic and subterranean environments in the region of the Project was undertaken to investigate the occurrence of communities and taxa of conservation significance. Information was compiled from reports, books, journals, and relevant government, university or regulatory publications. While a number of aquatic ecology reference sources were available in relation to Lake Cowal, the majority comprised monitoring reports (supplied by Evolution) which did not necessarily provide additional/new data as monitoring progressed. A limited number of subterranean fauna (to within 200 km of the Project) assessments have been undertaken in the vicinity of the Project.

Information was also taken from the documents below, where applicable:

- *Water Sharing Plan for the Lachlan Regulated River Water Source 2016*;
- *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources Order 2020*; and
- *Water Sharing Plan for the Mandagery Creek Water Source 2003*.

A summary of the results of the literature review are provided in Appendix B (excluding online databases, websites and reports listed in Section 3.1.1.)

3.1.3. Likelihood of Occurrence Assessment

The criteria for assessing the likelihood of occurrence of threatened species is summarised in Table 3-1. While Commonwealth and State data sources indicate possible presence of species and habitats, local conditions should be considered when determining their actual likelihood of occurrence. Threatened habitats and/or communities that have the potential to be indirectly impacted by downstream effects are included in the assessment, as are threatened species and/or populations that have the potential to occur within the Lachlan River catchment. Due to the lack of knowledge of the occurrence and distribution of subterranean fauna in NSW, all communities within similar geologies were considered 'possible' to occur. The results of the likelihood of occurrence assessment are provided in Appendix C - Likelihood of for all species identified during the desktop assessment.

Table 3-1: Likelihood of occurrence criteria

Likelihood	Description	Further assessment conducted?
Negligible	The potential for the species to occur is considered so unlikely as to not be worth considering.	No
Low	Based on data collected during the field survey, it was considered that the species was unlikely to occur in, or use habitats within, the Project footprint. A species may utilise identified habitat on rare occasions.	No
Moderate	The species is known to occur in the catchment/sub-catchment/waterway and the field survey identified some habitat value for the species. Habitat values are somewhat degraded and considered suboptimal.	Yes
Likely	The species is known to occur in the catchment/sub-catchment/waterway and the field survey identified optimal habitat features for the species.	Yes
Recorded	The species was recorded during the field survey. The species has been recorded in the catchment/sub-catchment/waterway previously and there has not been any change in habitat values since this time.	Yes

3.2. Field Survey Design

To aid in determining the ecological values of waterways with the potential to be impacted by the Project, a field survey was undertaken from 25 to 27 November 2020. A total of eight sites were assessed within Lake Cowal and Bland Creek within, upstream and downstream of the disturbance area (Figure 3-1). The survey comprised a range of abiotic and biotic components (Table 3-2). Field sampling was undertaken in accordance with DPI Fisheries s 37 FM Act Scientific Collection Permit No P19/0025-1.0.

At each site, waterway type and waterway class assessments were completed, and broad habitat characterisation was undertaken to document attributes of the local ecosystem including:

- habitat and substrate types;
- riparian vegetation condition and presence of weeds;
- vegetation cover and presence of native species;
- waterway morphology and presence/absence/flow of surface water;
- refuge availability (snags , aquatic vegetation, rocks, etc.);
- amount of erosion and bank incision; and
- livestock impact.

Photographs were taken of upstream and downstream condition, as well as the bed, banks and riparian zone at all sites (where the features were present) to provide a record of habitat conditions at the time of assessment (Appendix D - Site Photographs, November 2020). Each waterway assessed had previously been ranked by the DPI according to the Strahler (1952) method of waterway ordering, and only waterways ranked as 3rd order and above have been included in the aquatic ecology assessment.

The content of the aquatic ecology assessment was limited to aquatic and instream habitat and did not address terrestrial ecology or document plant species. Further information on riparian plant species that may be impacted by the Project are detailed in EMM Consulting Pty Limited (2023a). Riparian vegetation is defined by the DPI Fisheries as "*The plants growing on the water's edge, the banks of rivers and creeks and along the edges of wetlands*…", and consist of trees, shrubs, grasses and/or vines across a number of structural components (ie groundcovers, understorey and canopy) (Department of Primary Industries, 2019).

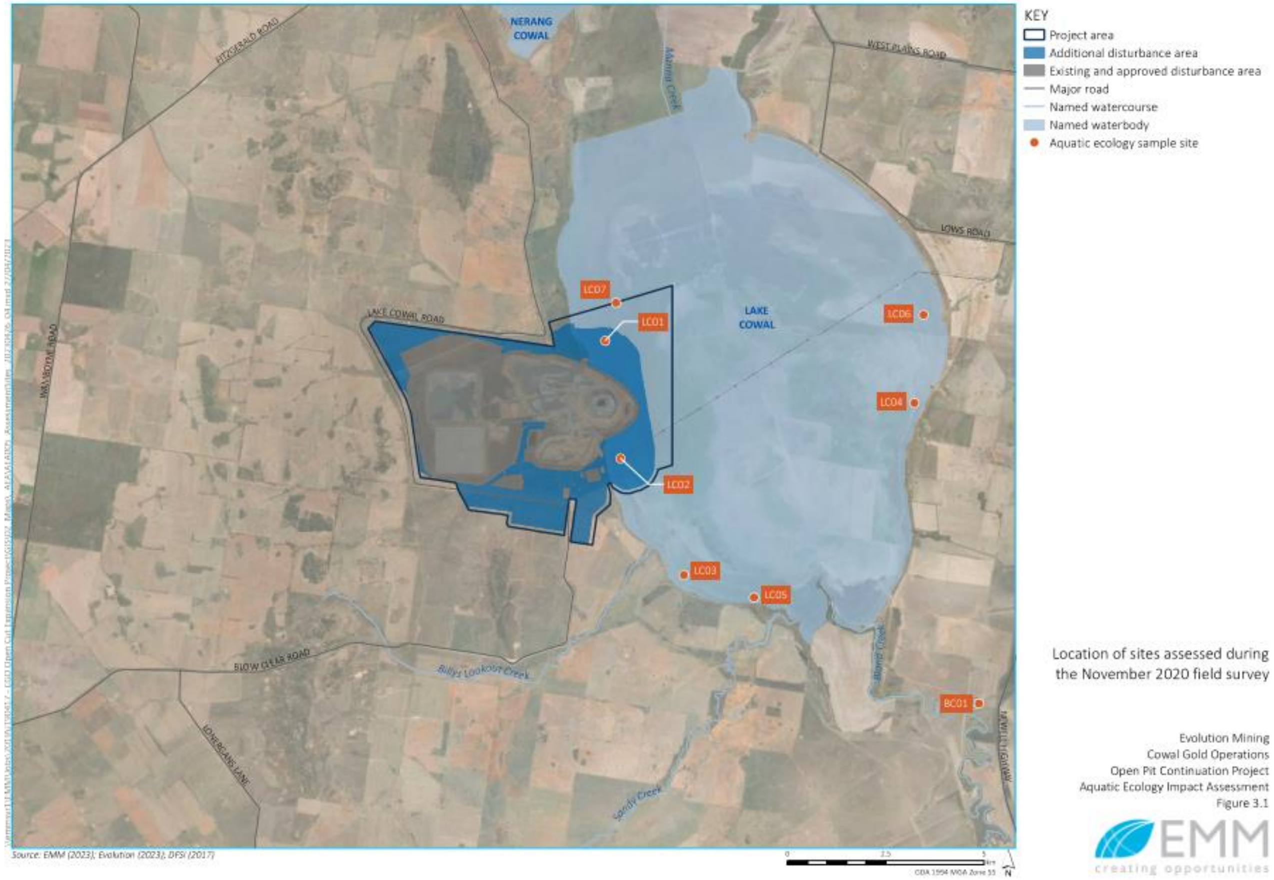

Figure 3-1: Location of aquatic ecology sites assessed during the November 2020 field survey (Source: EMM Consulting Pty Limited)

Table 3-2: Location of, and components sampled at, each aquatic ecology site during the November 2020 field survey

Classification	Waterway	Site	PCT	Strahler (1952) order	Coordinates	Sample date	Key fish habitat	Water quality	Sediment quality	Macrophytes	Phytoplankton	Aquatic invertebrates	Aquatic vertebrates
Impact	Lake Cowal	LC01	53	7th	-33.6226047 147.4086807	25-November-2020	✓	✓	✓	✓	✓	✓	✓
Impact	Lake Cowal	LC02	53	7th	-33.6495909 147.4129559	25-November-2020	✓	✓	✓	✓	✓	✓	✓*
Impact	Lake Cowal	LC07	53	7th	-33.6138483 147.4115513	26-November-2020	✓	✓	✓	✓	✓	✓	✓
Reference	Bland Creek	BC01	-	7th	-33.7055227 147.5117991	25-November-2020	✓	✓	✓	✓	✓	✓	✓
Reference	Lake Cowal	LC03	53	7th	-33.6763134 147.4305451	25-November-2020	✓	✓	✓	✓	✓	✓	✓*
Reference	Lake Cowal	LC04	-	7th	-33.6365796 147.493619	26-November-2020	✓	✓	✓	✓	✓	✓	✓*
Reference	Lake Cowal	LC05	53	7th	-33.6813888 147.4498375	27-November-2020	✓	✓	✓	✓	✓	✓	✓*
Reference	Lake Cowal	LC06	-	7th	-33.61629 147.4960417	26-November-2020	✓	✓	✓	✓	✓	✓	✓

Note: * indicates bait traps and a seine net were used instead of an electrofisher.

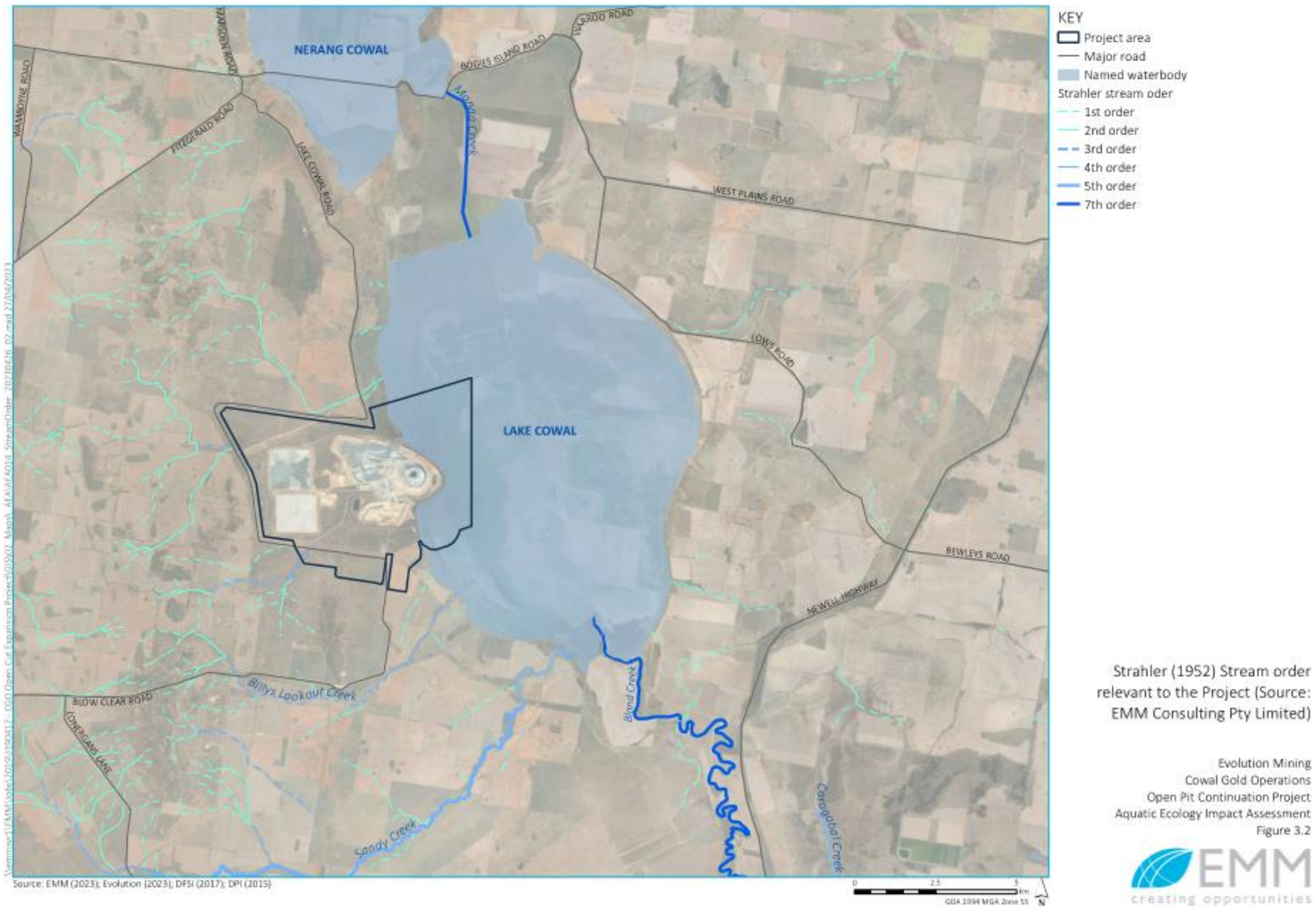

Figure 3-2: Strahler (1952) **Stream order relevant to the Project (Source: EMM Consulting Pty Limited)**

3.2.1. Key Fish Habitat

In accordance with *Policy and guidelines for fish habitat conservation and management* (Department of Primary Industries, 2013) habitat sensitivity was assessed at eight sites (Figure 3-1; Table 3-2) by assigning a 'waterway type', while the functionality of the waterway as fish passage was assessed by assigning a 'waterway class'. 'Sensitivity' is defined by '…*the importance of the habitat to the survival of fish and its robustness (ability to withstand disturbance)*' (Department of Primary Industries, 2013). Definitions, relevant to the aquatic ecology assessment report, of the waterway types and waterway classes are summarised in Table 3-3 and Table 3-4, respectively. The Department of Primary Industries (Fisheries) (2013) only recognises native aquatic plants with regard to waterway type classification. Where it was not known as to whether an aquatic plant was native or exotic, a conservative approach was taken, potentially overestimating the native vegetation component of waterway type classification.

Table 3-3: Waterway type definitions for habitat sensitivity

Classification	Characteristics of waterway class
Type 1 – Highly sensitive key fish habitat	Freshwater habitats that contain in-stream gravel beds, rocks greater than 500 mm in two dimensions, snags greater than 300 mm in diameter or 3 metres in length, or native aquatic plants.
Type 2 – Moderately sensitive key fish habitat	Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in Type 1.
Type 3 – Minimally sensitive key fish habitat	Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation.

Table 3-4: Waterway class definitions for fish passage

Classification	Characteristics of waterway class
Class 1 – Major key fish habitat	Marine or estuarine waterway or permanently flowing or flooded freshwater waterway (e.g. river or major creek), habitat of a threatened or protected fish species or 'critical habitat'.
Class 2 – Moderate key fish habitat	Generally named intermittently flowing stream, creek or waterway with clearly defined bed and banks, semi-permanent to permanent water in pools or in connected wetland areas. Freshwater aquatic vegetation is present. Type 1 and Type 2 habitats present.
Class 3 – Minimal key fish habitat	Named or unnamed waterway with intermittent flow and sporadic refuge, breeding or feeding areas for aquatic fauna (e.g., fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or other Class 1-3 fish habitats.

Class 4 – Unlikely key fish habitat	Generally unnamed waterway with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free-standing water or pools post-rain events (e.g., dry gullies, shallow floodplain depressions with no aquatic flora).

3.2.2. Water Quality

Surface water samples were collected at eight sites (Table 3-2; Figure 3-1) using sterilised bottles provided by the NATA accredited Australian Laboratory Group (ALS), containing preservative where required. Bottles were completely filled with water and sealed, excluding air from the samples where possible. Samples were then couriered to ALS for analysis (Table 3-5). Samples collected for the analysis of dissolved metals, metalloids and other trace elements ("metals") were filtered in the laboratory. Holding times were breached for the following parameters and therefore these results should be considered indicative only:

- pH, turbidity, nitrite, dissolved organic carbon and dissolved oxygen at all sites; and
- dissolved major cations at LC01, LC02, LC03, LC04 and BC01.

In situ water quality measurements were also recorded via the use of a handheld water quality meter (pH, electrical conductivity, dissolved oxygen, turbidity, temperature, depth, anoxic layer presence; Appendix F - In Situ Water Quality, November 2020).

Surface water pH was compared to the classification system developed by Foged (1978), comprising acidic water (4.5 to 6.5), circumneutral water (6.5 to 7.5), and alkaline water (>7.5). Salinity was compared to Hammer (1986), classifying surface water into freshwater (<3,000 mg/L), hyposaline (3,000 mg/L to 20,000 mg/L), mesosaline (20,000 mg/L to 50,000 mg/L) and hypersaline (>50,000 mg/L) categories. Basic water quality parameters and nutrient concentrations were compared to ANZECC and ARMCANZ (2000) guideline trigger values ("trigger values"), where available, representative of slightly disturbed ecosystems (freshwater lakes and reservoirs) in south-east Australia. Metal concentrations were compared to the Australian and New Zealand Guidelines for Fresh & Marine Water Quality (ANZG) (Water Quality Australia, 2018) toxicant default guideline values (DGV) for the protection of 80% of species in freshwater, representative of highly disturbed ecosystem (where available).

Table 3-5: Water quality parameters analysed from surface water during the November 2020 field survey

Basic	Major Ions	Nutrients	Dissolved Metals	
pH	Calcium	Nitrogen (total)	Arsenic	Manganese
Total dissolved solids	Sodium	Kjeldahl Nitrogen (total)	Barium	Mercury
Electrical conductivity	Magnesium	Nitrate	Beryllium	Nickel
Suspended solids	Potassium	Nitrite	Boron	Selenium
Turbidity	Bicarbonate	Nitrite + Nitrate	Cadmium	Vanadium
Dissolved oxygen	Sulphate	Ammonia	Chromium	Zinc
	Chloride	Phosphorus (total)	Cobalt	
	Carbonate	Organic carbon (total)	Copper	
	Hydroxide		Iron	
	Alkalinity (total)		Lead	

Note: Sample holding time is generally defined as the time between sample collection and completion of analysis in a laboratory, with recommended holding times provided by the analytical laboratory to ensure accurate analytical results are provided. While the Nandewar Northern Complex and Tenterfield Plateau sub-catchments are considered to be disturbed, there are only guideline values available for slightly disturbed ecosystems.

3.2.3. Sediment Quality

Surface sediment samples were collected at eight sites (Table 3-2, Figure 3-1) using sterilised glass jars provided by ALS. The top two to three centimetres of sediment was scraped into a sterilised glass container and couriered to ALS for analysis (Table 3-6). Samples were collected for the analysis of total metals, metalloids and other trace elements ("metals"). The holding time for pH was breached at site LC01 and therefore these results should be considered indicative only.

Sediment pH was compared to Hazelton and Murphy (2007) which ranges from very strongly acidic (<5.0) to very strongly alkaline (>9.0). Metal concentrations were compared to the DGV and GV High (Water Quality Australia 2018) (where available).

Table 3-6: Sediment quality parameters analysed during the November 2020 field survey

Basic	Major Ions	Nutrients	Total Metals	
pH	Calcium	Nitrogen (total)	Arsenic	Manganese
Total soluble salts	Sodium	Kjeldahl nitrogen (total)	Barium	Mercury
Moisture content	Potassium	Nitrite + Nitrate	Beryllium	Nickel
	Magnesium	Phosphorus (total)	Boron	Selenium
	Chloride	Organic carbon (total) (%)	Cadmium	Vanadium
	Sulphate		Chromium	Zinc
			Cobalt	
			Copper	
			Iron	
			Lead	

3.2.4. Algae and Macrophytes

Samples of phytoplankton, periphyton and macrophytes were collected from surface water at eight sites (Table 3-2; Figure 3-1) during the November 2020 field survey. Details are provided below.

I. Phytoplankton

A sample of phytoplankton (free-floating algae) was collected from surface water to document algal communities (in particular, toxic and/or bloom-forming taxa) within Lake Cowal and Bland Creek. A 45 micrometre (μm) mesh net was towed through the water along an L shaped transect (30 x 30 metres (m)). Each sample was transferred into a 70 millilitre (mL) vial and kept cool to preserve the algae. In the laboratory, three representative slides were prepared and observed under a compound microscope at 40X magnification. Algae were identified to at least genus level, using appropriate taxonomic literature. The relative abundance was recorded for each taxon, calculated per cell, colony or filament, dependent on the morphological form.

II. Periphyton

Periphyton growing on submerged vegetation, sediment, rocks or woody debris in shallow surface water was collected for the analysis of diatoms (microalgae). Samples were placed into 70 mL vials and kept cool to preserve diatom frustules. In the laboratory, diatoms were treated in 70% nitric acid to remove organic material, and permanent slides were prepared according to John (1983). Three replicate slides were made from each sample, and enumeration was carried out at 100X magnification under a compound microscope. A maximum of 100 diatoms were counted at each site to provide a representation of community structure. The abundance and diversity of taxa were recorded, with identification to species level undertaken using appropriate literature.

III. Macrophytes

During the November 2020 field survey, macrophytes (aquatic plants) were assessed and documented in the field by an experienced aquatic ecologist. Where specimens were unable to be identified in situ, samples were collected and placed in 250 mL polycarbonate containers or ziplock plastic bags, dependant on their morphology, and kept cool to preserve structure. In the laboratory, macrophyte samples were examined under a dissecting microscope and identified. Taxonomic verification was undertaken to at least genus level (where possible) using appropriate taxonomic literature.

3.2.5. Aquatic Invertebrates

During the November 2020 field survey, microinvertebrate and macroinvertebrate samples were collected from eight sites (Table 3-2; Figure 3-1). A 45 µm mesh net was towed through the water column to sample microinvertebrates, while a 250 µm D frame mesh net was used to sample macroinvertebrates, targeting a variety of habitats along the benthic environment. For both nets, an L shaped transect (30 x 30 m) was traversed perpendicular to the shore, where possible. Microinvertebrate samples were transferred into 250 mL polycarbonate vials and preserved in 70% denatured ethanol. Macroinvertebrate samples were live picked in situ, following appropriate live picking methodology (Turak, Waddell, & Johnstone, 2004), with the resultant samples also transferred into 250 mL polycarbonate vials and preserved in 70% denatured ethanol.

Further sorting and identification of macroinvertebrate samples was completed in the laboratory under a dissecting microscope, with abundance of invertebrates recorded. Specimens were separated into broad taxonomic groups and placed into microvials. Identification of taxa to at least family level was completed, using appropriate literature and keys. Sorting of microinvertebrate samples was completed in the laboratory under a compound microscope, with abundance of invertebrates recorded. Specimens were separated into broad taxonomic groups and placed into microvials. Identification of taxa to at least family level was completed, using appropriate literature and keys. For the purposes of reporting, microinvertebrate and macroinvertebrate data have been combined.

3.2.6. Aquatic vertebrates

During the November 2020 field survey, aquatic vertebrates were assessed at eight sites (Table 3-2, Figure 3-1), using a number of methods to sample aquatic vertebrate fauna (electrofisher, bait traps, seine net, eDNA sampling), following the Survey guidelines for Australia's threatened fish: *Guidelines for detecting fish listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999* (Department of Sustainability, Environment, Water, Population and Communities, 2011). For the purposes of reporting, aquatic vertebrate data has been combined, irrespective of collection method. Exotic species were not returned to the water.

I. Electrofisher

Electrofishing was undertaken at four sites (BC01, LC01, LC06, LC07) to assess the presence of small bodied and large bodied fish. Electrofishing involves passing an electrical current through water, stunning aquatic fauna so that they can be netted and identified. Water temperature was monitored closely to ensure that an appropriate electrical current was maintained. The electrofisher maintained an upstream path to avoid recapture of previously stunned individuals. The voltage output was also monitored continuously, to ensure only the minimum current necessary was used to attract and capture fish effectively. The electrofisher was active for an average of 14 minutes per site and averaged 288 volts and 120 Hz at a duty cycle of 12%. Electrofisher settings per site are provided in Appendix G - Electrofisher Settings, November 2020. Once aquatic fauna entered the electric field, the operator ceased administering current into the water and the second field team member netted the individuals and placed them into a holding container fitted with an aeration system. Taxonomic verification was undertaken in situ at all sites using appropriate taxonomic literature. Specimens were measured using a ruler and, once recovered, gently placed back into the same waterway in an area of slow flow near the bank. The electrofisher was cleaned before leaving each site to prevent transfer of specimens and pathogens.

II. Bait traps

Bait traps were deployed at four sites (LC02, LC03, LC04, LC05) where the water temperature was too hot to safely use the electrofisher. Entrance openings were small enough to avoid capture of larger animals such as the Platypus (*Ornithorhynchus anatinus*) and turtles. Each trap was baited with cat biscuits secured in a pouch. The traps were deployed upon arrival at site and removed upon completion of all other sampling components at that site (approximately 1-2 hours). Bait traps were unable to be left over longer periods due to the large distances between sites, potentially preventing recovery prior to nightfall. Captured fish were processed on a flat area immediately adjacent to the site. If specimens were unable to be identified immediately upon removal from the trap, they were transferred into a holding container fitted with an aeration system and held for as short a period as necessary to undertake identification. Taxonomic verification was undertaken in situ at all sites using appropriate taxonomic literature. Each bait trap was cleaned and dried before leaving each site to prevent transfer of specimens and pathogens.

Note: Electrofishing was not undertaken at LC02, LC03, LC04 and LC05 due to the high temperature of the water.

III. Seine net

A seine net was used at four sites (LC02, LC03, LC04, LC05) where the water temperature was too hot to safely use the electrofisher. Seine nets are lengths of netting which are weighted at the bottom and supported by floats at the top and are set to enclose an area and then dragged to the shore. Captured fish were processed on a flat area immediately adjacent to the site. If specimens were unable to be identified immediately upon removal from the net, they were transferred into a holding container fitted with an aeration system and held for as short a period as necessary to undertake identification. Taxonomic verification was undertaken in situ at all sites using appropriate taxonomic literature. The seine net was cleaned and dried before leaving each site to prevent transfer of specimens and pathogens.

IV. eDNA sampling

Water samples for eDNA analysis were collected from eight sites to assess the presence of the Murray Cod (*Maccullochella peelii*), the Eel-tailed Catfish (*Tandanus tandanus*), and the Flathead Galaxias (*Galaxias rostratus*). Three eDNA filters were collected from each of the eight sites (total of 24 filters) to ensure the rate of positive detection was 95%. At each site, a new pair of latex gloves were worn, three eDNA filters were removed from sterile packaging, and the packaging was labelled with the site name and filter number. A 50 mL syringe was used to draw water from each site and the filter was attached without touching either end. The syringe was then used to push water through the filter and the filter was removed. This process was repeated until water could no longer be pushed through the filter, or up to a volume of 500 mL had been collected. The total volume of water pushed through each filter was noted on the packet next to the site name and filter number, and the filter was placed inside. This process was repeated for each filter at each site. All filters were placed within a sterile zip lock bag and stored in an esky containing ice bricks. The samples were couriered to EnviroDNA for analysis.

3.3. Risk Assessment

A risk assessment matrix has been utilised to assess the degree of impact an event or action will have on a species, or species habitat. The consequence criteria (Table 3-7), likelihood descriptors (Table 3-8) and risk matrix (Table 3-9) adopted for the risk assessment are provided below.

Table 3-7: Consequence Criteria adopted for the Risk Assessment

	Insignificant	Minor	Moderate	Major	Catastrophic
	Minimal, if any, impact which have an overall negligible net effect	Localised, reversible short term reversible event with minor effects which are contained to an onsite level	Localised long term but reversible event with moderate impacts on a local level	Extensive, long term, but reversible event with high impacts on a regional level	Long term, extensive, irreversible with high level impacts at potential state wide levels
Species Specific (state or nationally listed species)	No detectable permanent impacts on population of a listed species; AND/OR short term removal of >1% of the site population but <1% of the local, regional or state population of a listed species	Permanent removal of >1% of the site population but <1% of the local, regional or state population of a listed species; AND/OR short term removal of >1% of the local population but <1% of the regional or state population of a listed species	Permanent removal of >1% of the local population but <1% of the regional or state population of a listed species; AND/OR short term removal of >1% of the regional population but <1% of the state population of a listed species	Permanent removal of >1% of the regional population but <1% of the state population of a listed species; AND/OR short term removal of >1% of the state or national population of a listed species	Permanent removal of >1% of the state or national population of a listed species
Species Specific Interactions- Aquatic Ecology	No measurable permanent impacts on aquatic ecology values	Minor short term impacts, life cycle may be disrupted but for less than a year. Annual recruitment should still occur. Short and long term viability of individual species not impacted	Medium term (1-2 year) impacts, life cycle disrupted and resulting in no recruitment for a year. Short term viability of individual species impacted recovery within 1 -5 years. Long term viability of species not impacted	Long term (2-5 year) impacts, life cycle significantly disrupted no recruitment for successive years. Short term and long term viability individual species impacted recovery time frame (5-10 years)	Loss of species and population. Minimal possibility of recovery
Surface Water - Water Quality	No measurable change to surface water quality or quality changes are not measurable	Changes to Surface Water quality during the activity, no further changes noted once activity is finished	Changes to Surface Water quality due to activity, recovery up to 1 year	Changes to Surface Water Quality due to activity, recovery 1-2 years	Changes to Surface water quality, where water becomes toxic, or permanent changes to quality, recovery is greater than 2 years

Table 3-8: Likelihood descriptors adopted for the Risk Assessment

Level	Descriptor	Description
5	Almost Certain	The event is expected to occur in most circumstances during the period under review.
4	Likely	The event is likely to occur during the period under review.
3	Possible	The event might occur during the period under review
2	Unlikely	The event is not likely to occur during the period under review
1	Rare	The event will only occur in exceptional circumstances during the period under review. No previous occurrence in similar circumstances.

Table 3-9: Risk matrix adopted for the Risk assessment

		Likelihood				
		Almost Certain	Likely	Possible	Unlikely	Rare
Consequence	Insignificant	M	L	L	L	L
	Minor	M	M	L	L	L
	Moderate	H	H	M	M	L
	Major	E	H	H	M	M
	Catastrophic	E	E	H	H	M

3.4. Limitations

Austral has prepared this report based solely on data provided by EMM Consulting Pty Limited and ATC Williams. All impact assessments are based on the provided data. No field work or collection of field data was undertaken by Austral. All data provided is understood to be correct at the time of collection.

The eDNA results are presented as 'positive', 'negative' or 'equivocal' where equivocal indicates that only one or two of the three assays returned a positive result, indicating very low levels of target DNA were present. This may happen as a result of sample contamination through the sampling or laboratory screening process, facilitated movement of DNA between waterbodies, or dispersal from further upstream. In addition, fauna DNA usually degrades after approximately one to seven days, independent of the animal, in the environment (J. Griffiths, pers. comm, March 2020), meaning that while a 'positive' result is likely to confirm presence, a 'negative' result does not necessarily exclude presence of at species from a site at that point in time.

The assay for the Murray Cod does not distinguish between the Murray Cod, the Eastern Freshwater Cod (*Maccullochella ikei*) or the Mary River Cod (*Maccullochella peelii mariensis*); however, the Eastern Freshwater Cod is currently restricted to the Clarence River catchment of northern NSW (Department of Primary Industries, 2017), while the Mary River Cod occurs only with the coastal drainages of southeast Qld (Simpson & Jackson, 1996). Therefore, where *Maccullochella* sp. has been identified it is assumed to be the Murray Cod.

The following limitations apply to the aquatic ecology assessment:

- Aquatic ecology field surveys provide a sample of the conditions and species present at a site at that point in time. However, there are a number of reasons as to why not all of the predicted species will be recorded during that field survey, including absence within the catchment/waterway, low abundance, variability in distribution within a catchment/waterway site, seasonal and daily conditions, water temperature, and species activity at the time of sampling.

While some species have been assessed as having a low likelihood of occurrence, it is acknowledged that this does not indicate the species will never occur. Rather, it means that based on the desktop assessment and/or the field survey it was considered that the species was unlikely to occur within the catchment or waterway. A species may utilise the catchment/waterway on rare occasions and is therefore unlikely to be impacted by the proposed Project.

It is considered a limitation that the bait traps were unable to be left in situ for a sufficient period to target particular threatened species; however, traps were deployed at each site for as long as practicable, considering travel distance between sites, accessibly, and landholder access requirements. It is not considered that this limitation would have significantly impacted the results of the field survey due to the multiple survey techniques employed at each field survey site.

4. Results

4.1. Desktop Assessment Results

4.1.1. Biogeographical Context

The South-Western Slopes bioregion comprises foothills and isolated ranges of the lower inland slopes of the Great Dividing Range, covering approximately 8,681,126 ha (NSW National Parks and Wildlife Service, 2003). Approximately 93% of the bioregion occurs in NSW, with the remainder in Victoria. The bioregion extends from Albury in the south to Dunedoo in the northeast. Major towns include Wagga Wagga, Mudgee, Cootamundra, Narrandera, Parkes, Gundagai and Young. Parts of the Murray, Murrumbidgee, Lachlan and Macquarie River catchments are located within the South-Western Slopes bioregion. Lake Cowal is located within the Lower Slopes IBRA subregion (NSS02) (Figure 4-1) (Department of Climate Change, Energy, the Environment and Water, 2021).

4.1.2. Land Use

Approximately 2.3% (184 739.16 ha) of the South-Western Slopes bioregion comprises conservation tenure, with 1.2% (97 246.98 ha) managed within national parks or nature reserves (National Parks and Wildlife Act 1974) (NSW National Parks and Wildlife Service, 2003). Crown Land reserves comprise approximately 0.02% of the bioregion (1 933.52 ha), and the Hill End and Yuranighs Aboriginal Grave Historic Sites occupy 0.0003% of the bioregion (NSW National Parks and Wildlife Service, 2003). Landholders on seven properties have entered into voluntary conservation agreements, comprising 0.01% of the bioregion (884.20 ha), and 127 properties manage approximately 0.09% of land dedicated to conservation zones (NSW National Parks and Wildlife Service, 2003). Eight flora reserves (0.06%) and a number of State forests (forestry activities; 1.43%) are also located within the South-Western Slopes bioregion. Lake Cowal is located in the vicinity of a number of Reserves and State Forests including Clear Ridge, Corringle and Lake View (NSW National Parks and Wildlife Service, 2003).

As the South-Western Slopes Bioregion has been intensively cleared and cultivated, what remains is mostly fragmented vegetation, a landscape conducive to the decline of terrestrial and aquatic flora and fauna populations. Waterways and wetlands are also subject to influence from agriculture, and to a lesser degree urbanisation. When the lake is dry, grazing and cropping occur, and following flood events the lake supports a commercial fishery. Other land uses include irrigation, mining, recreation and bird watching (NSW National Parks and Wildlife Service, 2003).

4.1.3. Climate

The South-Western Slopes bioregion (NSW National Parks and Wildlife Service, 2003) has a sub-humid climate with hot summers and no dry season, with variability between a temperate climate at higher elevations along the eastern boundary of the bioregion, and a warmer climate in the north and west of the bioregion. This is due to its location at the boundary between the south-eastern semi-arid and south-eastern temperate regions of Australia (NSW National Parks and Wildlife Service, 2003). The minimum mean temperature is -0.7 – 3.2 °C to 24.6 – 33.5 °C (NSW National Parks and Wildlife Service, 2003).

The mean annual rainfall for the bioregion is 360 – 1266 mm and the mean annual temperature ranges from 11 – 17 °C (NSW National Parks and Wildlife Service, 2003).

Rainfall varies across the bioregion with high annual average rainfall (up to 1266 mm) occurring in the east, and lower rainfall (360 mm) occurring in the west (NSW National Parks and Wildlife Service, 2003). Average annual rainfall at CGO is 485 mm which occurs relatively evenly during the year; however, rainfall events that result in filling of Lake Cowal are more likely to occur across the broader catchment, flowing into Lake Cowal via Bland Creek and overland runoff. Average annual evaporation within the local area ranges from 1,690 mm at CGO to 1,990 mm at the Condobolin Agricultural Research Station, approximately 60 km north northwest of Lake Cowal, with evaporation highest during December and January (310 mm/month) and lowest during June and July (49 mm/month) (Department of Primary Industries 2022b).

The nearest Bureau of Meteorology weather station to Lake Cowal is at West Wyalong (West Wyalong Airport AWS; 050017). Annual rainfall in the 12 months prior to, and including, the November 2020 field survey totalled 688 mm, exceeding the long term average of 463.7 mm (Figure 4-2) (Bureau of Meteorology, 2022a). This was attributed to above average rainfall recorded during February, March, April, June, July, August, and October 2020, where monthly totals were at least 43.16 mm higher, on average, than the corresponding monthly mean total (Figure 4-2) (Bureau of Meteorology, 2022a). Over the 10 years leading up to the 2020 field surveys, three years have recorded rainfall higher than the long term annual average, including 2020 which exceeded the annual average at the time of the November 2020 field survey by more than 245 mm (Figure 4-3) (Bureau of Meteorology, 2022b). This resulted in the complete inundation of the lake, with water persisting into the latter part of 2021, and providing inundated conditions for sampling during the November 2020 field survey.

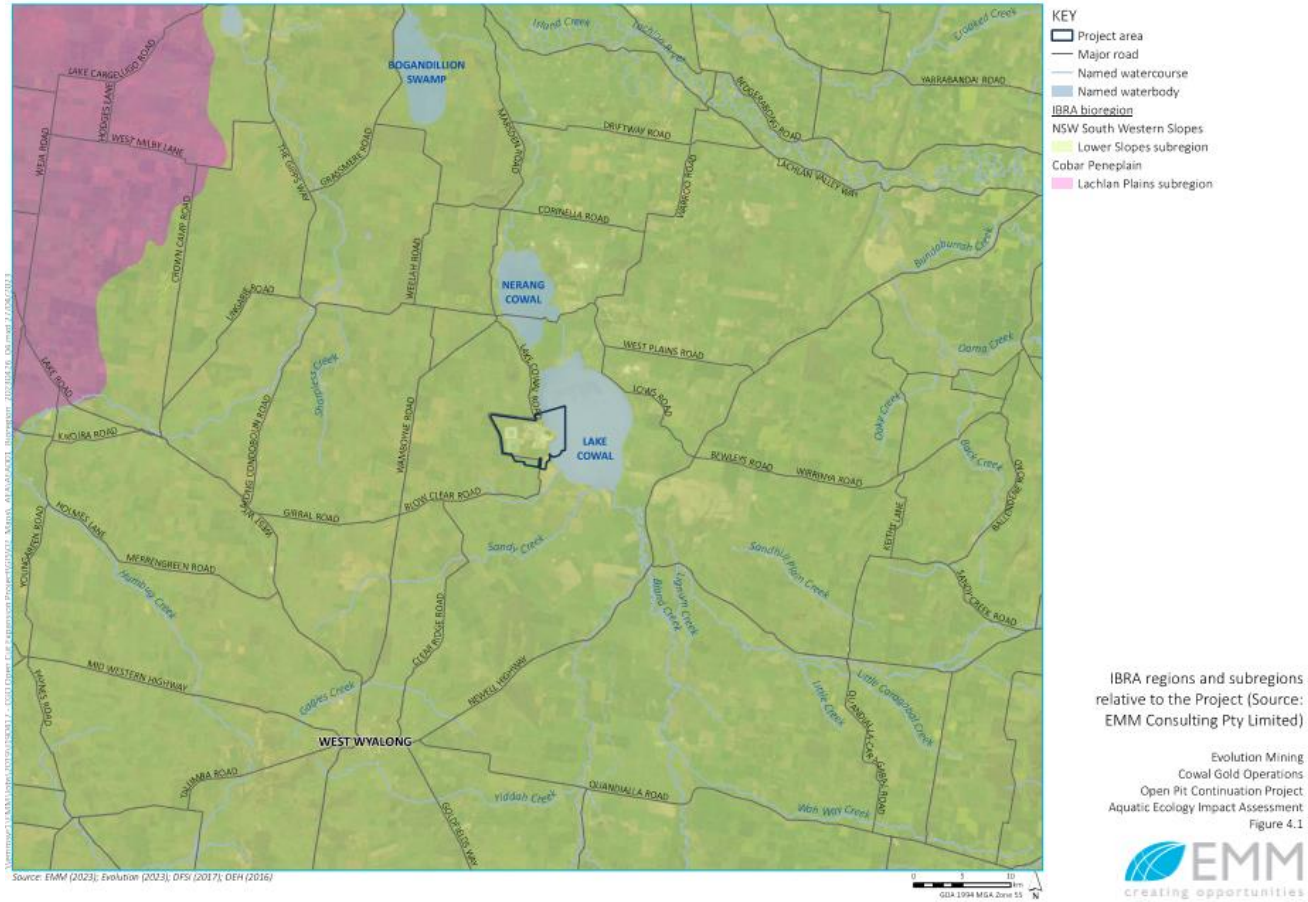

Figure 4-1: IBRA regions and subregions relative to the Project (Source: EMM Consulting Pty Limited)

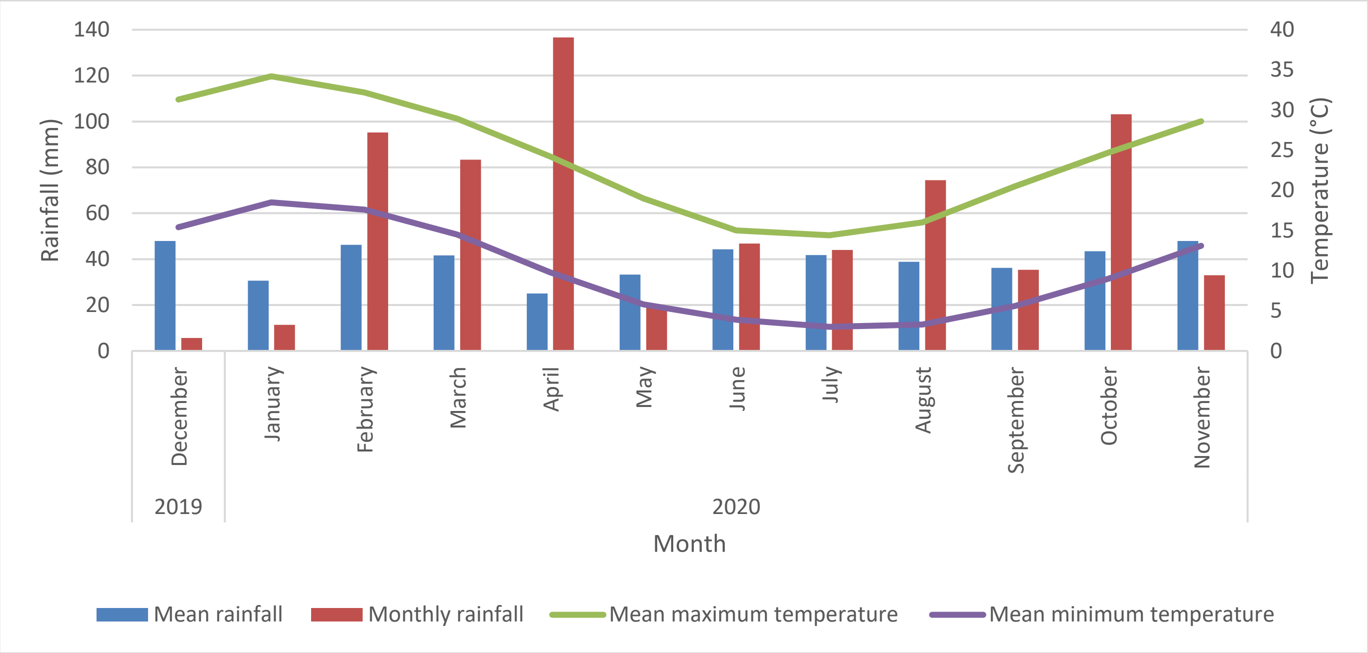

Figure 4-2: Monthly rainfall compared to long-term mean monthly rainfall and mean minimum and mean maximum temperature (mean = 1999-2022)

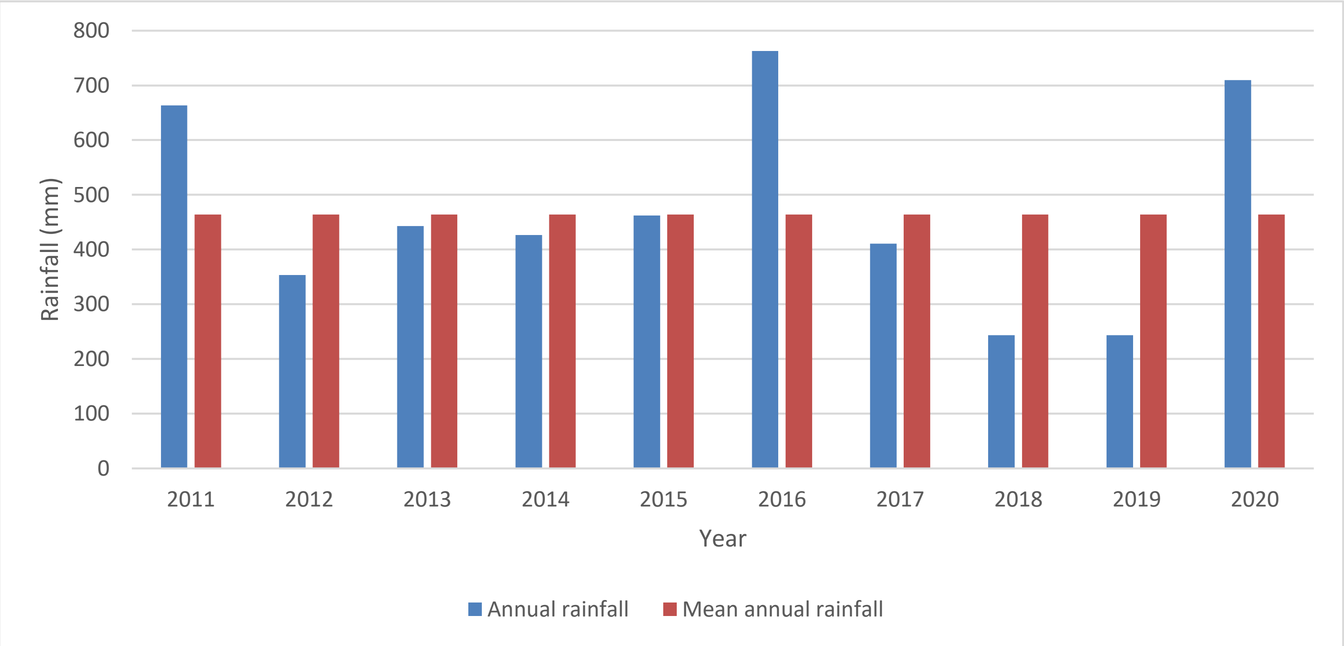

Figure 4-3: Annual rainfall compared to long-term mean annual rainfall (1999-2022)

4.1.4. Geology and Topography

I. Topography

The South-Western Slopes Bioregion is a large area of foothills and ranges comprising the western fall of the Great Dividing Range to the edge of the Riverina Bioregion. A very wide range of rock types is found across the bioregion, which is also affected by topographic and rainfall gradients that decrease toward the west. These physical differences have an impact on the nature of the soils and vegetation found across the bioregion (NSW National Parks and Wildlife Service, 2003). Waterways pass through the slopes in confined valleys with terraces and local areas of sedimentation. Geology, soils and vegetation are complex and diverse but typified by granites and meta-sediments, texture contrast soils and a variety of eucalypt woodlands, making this bioregion the southern equivalent of the Nandewar Bioregion (NSW National Parks and Wildlife Service, 2003).

II. Geology and Geomorphology

The South-Western Slopes bioregion lies wholly within the eastern part of the Lachlan Fold Belt which consists of a complex series of north to north-westerly trending folded bodies of Cambrian to Early Carboniferous sedimentary and volcanic rocks. Granites are typical of the region and mostly located in large scale upfolded bodies of rock. Granite landscapes occur either as central basins surrounded by steep hills formed on contact metamorphic rocks, or as high blocky plateau features with rocky outcrops and tors (NSW National Parks and Wildlife Service, 2003). Hilly landscapes that have developed are controlled by structural features (bedding and faults) and typically form lines of hills extended along the strike of more resistant rocks such as quartzite. The valleys between ranges are either in granite or generally softer rocks such as shale, phyllite or slate (NSW National Parks and Wildlife Service, 2003). Limited areas of Tertiary basalt with underlying river gravels and sands occur, and as the country becomes lower to the west and north, wide valleys filled with Quaternary alluvium and occasional lakes become the dominant landscape form (NSW National Parks and Wildlife Service, 2003). At the western edge of the bioregion the alluvial fans of the Riverine Plain have largely buried bedrock forms. Remnants of earlier gravel deposition on these fans, indicative of higher river discharges than today, are found as terrace features in the valleys and as gravel outwash plains (NSW National Parks and Wildlife Service, 2003). Several limestone outcrops are known within the bioregion, all of which have developed karst topography and carry locally different vegetation. A narrow belt of serpentinite with chemically distinctive soil runs northwest from Tumut to Cootamundra. A very large number of mineral deposits have supported the mining industry over the past 150 years (NSW National Parks and Wildlife Service, 2003).

III. Geodiversity

The South-Western Slopes bioregion supports significant diversity with regard to geology, geomorphology and biota. In addition to this diversity there are a number of special features to be noted, as follows:

- occurrences of limestone with well-developed karst landscape and rich fossil assemblages;

- numerous fossil occurrences in other locations;
- the serpentinite belt with its unusual mineralisation, soils and vegetation;
- a very large range of economic mineral occurrences with their attendant mining heritage; and,
- numerous sites exhibiting important structural features of folds and faults in the bedrock.

IV. Soils

Soils within the South-Western Slopes bioregion are typically shallow and stony soils and are found on the tops of ridges and hills. Downslope, texture contrast soils are typical with subsoils derived from the underlying weathered rock and the topsoils being a homogenised surface mantle of coarser material derived from all parts of the slope (Department of Planning and Environment 2003). The valley floors subsoils have drabber colours indicative of poor drainage and are known to accumulate soluble salts. Dryland salinity is widespread. Alluvial sands and loams are more common than clays in most parts of the landscape but alluvial clays become more important nearer to the Riverine Plain. Over the Quaternary, soils in these landscapes have accumulated a considerable quantity of wind-blown silt and clay from western NSW (NSW National Parks and Wildlife Service, 2003).

4.1.5. Catchment and Hydrology

The Project is located within the lower Lachlan River catchment and the Lower Slopes sub-catchment (Figure 4-4). The Lachlan River catchment covers an area of approximately 86,500 km^2 and is bounded by the Great Dividing Range, the Macquarie catchment, the Murrumbidgee catchment and the Darling catchment (Green, Petrovic, Burrell, & Moss, 2011). The primary drainage channel is the Lachlan River which terminates in the Great Cumbung Swamp wetlands, recognised as a nationally important wetland (Department of Climate Change, Energy, the Environment and Water, 2021), with both waterways rarely flowing into the adjacent Murrumbidgee River except during major flood events. Major tributaries include the Abercrombie, Belubula and Boorowa rivers, and Mandagery Creek (Green, Petrovic, Burrell, & Moss, 2011).

Major water storages in the catchment include the Wyangala Dam (1,220 GL), Lake Cargelligo (36 GL) and the Carcoar Dam (36 GL). While Lake Cowal itself is not regulated or used for water storage, there are a number of weirs located upstream in Bland Creek and Caragabal Creek, and downstream in Bogandillon Creek, as well as numerous other weirs and regulators, used mostly for storage and re-regulation, located along the Lachlan River and its tributaries and anabranches (Figure 4-4). The Lachlan River catchment has been sustainably altered by headwater dams, weirs, and river and creek modifications. Patterns and total volumes of flows, as well as the regularity of small to moderate-sized events, have reduced as a result, with aquatic habitat declining considerably in some areas as a result.

Lake Cowal is a freshwater lake occurring in a shallow basin on the Lachlan River floodplain. It is the largest natural lake in the Lachlan Valley and is part of a chain of wetlands including Lake Cowal, Nerang Cowal and Bogandillon Swamp (Department of Climate Change, Energy, the Environment and Water, 2021). Its inundated area is dependent on the magnitude of inflows as well as evaporation and has a maximum depth of 4.2 m, with filling occurring via the large local catchment of the wetland during minor and moderate flood events. Following major flood events, Lake Cowal receives flow from the Lachlan River via its floodplain (Department of Climate Change, Energy, the Environment and Water, 2021). Following complete inundation, Lake Cowal overflows into the shallow Lake Nerang Cowal to the north, creating a wetland of approximately 16,000 ha (Green, Petrovic, Burrell, & Moss, 2011), and water may persist in Lake Cowal for up to three years. Lake Cowal is flooded approximately 50% of the time.

Waterway/waterbody intersects the Project are shown in Figure 4-5 and include the 7th order Lake Cowal, with the 7th order Bland Creek located upstream and the 7th order Manna Creek located downstream (Figure 4-5).

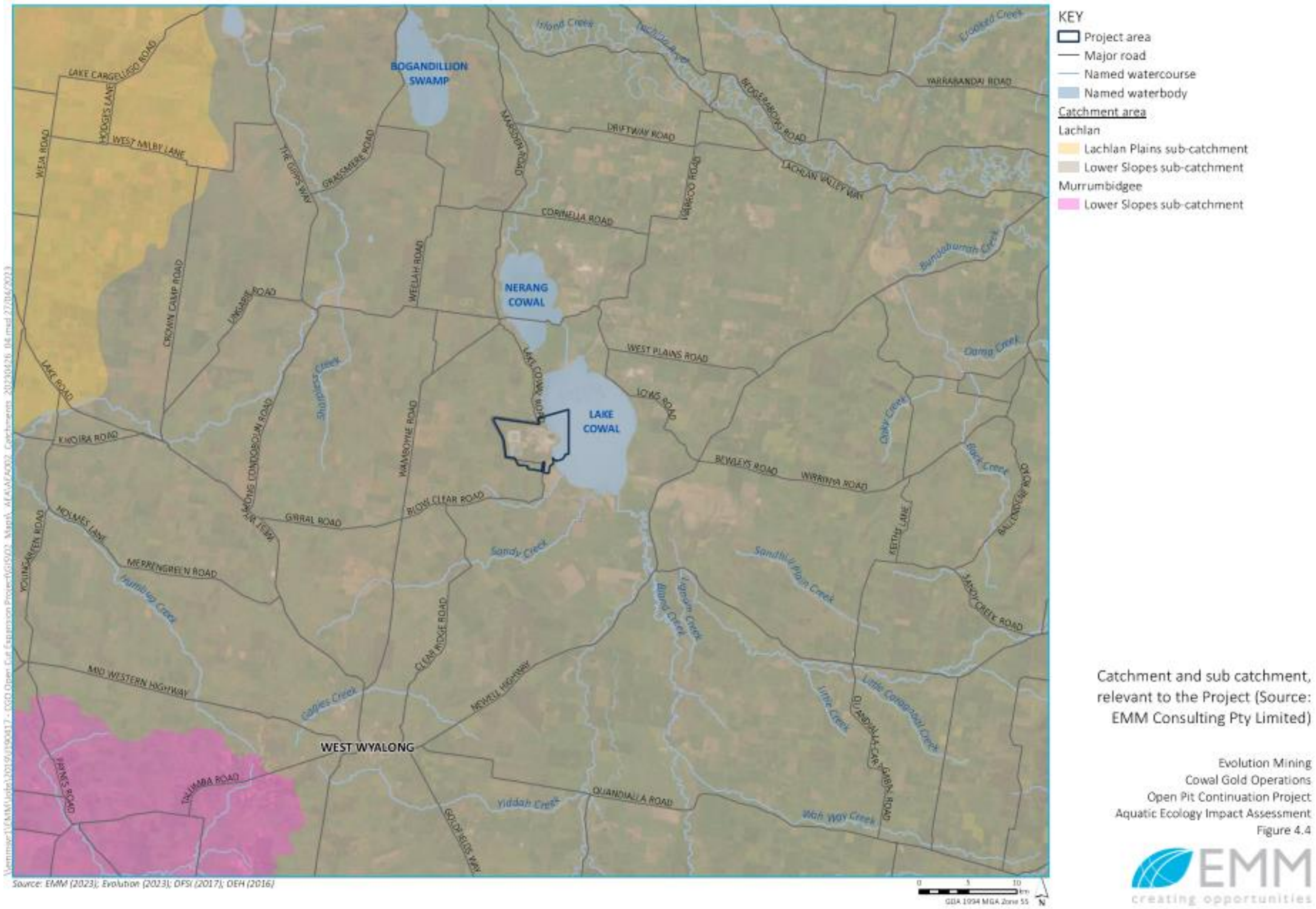

Figure 4-4: Catchment and sub catchment, relevant to the Project (Source: EMM Consulting Pty Limited)

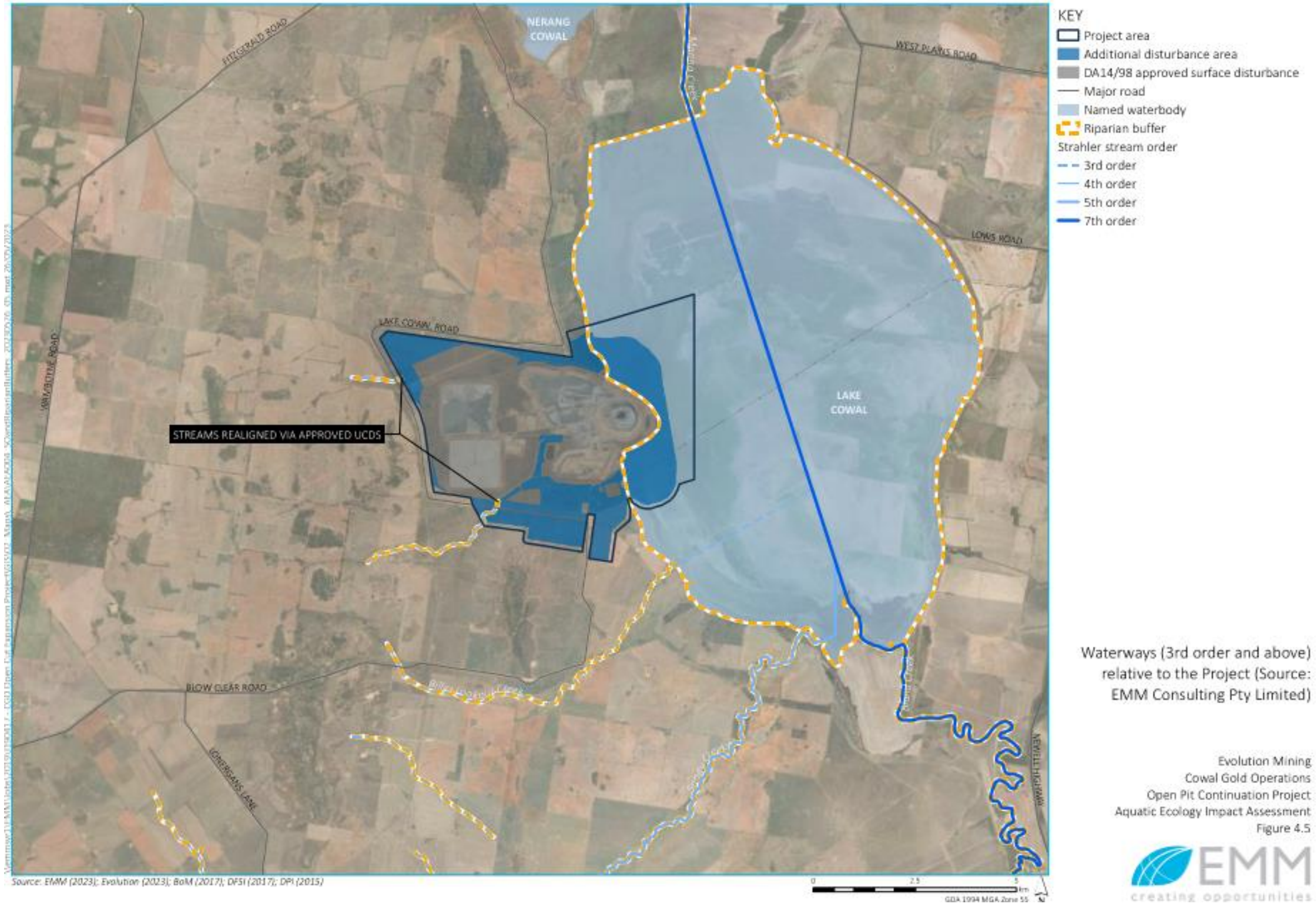

Figure 4-5: Waterways (3rd order and above) relative to the Project (Source: EMM Consulting Pty Limited)

4.1.6. Aquatic Habitats

The Lachlan River is the fourth longest river in Australia. The river runs from the Great Dividing Range in central New South Wales, westwards through sloping country in the central catchment, and then across river plains. The river ends at the Great Cumbung Swamp. In times of high flow, water will continue southwards through the swamp to reach floodwaters of the Murrumbidgee River (Department of Planning and Environment, 2016). The Lachlan River catchment is home to about 4% of the population of the Murray–Darling Basin, and the income of the population is primarily derived from agriculture and the supporting industries and services in regional centres (Green, Petrovic, Burrell, & Moss, 2011). The traditional people of the slopes and plains of the Lachlan catchment are mainly the Wiradjuri, whose nation is the largest Aboriginal Nation in New South Wales, and extends from the River Murray to beyond Dubbo, and west to Balranald. Other parts of the catchment are the traditional lands of the Nari Nari, Ngiyampaa and Yita Yita nations (Green, Petrovic, Burrell, & Moss, 2011). European settlement of the Lachlan catchment began in the 1830s, with the establishment of pastoral landholdings; and cropping began in the 1860s with a focus on wheat production. The wheat industry gave rise to milling and transport infrastructure, and additional fodder and grain crops such as oats, rye, maize and barley were established. Market gardening and fruit orchards in the upper Lachlan took advantage of the transport connections to Sydney, and a canning plant was established at Cowra in the 1940s. Viticulture was identified as a potentially productive activity at the turn of the 20th century, and a wine industry was established by the 1920s (Green, Petrovic, Burrell, & Moss, 2011). The region uses 3.5 percent of the surface water diverted for irrigation and 14.1 percent of the groundwater used in the Murray-Darling basin (MDB) (one of the highest levels of groundwater extraction within the MDB). Wyangala Dam located on the Lachlan River upstream of Cowra is the major water storage in the region. Approximately two-thirds of the irrigation water used is sourced from surface water diversions. Groundwater is extracted from alluvial aquifers in the western portion of the region to irrigate cotton crops, and for stock and domestic purposes (CSIRO, 2008).

The Sustainable Rivers Audit 2 reported that the overall ecosystem health of the Lachlan River Valley was “very poor” (Murray-Darling Basin Authority, 2012). Drought had severely affected species abundance and diversity of fish, with the health of the fish community rated “extremely poor” (Murray-Darling Basin Authority, 2012). The macroinvertebrate community was rated as “moderate” condition throughout the valley (Murray-Darling Basin Authority, 2012). Riverine vegetation was rated as “poor” condition in the valley overall; however condition was “good” in the lowlands zone but “very poor” in the slopes, upland and the montane (lower mountain) zones (Murray-Darling Basin Authority, 2012). The physical form of the river was rated “good” but widespread channel straightening and enlargement has occurred, in the slopes zone in particular. Sediment loads have also increased since European settlement. Flow seasonality and variability was rated “moderate” in the valley overall, but “poor” in the lowland zone where flows were impacted by seasonality and extraction of supply for irrigation (Murray-Darling Basin Authority, 2012).

The Lachlan River system, swamps and wetlands provide habitat for a range of native fish including Murray Cod (*Maccullochella peelii*), Golden Perch (*Macquaria ambigua*), Silver Perch (*Bidyanus bidyanus*), Eel-tailed Catfish (*Tandanus tandanus*) and an endangered population of Olive Perchlet

(*Ambassis agassizii*). These wetlands also feature areas of valuable River Red Gum (*Eucalyptus camaldulensis*) forest and woodlands, Blackbox (*Eucalyptus largiflorens*) woodland and Lignum (*Muehlenbeckia florulenta*). The lower Lachlan floodplain is home to 9 nationally important wetlands, including Lake Brewster, the Booligal Wetlands and The Great Cumbung. The Great Cumbung, covering 20,000 hectares, contains one of the largest remnant examples of common reed (*Phragmites australis*) swamps and stands of river red gums in NSW (Green, Petrovic, Burrell, & Moss, 2011).

Three bioregionally significant wetlands occur within the South-Western Slopes bioregion; the Barmedman/Yiddah Creek Floodplain, the Lake Burrendong Reservoir and Wiesners Swamp (NSW National Parks and Wildlife Service, 2003). One nationally significant wetland, listed as the Lake Cowal/Wilbertroy Wetlands (NSW040), occurs (Department of Climate Change, Energy, the Environment and Water, 2019). No internationally listed wetlands occur within South-Western Slopes bioregion (Department of Climate Change, Energy, the Environment and Water, 2023). Overall, the biodiversity of the wetlands within the bioregion is affected by a range of threats, including feral animals, exotic weeds, inappropriate recreational activities, erosion, increased nutrients, sedimentation, altered hydrology, salinity, water extraction and regulation, grazing pressure, pollution from gold mining, lakebed cropping when dry and indiscriminate duck shooting and commercial fishing (NSW National Parks and Wildlife Service, 2003).

The Lake system, which includes Lake Cowal, Nerang Cowal and Bogandillon Swamp covers approximately 25 500 ha and is the largest natural lake in the Lachlan Valley (Lachlan Riverine Working Group, 2014). Lake Cowal forms the terminal drainage for the Bland Creek Catchment, which is situated in an upstream area of the lake and covers approximately 400 000 ha. The lake is fringed, in the shallow northern area, with River Red Gum and a Lignum understorey. Native fish species which have been recorded within Lake Cowal include Australian Smelt (*Retropinna semoni*), Eel-tailed Catfish, Silver Perch, Golden Perch, Flathead Gudgeon (*Philypnodon grandiceps*), and Western Carp Gudgeon (*Hypseleotris klunzingeri*) (Department of Climate Change, Energy, the Environment and Water, 2019). Large numbers of many waterbird species utilise the wetland, and many species breed there. 11 species of amphibian, 30 species of reptiles, 14 species of mammal and 172 species of bird have been recorded utilising Lake Cowal (Department of Climate Change, Energy, the Environment and Water, 2019).

The land surrounding Lake Cowal is highly fragmented, with native vegetation occurring only in isolated patches and surrounded by agricultural land. Lake Cowal itself is also subject to agricultural practises, with dryland cropping occurring during dry conditions, and commercial fishing occurring during inundated conditions. In addition, aquatic and riparian habitat is generally of poor condition, with invasive exotic species dominant and habitat modification prevalent, although some areas of riparian vegetation immediately adjacent to the lake, and within the lake, are intact (Lachlan Riverine Working Group, 2014).

4.1.6.1. Threatened communities and habitats

A review of online databases indicated that no EPBC Act-listed waterways or wetlands of international significance occur within, or adjacent to, the Project (Department of Climate Change, Energy, the

Environment and Water, 2023) (Appendix C - Likelihood of). A number of significant ecosystems and nationally important wetlands are located more than 140 km downstream of Lake Cowal (Department of Climate Change, Energy, the Environment and Water, 2019) (Appendix C - Likelihood of). Lake Cowal itself is a nationally important wetland (Department of Climate Change, Energy, the Environment and Water, 2019). No threatened ecological communities (TECs) listed under the EPBC Act were identified within the vicinity of the Project. Lake Cowal also forms part of one TEC listed under the FM Act; the aquatic ecological community in the natural drainage system of the lowland catchment of the Lachlan River (Lowland Lachlan River EEC) which is listed as an endangered ecological community.

I. Lowland Lachlan River EEC

The Lowland Lachlan River EEC includes the Lachlan River downstream of the Wyangala Dam, the Belubula River downstream of the Carcoar Dam, the Boorowa River, Mandagery Creek, Goobang Creek, Crowie Creek, Lake Cowal (including Bland Creek and its tributaries), Lake Brewster, Lake Cargelligo, Willandra Creek, Moolbang Creek, Merrowie Creek and the Great Cumbung Swamp (Department of Primary Industries, 2006) (Figure 4-6). The Lowland Lachlan River EEC terminates at the confluence of the Lachlan River with the Murrumbidgee River. The majority of the lowland Lachlan River catchment comprises riverine environments characterised by meandering channels, floodplains, anabranches and effluent creeks (Department of Primary Industries, 2006). The majority of surface water flow along the Lachlan River terminates in the Great Cumbung Swamp, with substantially less flowing on to the Murrumbidgee River. The hydrology of waterways and waterbodies within the catchment is highly variable, comprising periods of high flow and low flow, resulting in the reliance of native aquatic fauna on changing water level for triggering spawning (Department of Primary Industries, 2006).

The Lowland Lachlan River EEC is comprised of a number of different habitat types, including permanent and temporary wetlands, pools, run/riffle complexes, backwaters, in-stream woody habitat and aquatic plants. The aquatic ecological community encompassed by the listing includes "*…all native fish and aquatic invertebrates within all natural rivers, creeks, streams and associated lagoons, billabongs, lakes, wetlands, paleochannels, flood-runners, floodplains and effluent streams of the Lachlan River."* (Department of Primary Industries, 2006). At least 19 fish, 10 crustacean, eight mollusc and two sponge species have been recorded, as well as numerous insects comprising resident and transient representatives (Department of Primary Industries, 2006).

A substantial cause of degradation to the Lowland Lachlan River EEC within the Lachlan River catchment is the modification of natural flow attributed to river regulation. Other factors contributing to habitat degradation include agricultural practices, removal of in-stream woody debris, modification of natural flow, and cold-water pollution from dams. Predation, diseases and competition from introduced species, as well as overfishing are also responsible for the declines of native aquatic species in the community (Department of Primary Industries 2006).

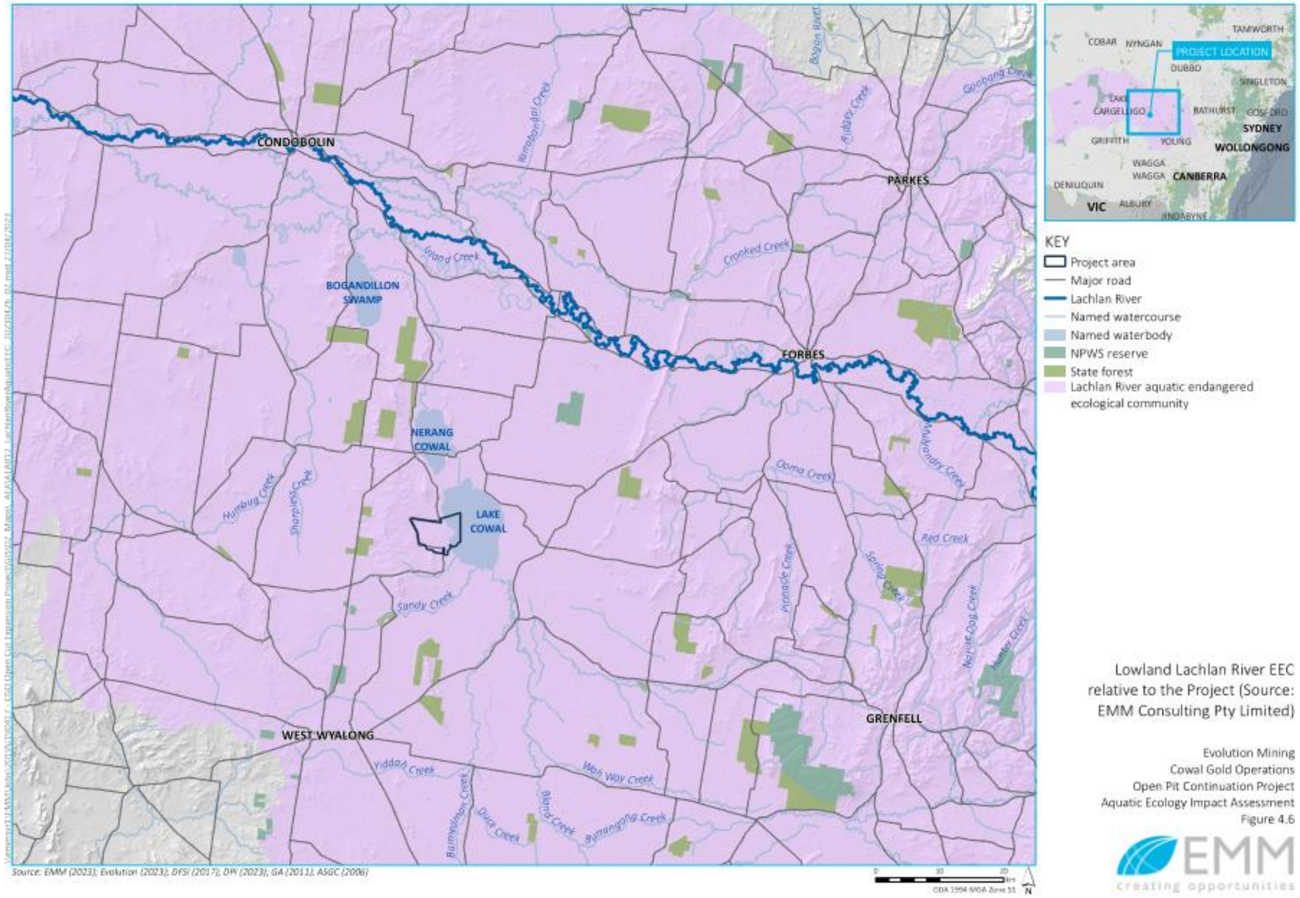

Figure 4-6: Lowland Lachlan River EEC relative to the Project (Source: EMM Consulting Pty Limited)

4.1.6.2. Key fish habitat

The key fish habitat map for the Bland, Lachlan, Forbes and Weddin Local Government Authorities (LGA) (Figure 4-7) (Department of Primary Industries 2022a) indicate that, of the waterways within the catchment (Figure 4-8), the majority are considered to contain key fish habitat, including Lake Cowal, Nerang Cowal, Manna Creek, and Bland Creek. Lake Cowal, mapped as key fish habitat (Figure 4-7) intersects the project.

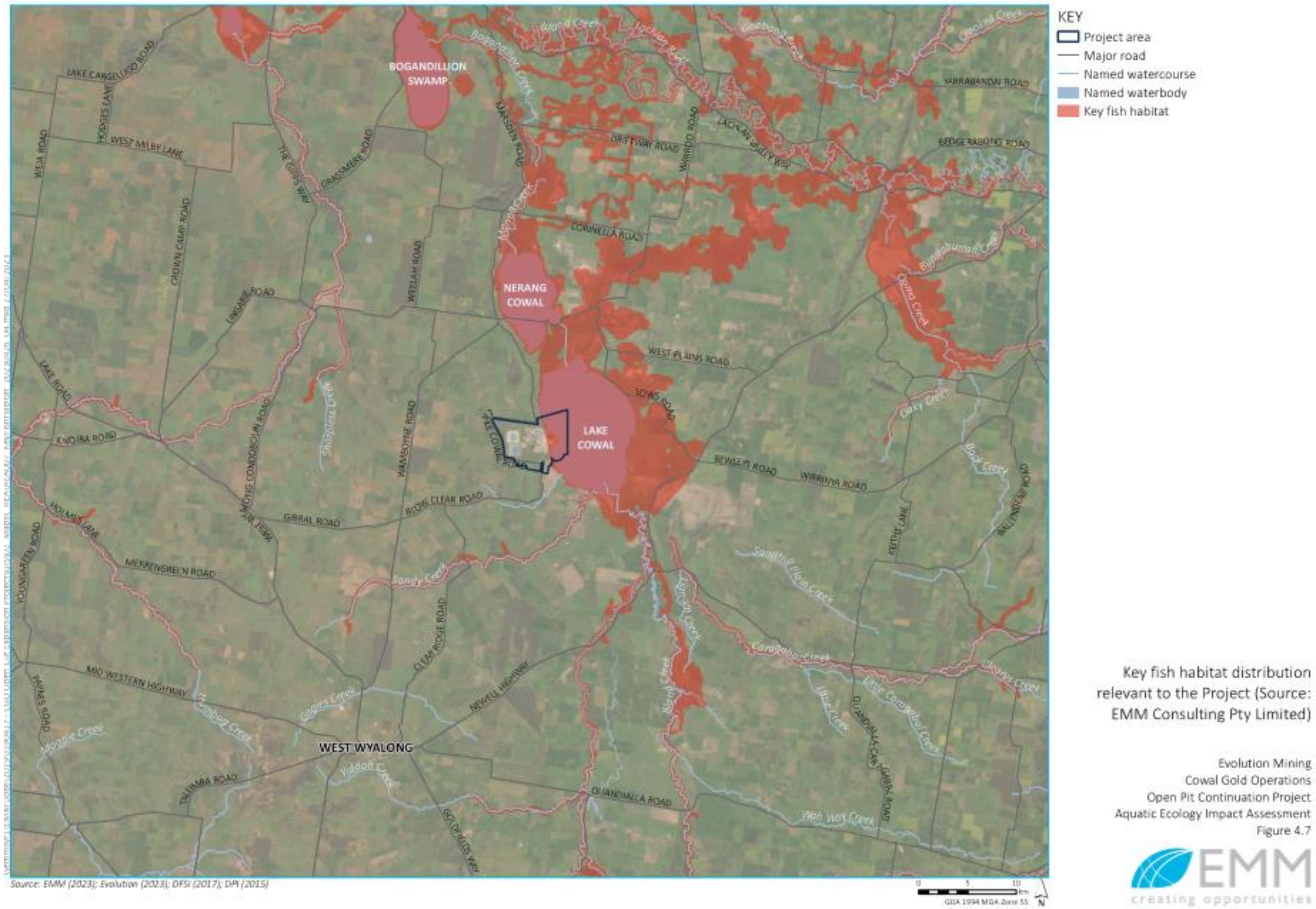

Figure 4-7: key fish habitat distribution relevant to the Project (Source: EMM Consulting Pty Limited)

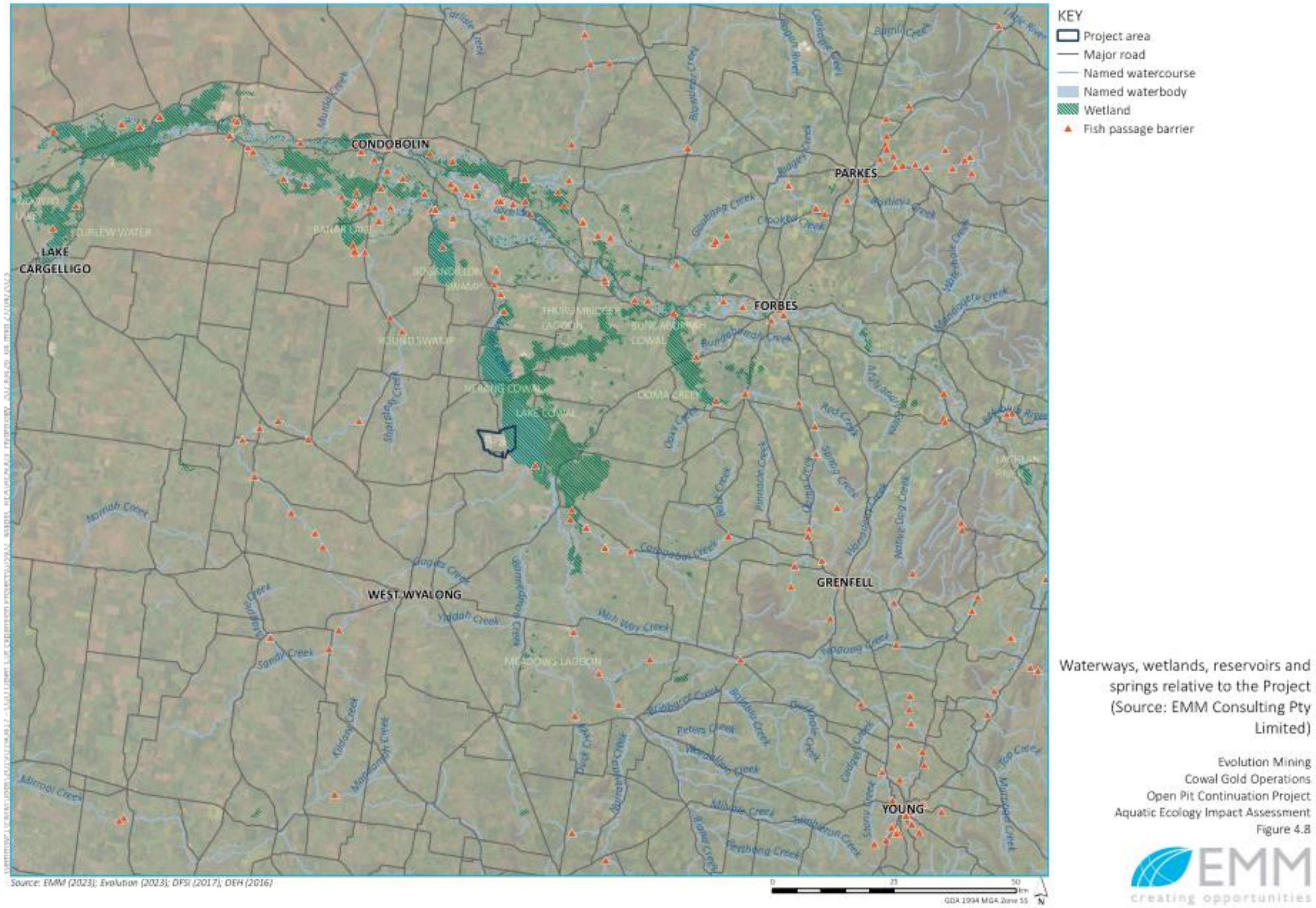

Figure 4-8 Waterways, wetlands, reservoirs and springs relative to the Project (Source: EMM Consulting Pty Limited)

4.1.7. Water and Sediment Quality

Limited information on water quality and no information on sediment quality was available for Lake Cowal. Information on water quality within Lake Cowal was limited to published Environmental Monitoring reports for Evolution Mining (Evolution Mining, 2022). Evolution Mining's (2022) reported water quality for Lake Cowal for 2022 is provided in Table 4-1. pH exceeded the ANZECC and ARMCANZ (2000) trigger values for slightly disturbed ecosystems in south-eastern Australian (freshwater lakes and reservoirs) as did electrical conductivity. No metals or metalloids exceeded the DGVs for the protection of 80% of species representative of highly disturbed systems.

Table 4-1 Water Quality for Lake Cowal as published by Evolution Mining (2022)

Water Quality Parameter	Range	ANZECC & ARMCANZ (2000) triggers		"DGVs for 80% species protection"
		Lower	Upper	
pH	6.96-9.10	6.5	8.0	-
Electrical Conductivity ($\mu S.cm^{-1}$)	166-411	20.0	30.0	-
Total Suspended Solids ($mg.L^{-1}$)	16-120	-	-	-
Alkalinity ($mg.L^{-1}$)	95-126	-	-	-
Antimony ($mg.L^{-1}$)	<0.001	-	-	0.009
Arsenic ($mg.L^{-1}$)	0.003-0.005	-	-	0.140
Cadmium ($mg.L^{-1}$)	<0.001	-	-	0.0008
Copper ($mg.L^{-1}$)	<0.001-0.002	-	-	0.003
Lead ($mg.L^{-1}$)	<0.001	-	-	0.009
Molybdenum ($mg.L^{-1}$)	<0.001	-	-	0.034
Nickel ($mg.L^{-1}$)	0.003	-	-	0.017
Selenium ($mg.L^{-1}$)	<0.01	-	-	0.03
Zinc ($mg.L^{-1}$)	<0.005	-	-	0.031

4.1.8. Aquatic Flora

One aquatic flora species, River Swamp Wallaby-grass (*Amphibromus fluitans*), Listed as Vulnerable under the EPBC Act and Vulnerable under the BC Act was reported as occurring within Lake Cowal (circa 1977) (Vestjens, 1977). No other aquatic flora species or riparian vegetation communities listed under the FM Act or the EBPC Act were identified during the desktop assessment or literature review. Limited information on aquatic flora was available for Lake Cowal. One CSIRO report from 1977 reports a number of aquatic plants occurring within Lake Cowal including: Ribbon Weed (*Vallisneria spiralis*), Water Milfoil (*Myriophyllum verrucosum*), Nardoo (*Marsilea drummondii*), Liverwort (*Ricciocarpus natans*), Bulrush (*Typha* sp.), *Azolla* sp., Slender Pondweed (*Potamogeton* sp.), Thin-leaved naiad (*Najas tenuifolia*), Water-ribbon (*Triglochin procera*), Swamp Lily (*Crinum pedunculatum*), Marsh Foxtail

(*Alopecurus geniculatus*), Pale Spike-sedge (*Eleocharis pallens*) and Common Duckweed (*Lemna minor*) (Vestjens, 1977).

4.1.9. Aquatic Fauna

DPI Fisheries provides data on the condition of freshwater fish communities in terms of distribution, diversity and abundance of native and exotic species. The status of the Lachlan River and the majority of its tributaries including Bogandillon Creek which flows north from Nerang Cowal, in the vicinity of Lake Cowal, are 'very poor', while the southern tributaries of Lake Cowal are considered "poor" (Bland Creek, Barmedman Creek) (Department of Primary Industries, 2023a). Influences contributing to these "poor" to "very poor" classifications include the introduction of exotic species, river regulation, installation of fish passage barriers, agriculture and urbanisation, and climate change.

A number of non-threatened native fish species inhabit the Lachlan River catchment, and/or Lake Cowal specifically, including the Australian Smelt, Golden Perch, Bony Bream (*Nematalosa erebi*), Flathead Gudgeon, Mountain Galaxias (*Galaxias olidus*), Murray River Rainbowfish (*Melanotaenia fluviatilis*), Fly-specked Hardyhead (*Craterocephalus stercusmuscarum*), a number of unidentified Carp Gudgeon species (*Hypseleotris* sp.), and a number of gudgeon species (Murray-Darling Basin Authority, 2012; frc Environmental, 2022; Department of Primary Industries, 2023a; Department of Environment and Heritage, 2023) (Appendix A – Database Search Summary; Appendix B - Literature Review).

In terms of commercial fisheries and fish stocking, Silver Perch and Murray Cod formed part of the commercial yield; however, it is likely that these species migrated from the Lachlan River during major flood events which facilitated connectivity of the waterbodies (EMM Consulting Pty Limited, 2020), with Lake Cowal not providing suitable habitat for these species. Golden Perch has been stocked at two places within Bland Creek, immediately upstream of Lake Cowal, and within the Lachlan River or its tributaries upstream and downstream of the confluences of Wallaroi Creek and Nerathong Creek with the Lachlan River (Department of Primary Industries, 2023b). Murray Cod have also been stocked within Gum Bend Lake at Condobolin (Department of Primary Industries, 2023b); however, it is unlikely that Gum Bend Lake maintains any connectivity with the Lachlan River or Lake Cowal.

A number of macroinvertebrates are also known from the Lachlan River catchment, and/or Lake Cowal specifically, including the Common Yabby (*Cherax destructor*), the Common Australian River Prawn (*Macrobrachium australiense*) and a species of freshwater prawn (*Atyidae* sp.) (Department of Environment and Heritage, 2023; frc Environmental, 2022) (Appendix A – Database Search Summary). Limited information was available or accessible with regard to macroinvertebrate assemblages within Lake Cowal. One aquatic invertebrate survey reported that more than 25 taxa are present within the broader Lachlan River region however only five macroinvertebrate families were present with Lake Cowal proper, with diversity and abundance determined by habitat type (e.g. Lignum, River Redgum, Cane Grass) (Gilligan, et al., 2010). Hawking (1991)) reported in NSR Environmental Consultants Pty Ltd (1995) that a total of 49 macroinvertebrate species were recorded in Lake Cowal in 1991. Further assessments undertaken by Hawking in 1995 (reported in NSR Environmental Consultants Pty Ltd (1995)) reported only 25 species were present within Lake Cowal. These variances in abundance are likely due to variations in the quantity of water present within Lake Cowal at the time, which will have flow on effects with regard to the quantity and quality of available habitat. The Sustainable Rivers Audit 2 reports macroinvertebrate health for the Lachlan River Valley as 'moderate' with 63 macroinvertebrate families recorded across 35 sites and a mean of 27 families present at each site. The ten most common macroinvertebrate taxa recorded are as follows: *Chironominae* were reported as the most prevalent taxa recorded followed by *Corixidae*, *Leptoceridae*, *Tanypodinae*, *Dytiscidae*, *Veliidae*, *Ceratopogonidae*, *Hydrophilidae*, *Notonectidae* and *Acarina* (Murray-Darling Basin Authority, 2012).

Exotic aquatic fauna species known from the Lachlan River catchment, and/or Lake Cowal specifically, include the Brown Trout (*Salmo trutta*), Common Carp (*Cyprinus carpio*), Eastern Gambusia (*Gambusia holbrooki*), Goldfish (*Carassius auratus*), Rainbow Trout (*Oncorhynchus mykiss*), Tench (*Tinca tinca*) and Redfin Perch (*Perca fluviatilis*) (Murray-Darling Basin Authority, 2012; Department of Environment and Heritage, 2023; Gilligan, et al., 2010; frc Environmental, 2022; Department of Primary Industries, 2023c). Redfin Perch was likely deliberately introduced to the upper Lachlan River catchment and was discovered by the DPI Fisheries in 2006 (Department of Primary Industries, 2023c). The Redfin Perch is listed as a Class 1 noxious fish under the FM Act and the Common Carp is listed as a Class 3 noxious fish, while the Eastern Gambusia is listed as a pest in NSW (Department of Primary Industries, 2023c; Department of Primary Industries, 2023d)

4.1.10. Threatened Aquatic Fauna

The results of the desktop assessment and literature review indicate that 10 threatened aquatic species or species comprising a threatened population, listed under the FM Act and/or the EPBC Act, and the Platypus have the potential to occur in waterways associated with the Lachlan River catchment (Murray-Darling Basin Authority, 2012; Department of Environment and Heritage, 2023; frc Environmental, 2022; Department of Primary Industries, 2023a) (Appendix A – Database Search Summary; Appendix B - Literature Review).

- Southern Purple-spotted Gudgeon (*Mogurnda adspersa*);
- Flathead Galaxias;
- Murray Hardyhead;
- Silver Perch;
- Murray Cod;
- Macquarie Perch (*Macquaria australasica*);
- Western population of Olive Perchlet;
- Murray-Darling Basin population of Eel-tailed Catfish;
- Hanleys River Snail (*Notopala hanleyi*); and
- Platypus.

Of these species, the Platypus, the Flathead Galaxias and the Macquarie Perch are included on the DCCEEW (2020) provisional list of animal species identified as requiring urgent management intervention following the 2019/2020 bushfire season.

The Southern Purple-spotted Gudgeon is listed as endangered under the FM Act, while the western population of Olive Perchlet and the Murray-Darling Basin population of Eel-tailed Catfish are listed as endangered populations under the FM Act. Murray Cod is not listed under the FM Act but is listed as vulnerable under the EPBC Act. While the Platypus is not currently listed under the FM Act or the EPBC Act, there is currently a lack of knowledge regarding species abundance at a local catchment level (Australian Museum, 2022) and the species is subject to similar impacts as threatened fish, including waterway bank erosion, channel sedimentation, regulated waterways, barriers to water flow (eg dams and weirs), riparian zone degradation and loss of riparian vegetation (Grant & Temple-Smith, 2003; Bino, et al., 2019).

An assessment was undertaken to evaluate the likelihood of each of these threatened aquatic species occurring within waterways intersecting the Project, or downstream of the Project, based on the aquatic habitats likely to be present as well as existing literature and Department of Primary Industries (Fisheries) datasets (Department of Climate Change, Energy, the Environment and Water, 2023; Department of Environment and Heritage, 2023; Department of Primary Industries, 2023a; Department of Primary Industries, 2020; frc Environmental, 2022) (Appendix A – Database Search Summary; Appendix B - Literature Review). Of the 10 species, none have been reported as occurring within Lake Cowal within the last 10 years (Department of Environment and Heritage, 2023); however, DPI Fisheries data indicates that three fish species have the potential to occur within, immediately upstream, or downstream of Lake Cowal, and therefore have the potential to be impacted by the Project (Figure 4-9). The NSW Bionet reports one record for Platypus occurred within Lake Cowal in 1997 however this is likely an errant record as no habitat for Platypus occurs within Lake Cowal and the nearest Platypus records outside of Lake Cowal occur approximately 72 km northwest of Lake Cowal, east of the township of Bogan Gate; approximately 90 km east of Lake Cowal in Conimbla National Park; and 106 km southeast in the town of Young (Department of Environment and Heritage, 2023). It is considered unlikely that Platypus occurs within Lake Cowal and this species is not considered further in this report.

The likelihood of occurrence assessment is provided in Appendix C - Likelihood of , and summaries of the ecology of the three species with the potential to occur are provided in subsequent sections.

Table 4-2: Threatened species with the potential to occur within, or downstream of, Lake Cowal

Family	Common name	Scientific name	Data source				Conservation status		LoO
			DPI	BioNet	PMST	Lit.	FM Act	EPBC Act	
Fish									
Ambassidae	Western population of Olive Perchlet	*Ambassis agassizii*	✓	-	-	-	EP	-	Unlikely
Eleotridae	Southern Purple-spotted Gudgeon	*Mogurnda adspersa*	✓	-	-	-	E	-	Unlikely
Galaxiidae	Flathead Galaxias	*Galaxias rostratus*	✓	-	✓	-	CE	CE	Unlikely

Note: LoO = Likelihood of occurrence; CE = Critically Endangered; E = Endangered, EP = Endangered population.

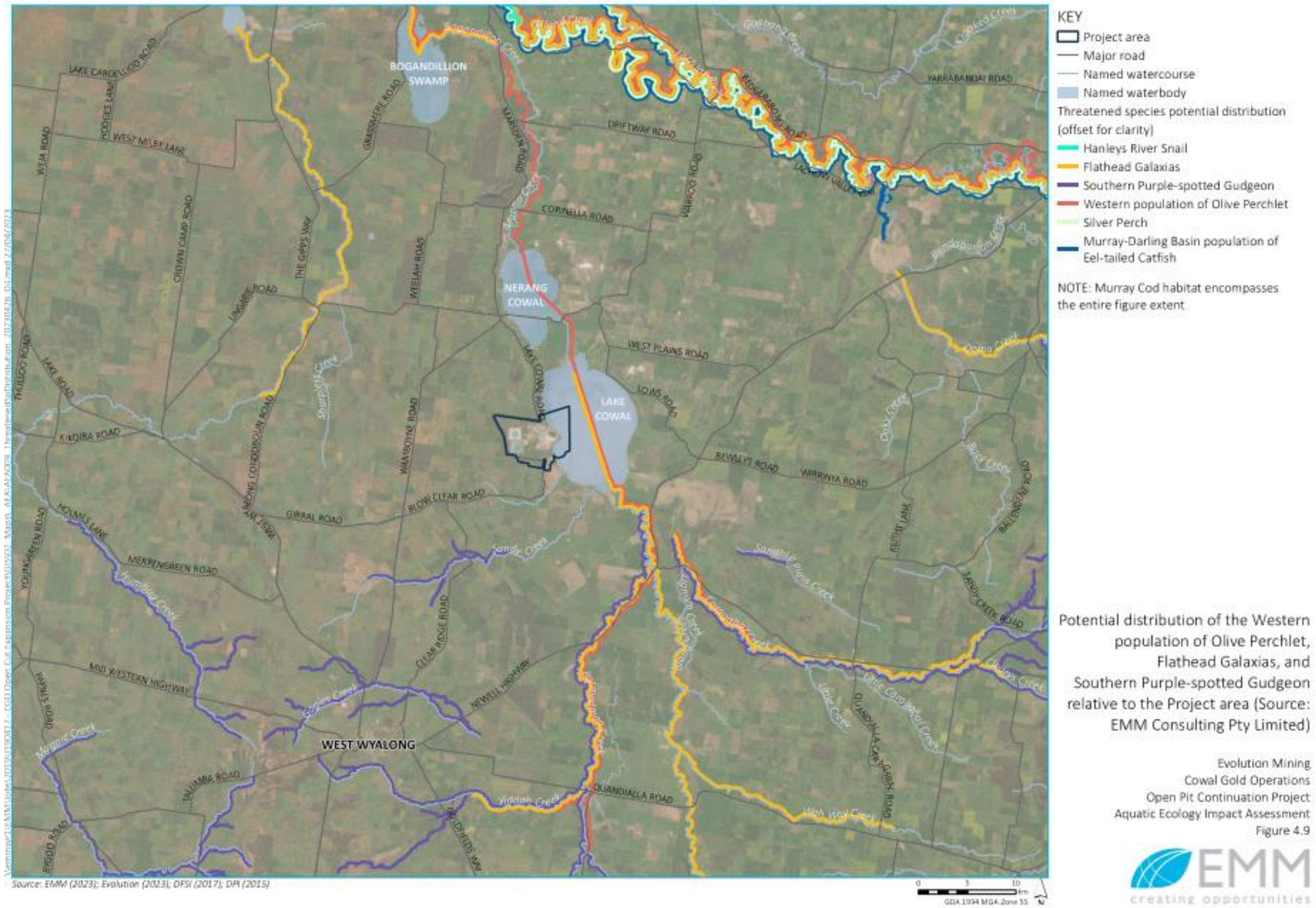

Figure 4-9: Potential distribution of the Western population of Olive Perchlet, Flathead Galaxias, and Southern Purple-spotted Gudgeon relative to the Project area (Source: EMM Consulting Pty Limited)

I. Western population of Olive Perchlet

The Olive Perchlet is a small fish that occurs in Murray Darling Basin catchments and coastal catchments, although they are considered to be genetically different between catchments. This species was initially widespread through the Murray Darling Basin within South Australia, Victoria, western NSW and southern Qld; however, it is currently only found at a few sites along the Darling River and associated waterways. Olive Perchlet inhabits rivers, creeks, ponds and swamps containing slow-flowing or still water among sheltered areas containing overhanging vegetation, aquatic macrophytes, logs, dead branches and boulders. This species may grow to a maximum of 80 mm but it generally approximately 40 mm or less. The species is carnivorous, consuming terrestrial and aquatic invertebrates (particularly microcrustaceans) and small fish (Lintermans, 2017). Both sexes live for between two and four years and mature at one year of age. They spawn during October though to December when water temperatures reach approximately 23° C. Females lay up to 700 eggs which they attach to aquatic plants and rocks on the waterway bed. Predation, by Eastern mosquitofish and Redfin Perch, and habitat degradation are key factors contributing to decline of the species. River regulation and water release from dams resulting in fluctuating water level, cold water pollution and a loss of aquatic macrophytes, impacting on reproduction and recruitment (spawning failures). The presence of the Common Carp is also known to degrade aquatic vegetation on which the Olive Perchlet depend. Given the ephemeral nature of Lake Cowal, the high abundance of exotic species known to degrade habitat for this species and the modified nature of the land around Lake Cowal it is considered unlikely that the species occurs within Lake Cowal.

II. Flathead Galaxias

The species is generally found mid-water in still and gently moving waters of small streams, lakes, lagoons, billabongs and backwaters. Habitat preferences comprise coarse sand or mud substrate and aquatic vegetation, where it feeds on aquatic insects and crustaceans. The Flathead Galaxias is endemic to the southern tributaries of the Murray-Darling River system, particularly the Murray, Murrumbidgee and Lachlan rivers and their tributaries, and the upper Macquarie-Bogan rivers catchment (Lintermans, 2017). The Flathead Galaxias has experienced significant declines in distribution and abundance in all river systems in NSW. Extensive scientific sampling over the last two decades has recorded extremely few specimens. The last record in the Murrumbidgee River is from 1971, and it is thought that the species may be locally extinct from the lower Murray, Murrumbidgee, Macquarie and Lachlan rivers. In addition, only very small numbers of specimens have been sampled from wetlands of the Murray River floodplain between Hume Dam and Lake Mulwala and the upper Murray River near Tintaldra. During periods of major flooding and inundation, muddy substrates and aquatic vegetation may be present within Lake Cowal, and this may provide suitable habitat for this species. It should be noted that the Flathead Galaxias was added to the DCCEEW (2020) provisional list of animal species that have been identified as requiring immediate urgent management intervention, following the 2019/2020 bushfire season in southern and eastern Australia.

The DPI Fisheries predicts that the Flathead Galaxias has the potential to occur within Lake Cowal, immediately upstream of Lake Cowal within Bland Creek and Barmedman Creek, and downstream within Bogandillon Creek and the Lachlan River (Department of Primary Industries, 2023a). The PMST indicates that the “species or species habitat may occur within the area” (Department of Climate Change, Energy, the Environment and Water, 2023). Available literature suggests that there is also the potential for occurrence; however, there is no evidence that demonstrates occurrence within Lake Cowal of its tributaries in recent years. Lintermans (2017) indicates that records for the species exist prior to 1980 within the Lachlan River catchment. While suitable habitat for the Flathead Galaxias likely occurs within Lake Cowal, it is considered unlikely that the Flathead Galaxias occurs, particularly given the ephemeral nature of Lake Cowal and the current agricultural land use of the lake.

III. Southern Purple-spotted Gudgeon

The Southern Purple-spotted Gudgeon prefers slow-flowing or still water with a substantial amount of macrophyte coverage or a rocky benthos (Department of Primary Industries, 2017), and is a benthopelagic feeder on larvae and small fish. This species is known to occur in quite shallow water; however, fluctuations in water volume/flow (affecting water level) as a result of river regulation have the potential to impact on important wetland habitat used for reproduction and recruitment. The Southern Purple-spotted Gudgeon requires a specific temperature range (19 °C-34 °C) for spawning, with water releases a potential impact to its lifecycle if released during late winter or early spring (cold water pollution, turbidity). This species requires solid substrates near vegetation on which to lay their eggs. Recent population decline is attributed to competition for resources with exotic species, habitat degradation, river regulation, cold water pollution and fishing pressure, with the Southern Purple-spotted Gudgeon subject to competition from the Eastern mosquitofish and predation by Redfin Perch (Department of Primary Industries, 2023e). The Southern Purple-spotted Gudgeon is currently considered to be extremely rare in inland NSW and has only been recorded once since 1983 (Department of Primary Industries, 2017). Limited, low quality habitat for Southern Purple-spotted Gudgeon is present in the vicinity of the study area. Based on the lack of habitat, the presence of exotic species known to degrade habitat for Southern Purple-spotted Gudgeon or compete for resources, the ephemeral nature of Lake Cowal and the highly modified land use around Lake Cowal it is considered unlikely that the species is present in the vicinity of the study area.

4.1.11. Groundwater Dependent Ecosystems

A detailed Groundwater assessment has been prepared by EMM Consulting Pty Limited as part of the EIS process. Please see *Cowal Gold Operation - Open Pit Continuation Project: Groundwater Impact Assessment* (EMM Consulting Pty Limited, 2023b) for the results of the groundwater assessment.

5. Field Survey Results

5.1. Key Fish Habitat and Habitat Characterisation

The results of the key fish habitat assessments undertaken at eight sites during the November 2020 field survey are discussed below. General habitat characteristics of each site are summarised in Table 5-1.

All sites were classified as Type 1 highly sensitive key fish habitat and Class 1 major key fish habitat. Type 1 highly sensitive key fish habitat classifications for all sites were assigned due to the sites containing in-stream snags or native aquatic plants, and the potential for the waterway to provide habitat for threatened aquatic species (ie Olive Perchlet, Southern Purple-spotted Gudgeon and Flathead Galaxias). It should be noted that classifications based on these features are considered conservative, as both waterways were generally defined by a cleared riparian zone; and structures providing in-stream habitat comprised of relatively sparse large snags and aquatic plants (Figure 5-1). Although sparse habitat features and very shallow surface water characterised Lake Cowal, all sites contained within it remained classified Type 1 highly sensitive key fish habitat due to the lake's listing in the Directory of Important Wetlands of Australia. It should be noted; however, site LC01 comprised of a dam with no surface water connectivity to Lake Cowal and although marginal habitat was present, passage into and out of the dam does not exist (Figure 5-2). Classification of this site is highly conservative when based on providing habitat for threatened species.

All sites within Lake Cowal and Bland Creek were classified as Class 1 major key fish habitat for fish passage primarily due to potentially containing habitat of a threatened or protected fish species. Bland Creek was also classified as a Class 1 major key fish habitat due to presenting a "…*permanently flowing or flooded freshwater waterway*…". As Lake Cowal holds surface water ephemerally it was not classified as a Class 1 major key fish habitat. Lake Cowal and Bland Creek contain slow flowing waters and cover from emergent vegetation and snags of which are important habitat features of the Olive Perchlet, Southern Purple-spotted Gudgeon and Flathead Galaxias. Whilst the waterways could provide habitat during periods of inundation, it is considered that the classification as Class 1 major key fish habitats is conservative, as these habitat features lack complexity and are generally sparse (particularly large instream woody debris). During periods of significant inundation Lake Cowal may also provide important fish passage for threatened species; however, it should be noted that a Block Dam at the confluence of Bland Creek to Lake Cowal presents a complete barrier to fish passage downstream, and a number of impoundments, including the Bogandillon Partnership Dam, are fish barriers to the Lachlan River further upstream.

Of the Type 1 highly sensitive key fish habitat and Class 1 major key fish habitat waterways in Lake Cowal, LC01 and LC02 will be subject to direct impacts as a result of construction and operation of the project.

Table 5-1: Habitat characteristics at each aquatic ecology site assessed during the November 2020 field survey.

Waterway	Project component	Site	Strahler (1952) order	Key fish habitat: Waterway type	Key fish habitat: Waterway class	Description
Bland Creek	Indirect impact area	BC01	7th	Type 1	Class 1	Slow flowing to standing turbid water approximately 0.5 m - 2 m deep. Banks and sediment are comprised of clay, sand and mud with a primarily cleared riparian zone. Riparian vegetation consists of pasture grasses and remnant trees, some trailing the water edge. Large woody debris from fallen trees along the bank edges present important habitat for aquatic species. Macrophytes were not observed, however, trailing terrestrial grasses may also provide refuge and spawning habitat.
Lake Cowal	Direct impact area	LC01	7th	Type 1	Class 1	A dam of standing, semi-turbid water to approximately 0.5 m deep. Embankments and bed sediment are comprised of clay with areas of sand and pebbles. Riparian condition is predominantly cleared, with few remnant trees close to the bank edges. *Eleocharis* sp. on bank edges present some trailing and emergent in-stream vegetation that may provide refuge and spawning habitat for aquatic species. Lake Cowal is adjacent to the site; however, no passage into, or out of, the dam exists for aquatic fish species.
	Direct impact area	LC02	7th	Type 1	Class 1	Clear shallow standing water to approximately 0.1 m deep over a clay and sand sediment. No banks are present at the site. Riparian vegetation is cleared, comprising of remnant trees some distance away from the water's edge. Inundated vehicle access tracks and terrestrial grasses dominate the site. Two macrophyte species, *Chara* sp. and *Marsilea* sp., were recorded. The emergent vegetation, though terrestrial dominated, could provide breeding and refuge habitat for aquatic species.
	Indirect impact area	LC03	7th	Type 1	Class 1	Shallow clear standing water to approximately 0.2 m deep over a mud sediment. No banks are present at the site. Riparian vegetation is cleared, comprising of remnant trees some distance away from the water's edge. Inundated vehicle access tracks and terrestrial grasses dominate the site. One macrophyte species, *Eleocharis* sp., was recorded. The emergent vegetation, though terrestrial dominated, could provide breeding and refuge habitat for aquatic species.
	Indirect impact area	LC04	7th	Type 1	Class 1	Shallow, turbid standing water approximately 0.15 m deep over a clay, mud and sand sediment. No banks are present at the site. Riparian zone is very gradual, owing to the floodplain nature of the site and consists of mostly cleared land for agricultural purposes with remnant trees. The site is dominated by inundated terrestrial grasses with some *Eleocharis* sp. and emergent living and standing dead trees adjacent to the site. Algae was observed on the surface of the water. The emergent vegetation, though terrestrial dominated, could provide breeding and refuge habitat for aquatic species.
	Indirect impact area	LC05	7th	Type 1	Class 1	Clear shallow standing water to approximately 0.2 m deep over a clay and sand sediment. Some pebbles and cobbles were present in small areas at the site. No banks are present at the site. Riparian vegetation is cleared, comprising of remnant trees some distance away from the water's edge. Inundated terrestrial grasses dominate the site. One macrophyte species, *Eleocharis* sp. was recorded. The emergent vegetation, though terrestrial dominated, could provide breeding and refuge habitat for aquatic species.
	Indirect impact area	LC06	7th	Type 1	Class 1	Shallow, turbid standing water approximately 0.1 m deep over a clay, mud and sand sediment. No banks are present at the site. Riparian zone is very gradual, owing to the floodplain nature of the site and consists of mostly cleared land for agricultural purposes with remnant trees further away from the site. The site itself is dominated by recently inundated terrestrial grasses with some *Eleocharis* sp. as well as standing and fallen dead trees. The emergent vegetation, though terrestrial dominated, could provide breeding and refuge habitat for aquatic species during times of inundation.
	Indirect impact area	LC07	7th	Type 1	Class 1	Turbid shallow standing water to approximately 0.05 m deep over a clay, mud and sand sediment. No banks are present at the site. Riparian vegetation is cleared, comprising of remnant trees some distance away from the site as well as from the water's edge. Water is present only within inundated vehicle access tracks and terrestrial grasses dominate the site. *Eleocharis sp.* was recorded. The emergent vegetation, though terrestrial dominated, could provide marginal breeding and refuge habitat for aquatic species during times of inundation.

Figure 5-1: Inundated terrestrial grasses with occasional *Eleocharis* sp. typical at sites within Lake Cowal during the November 2020 field survey

Figure 5-2: Dam at site LC01 containing no fish passage into or out of Lake Cowal

5.2. Water Quality

During the November 2020 field survey, the pH of surface water ranged from circumneutral (pH 7.1 at Bland Creek) to alkaline (pH 8.6 at Lake Cowal, Site 6) (Table 5-2). A total of 3 sites were above the upper limit of the ANZECC and ARMCANZ (2000) guideline trigger, all recorded in Lake Cowal (LC02, LC04 and LC06) (Table 5-2). The remaining sites were within the trigger values. The alkaline surface water recorded at Lake Cowal may be influenced by groundwater associated with the area. Overall, pH varied slightly between sites (Table 5-2).

The salinity of surface water (measured as Electrical Conductivity (EC)) at all sites was classified as fresh, with EC ranging from 485 µS/cm (LC01) to 1,340 µS/cm (LC06) (Table 5-2). EC exceeded the ANZECC and ARMCANZ (2000) trigger values of 30 µS/cm at all sites (Table 5-2). Overall, salinity measured higher in Lake Cowal than in Bland Creek, with the average salinity of sites within Lake Cowal totalling 724 µS/cm in comparison to 526 µS/cm. Site L06 had a substantially higher EC reading of 1,340 µS/cm compared to all other surveyed sites. Freshwater wetlands, such as Lake Cowal, may be saline seasonally as water evaporates over the long hot dry season and may explain why higher salinity was observed within these sites. While higher observations of salinity were observed in Lake Cowal, all sites were exceeded the trigger values (Table 5-2).

Contributing to salinity, the major ions recorded in surface water included sodium, magnesium, chloride and bicarbonate, with sodium and chloride the dominant ions. The ionic balance generally followed

Na>Ca>K>Mg for cations and HCO_3>Cl>SO_4 for anions (Table 5-2). Concentrations of major ions were variable both within and between waterways, with differences in ionic dominance likely occurring in response to various factors such as evapo-concentration, salinity, and local geology and hydrogeology (Boulton and Brock 1999).

Dissolved Oxygen concentrations were well below the ANZECC & ARMCANZ lower trigger value of 90 percent across all sites. Concentration of dissolved oxygen is known to vary with water temperature, salinity, photosynthetic acidity and microbial activity, and over short time periods of as little as twenty-four hours, particularly in systems where there is significant nutrient enrichment. Temperatures were generally high across both waterways. Sites at Lake Cowal varied significantly in temperature, with the highest recorded at LC04 (39°C) and the lowest temperature at LC07 (21.9°C) (Appendix F). Overall, Bland Creek was 2.5°C lower in temperature compared to the average temperature recorded at Lake Cowal (30.1°C). Seasonal variation and the time of the day sites were sampled during the field survey likely contributed to the range of temperatures and dissolved oxygen observed between sites.

Surface water turbidity varied amongst sites. Lake Cowal contained both the lowest and highest recordings, at 6.5 NTU (LC01) to 80.8 NTU (LC07) (Table 5-2). Turbidity exceeded the ANZECC & ARMCANZ maximum trigger value of 20 NTU at five sites within Lake Cowal (Table 5-2). Most Australian inland waters can experience naturally high turbidity due to extremely old land masses and highly clayey soils; however, extensive clearing for the widespread agricultural land uses in the locality is likely to have contributed to the significantly high turbidity observed within the lake. Despite the dominating land use, Bland Creek was recorded to be well within the ANZECC & ARMCANZ guidelines for turbidity (Table 5-2).

Concentrations of total nitrogen ranged from 1.9 mg/L (Bland Creek, BC01) to 16.5mg/L (Lake Cowal, LC06) (Table 5-2). The higher total nitrogen concentration recorded at Lake Cowal, particularly LC06, is likely attributed to its proximity to agricultural land and a lack of riparian vegetation or aquatic plants. Although higher values of nitrogen were observed in Lake Cowal, all sites were well within ANZECC & ARMCANZ guidelines.

Concentrations of total phosphorus across all sites were within ANZECC & ARMCANZ guidelines, ranging from 0.11mg/L (Lake Cowal, LC05) to 1.8mg/L (Lake Cowal, LC01). Concentrations of both dissolved and total organic carbon were consistently higher in comparison to nitrogen and phosphorus across the sites ranging from 21% (Bland Creek, BC01) to 170% (Lake Cowal, LC06) (Table 5-2).

Concentrations of dissolved metals and trace elements were generally either below the analytical limit of reporting or within ANZECC & ARMCANZ guideline trigger values with the exception of copper concentrations 0.003 and 0.004 (Sites LC04 and LC06 respectively), and a vanadium concentration of 0.01 (Site LC06) (Table 5-2).

Table 5-2: Water quality parameters recorded during the November 2020 field survey

Water quality parameters		Direct impact area		Indirect impact area						ANZECC & ARMCANZ (2000) triggers		"DGVs for 80% species protection"
		Lake Cowal		Bland Creek	Lake Cowal							
		LC01	LC02	BC01	LC03	LC04	LC05	LC06	LC07	Lower	Upper	
Basic	pH (units)	7.6	8.3	7.1	7.7	8.5	8.0	8.6	7.8	6.5	8.0	-
	Total Dissolved Solids	372	384	352	465	532	438	1,100	602	-	-	-
	Electrical Conductivity (µS/cm)	485	545	526	625	714	593	1,340	764	20.0	30.0	-
	Suspended Solids	14	55	21	74	114	35	104	196	-	-	-
	Turbidity (NTU)	6.5	27.4	11.9	39.3	29.8	10.6	57.2	80.8	1.0	20.0	-
	Dissolved Oxygen (%)	9.3	9.7	9.2	9.0	9.4	9.3	8.4	7.2	90.0	110.0	-
Major Ions	Sodium	32	35	45	68	93	53	218	96	-	-	-
	Calcium	36	38	27	30	19	31	29	24	-	-	-
	Potassium	19	22	14	23	28	19	51	29	-	-	-
	Magnesium	16	18	18	19	21	18	31	21	-	-	-
	Bicarbonate	210	222	158	258	247	236	408	292	-	-	-
	Chloride	24	38	66	43	60	41	164	58	-	-	-
	Sulphate	<1	<1	7	<1	<1	<1	<1	<1	-	-	-
	Carbonate	<1	<1	<1	<1	16	<1	48	<1	-	-	-
	Hydroxide	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-

	Alkalinity (total)	210	222	158	258	263	236	456	292	-	-	-
Nutrients	Nitrogen (total)	2.3	2.5	1.9	3.3	4.6	3.0	16.5	8.2	-	350.0	-
	Kjeldahl Nitrogen (total)	2.3	2.5	1.9	3.3	4.6	3.0	16.5	8.2	-	-	-
	Ammonia	0.24	0.03	0.09	0.09	0.05	0.03	0.48	0.19	-	10.0	2.30
	Nitrite	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	10.0	-
	Nitrate	<0.01	0.01	0.02	0.04	0.03	0.01	<0.01	<0.01	-	10.0	-
	Nitrite + Nitrate	<0.01	0.01	0.02	0.04	0.03	0.01	<0.01	<0.01	-	-	-
	Phosphorus (total)	1.80	0.13	0.26	0.17	0.23	0.11	0.76	0.83	-	10.0	-
	Organic Carbon (%)	28	29	21	36	49	37	170	70	-	-	-
Metals	Arsenic	0.019	0.020	0.004	0.007	0.012	0.006	0.068	0.020	-	-	0.140
	Barium	0.032	0.032	0.062	0.091	0.098	0.073	0.162	0.063	-	-	-
	Beryllium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-
	Boron	0.16	0.15	0.06	0.16	0.24	0.12	0.37	0.22	-	-	1.30
	Cadmium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	-	0.0008
	Chromium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	0.040
	Cobalt	0.001	0.001	<0.001	<0.001	0.002	<0.001	0.005	0.002	-	-	-
	Copper	0.001	0.002	<0.001	0.001	0.003	<0.001	0.004	<0.001	-	-	0.003
	Iron	<0.05	<0.05	<0.05	<0.05	<0.05	0.31	0.16	0.37	-	-	-
	Lead	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	0.009
	Manganese	0.381	0.356	0.071	0.008	0.011	0.010	0.023	0.052	-	-	3.600
	Mercury	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	-	0.0054
	Nickel	0.005	0.006	0.004	0.003	0.004	0.002	0.013	0.003	-	-	0.017

Selenium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	0.03
Vanadium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	-	-	0.01
Zinc	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-	0.031

Notes: All parameters are dissolved unless otherwise specified; all; units are mg/L unless otherwise specified; DGV for arsenic is AsV; DGV for chromium is CrVI; DGV for mercury is inorganic; DGV for selenium is total; DGV species protection level for vanadium is unknown; parameters are dissolved unless otherwise stated; brown shading indicates values below the lower limit and pink shading indicates values above the upper limit of either the ANZECC and ARMCANZ (2000) trigger values for slightly disturbed ecosystems in south-eastern Australian (freshwater lakes and reservoirs); DGVs are for the protection of 80% of species representative of highly disturbed systems.

5.3. Sediment Quality

During the November 2020 field survey, sediment pH ranged from 7.2 (site LC01) to 8.2 (site LC06) (Table 5-3) and can classified as moderately alkaline (Hazelton & Murphy, 2007). pH was also comparable to surface water pH with the maximum value of both being recorded at site LC06. Groundwater associated with the area, as well as a range of natural hydrogeochemical processes including concentrations of carbonates and organic matter, and redox reactions, can influence sediment pH (Ponnamperuma 1972). Changes in sediment pH are considered important due to the effects on the bioavailability of, and toxicity of metals to, aquatic biota (Shaheen, et al., 2019).

Salinity (measured as total soluble salts, TSS) ranged from 216 mg/kg (LC01) to 975 mg/kg (LC06) with a mean across the 8 sites of 505 mg/kg (Table 5-3). The high salinity concentrations are likely attributed to runoff from surrounding agricultural areas as well as the lack of flow contributing to the waterbody increasing concentrations over time. Calcium and potassium were the dominant ions recorded in sediment, on average; however, magnesium also experienced high concentration recordings across most sites (Table 5-3). The moisture content of sediment ranged from 33 percent (site LC05) to 56 percent (site LC06) across sites, potentially attributed to clayey sediment likely to repel water observed at site LC05 compared to spongier sediment with a higher degree of organic matter observed at site LC06.

Concentrations of total nitrogen and total phosphorus ranged from 510 mg/kg (LC02) to 2,910 mg/kg (LC01) and 90 mg/kg (LC02) to 781 mg/kg (LC01), respectively, with the highest concentrations of total nitrogen and total phosphorus recorded at Lake Cowal (LC01) (Table 5-3). This is attributed to the dominant land use of the surrounding area, being widespread agricultural, as well as the absence of a riparian zone. Riparian vegetation, and some groundcover, is known to filter runoff from the surrounding catchment and take up some nutrients and metals, reducing sediment and nutrients loads within waterways (Sheridan, Lowrance, & Bosch, 1999). Concentrations of total nitrogen and total phosphorus were high across all sites with the exception of site LC02, which recorded the lowest concentrations of total nitrogen and total phosphorus which is likely to be a result of its separation from the main waterbody of the Lake. Sediment is known to accumulate nutrients through deposition and decay of organic matter, with deposition occurring during low flow conditions, and nutrient release occurring under subsequent high flow events (Ockden, Deasy, Quinton, Surridge, & Stoate, 2014).

The concentration of metals was variable across sites during the November 2020 field survey; however, six parameters were below the limit of analytical reporting at all sites (Arsenic, beryllium, boron, cadmium, mercury, selenium) (Table 5-3). All metals that had an ANZECC and ARMCANZ (2000) ISQG trigger value were within their respective trigger value (Table 5-3) across all sites.

Table 5-3: Sediment quality parameters recorded during the November 2020 field survey

Sediment quality parameters		Direct impact area			Indirect impact area					DGV's	
		Lake Cowal		Bland Creek	Lake Cowal						
		LC01	LC02	BC01	LC03	LC04	LC05	LC06	LC07	DGV	DGV-high
Basic	pH (pH unit)	7.2	7.3	7.3	8.0	7.5	7.8	8.2	7.9	-	-
	Total Soluble Salts	216	509	294	365	637	377	975	667	-	-
	Moisture Content (%)	54	39	43	46	44	33	56	48	-	-
Major Ions	Calcium	2,480	2,100	1,420	2,200	1,080	840	3,630	1,690	-	-
	Potassium	2,630	1,910	1,520	2,670	1,190	1,030	2,680	1,690	-	-
	Magnesium	780	1,270	1,420	1,880	780	720	1,750	1,080	-	-
	Sodium	140	150	140	200	140	80	500	220	-	-
	Chloride	20	30	40	30	50	20	180	50	-	-
	Sulphate	20	<10	<10	<10	<10	<10	20	<10	-	-
Nutrients	Nitrogen	2,910	510	1,190	1,210	1,040	1,160	2,640	2,100	-	-
	Kjeldahl Nitrogen	2,910	510	1,190	1,210	1,040	1,160	2,640	2,100	-	-
	Nitrite + Nitrate	0.2	<0.1	0.1	0.3	0.2	0.1	0.2	0.2	-	-
	Phosphorus	781	90	244	178	123	166	341	259	-	-

	Organic Carbon (%)	3.41	0.95	1.40	0.88	1.52	0.80	2.47	2.08	-	-
Metals	Arsenic	<5	<5	<5	<5	<5	<5	<5	<5	20	70
	Barium	90	60	40	70	40	40	70	50	-	-
	Beryllium	<1	<1	<1	<1	<1	<1	<1	<1	-	-
	Boron	<50	<50	<50	<50	<50	<50	<50	<50	-	-
	Cadmium	<1	<1	<1	<1	<1	<1	<1	<1	2	10
	Chromium	15	9	9	13	5	6	10	7	80	370
	Cobalt	6	3	4	5	2	2	4	3	-	-
	Copper	19	8	7	15	<5	6	10	8	65	270
	Iron	11,000	7,160	7,840	9,480	3,970	5,910	7,480	5,120	-	-
	Lead	10	<5	7	7	<5	<5	6	<5	50	220
	Manganese	499	139	233	184	122	49	191	117	-	-
	Mercury	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	1.0
	Nickel	11	5	6	9	4	4	8	5	21	52
	Selenium	<5	<5	<5	<5	<5	<5	<5	<5	-	-
	Vanadium	31	20	17	27	10	17	19	14	-	-
	Zinc	35	10	12	16	8	7	14	13	200	410

Notes: All units are mg/kg unless otherwise specified.

5.4. Algae and Macrophytes

5.4.1. Phytoplankton

A total of 40 taxa were identified from the phytoplankton (free-floating algae) assemblage in the surface water at eight sites during the November 2020 survey (Table 5-4). This included representatives from four phyla; Bacillariophyta (diatoms), Chlorophyta (green algae), Cyanophyta (blue green algae) and Euglenozoa. The diversity and abundance of algal taxa was variable between sites, ranging from 10 to 19 taxa and from 24 cells to 206 cells (Table 5-4). The lowest diversity was recorded at LC05 and LC06 (10 and 11 taxa, respectively) and the highest at LC02 (19 taxa). Site LC02 recorded the second highest abundance, containing 20 less cells than LC07.

The majority of taxa recorded during the surveys belonged to bacillariophytes (20 taxa), while Chlorophyta accounted for 13 taxa, Cyanophyta for five taxa and Euglenozoa for 2 taxa (Table 5-4). The bacillariophytes were also most abundant (at least 1,671 cells), followed by Chlorophyta (at least 1,255 cells), Euglenozoa (43 cells) and then Cyanophyta (19 cells) (Table 5-4). Bacillariophytes and Chlorophyta were recorded from all sites, while euglenozoans were present at seven sites and cyanophytes at six sites (Table 5-4).

Of the bacillariophytes, *Nitzschia* spp. and *Navicula* spp. were the most abundant and recorded at all sites (Table 5-4). The *Nitzschia* genera occurs in fresh, estuarine, marine and hypersaline conditions and is considered to be widespread genera across Australia (McCarthy, 2013), however, the highest diversity is usually associated with fresh waters (John, 2000). The *Navicula* genus is abundant in most circumneutral to alkaline systems. Several species can be indicative of nutrient enrichment or elevated salinities (Gell, Sluiter, & Fluin, 2002).

Of the chlorophyta phylum, *Aphanothece* sp. was the most abundant but was only recorded within three waterways (BC01, LC04 and LC05). This genus can grow in damp soils on margins and banks of urban streams, as well as highly modified anthropogenic systems (Entwistle & Skinner, Non-marine algae of Australia: 4. Floristic survey of some colonial green macroalgae (Chlorophyta), 2002). *Closterium* sp. 1, *Gonium* sp. and *Mougeotia* sp. were also present among sites, often occurring free floating in lake environments.

Other taxa that have the potential to be toxic and/or bloom-forming and were recorded across the sites include the chlorophytes *Aphanocapsa* sp., *Aphanothece* sp. and *Pediastrum* sp. (bloom forming only), and cyanophytes *Anabaena* sp. The genus *Pediastrum* is considered widespread and is planktonic in standing water, occasionally forming blooms (Entwistle, Sonneman, & Lewis, Freswater Algae in Australia: A guide to conspicuous genera, 1997). The *Anabaena* genus is considered widespread across Australia and forms unbranched filaments which are planktonic in standing to slow flowing water (Entwisle, Sonneman et al. 1997). The genus has the potential to be toxic and/or bloom-forming (Mitrovic and Bowling 2013) and is seasonally abundant throughout late spring to autumn. Some species can produce an anatoxin which can result in livestock death after drinking and may cause skin irritation (Entwisle, Sonneman et al. 1997). *Anabaena* blooms can produce a distinctive musty odour linked to the chemical geosmin, and its toxin producing representatives in Australia, to date, include

Anabaena circinalis, *Anabaena bergii, Anabaena crassa* and *Anabaena flos-aquae* (Sydney Catchment Authority, 2010). It should be noted that only one cell was detected, in site LC07. Euglanids (*Euglena* sp. or *Phacus* sp.) that have the potential to form blooms were recorded at all sites except for LC05. This genus is primarily associated with standing water bodies (Entwistle, Sonneman, & Lewis, 1997), which may explain its presence at most sites.

Overall, none of the taxa recorded are considered to be threatened or of restricted distribution.

Table 5-4: Phytoplankton taxa recorded during the November 2020 field survey

Phytoplankton taxa	Direct impact area			Indirect impact area				
	Lake Cowal		Bland Creek	Lake Cowal				
	LC01	LC02	BC01	LC03	LC04	LC05	LC06	LC07
Bacillariophyta								
Achnanthidium sp.	2	4	58					
Amphora sp.	1	6		3	5			1
Bacillaria sp.	1							
Brachysira sp.	45			13				
Cocconeis sp.			4					
Cyclotella sp.	2	1	3		9	1	1	
Fragilaria sp.	9		6		4			6
Gomphonema sp. 1		28	19	2	26	4	3	7
Gomphonema sp. 2		42						9
Hantzschia sp.	3	1	4	1	3	3	5	13
Melosira varians				6				
Navicula sp. 1			13	1				
Navicula sp. 2	1			20				
Navicula sp. 3	1	6		3	90	9	>500	5
Nitzschia sp. 1	8	6	11	3	>500	8	1	93
Nitzschia sp. 2		1			1			
Nitzschia closterium								2

Phytoplankton taxa	Direct impact area			Indirect impact area				
	Lake Cowal		Bland Creek	Lake Cowal				
	LC01	LC02	BC01	LC03	LC04	LC05	LC06	LC07
Pinnularia sp.	1	1	3					
Planothidium lanceolatum	11							
Synedra sp.	3	5						
Chlorophyta								
Aphanocapsa sp.					1*			
Aphanothece sp.			>500*		1*	1*		
Botryococcus sp.				20*				
Closterium sp. 1		5			4		8	3
Cosmarium sp.	2	1			1			
Gonium sp.						4*	>500*	1*
Merismopedia sp.			1*	2*	3*			2*
Micractinium sp.								2*
Mougeotia sp.		7*						
Pediastrum sp.							1	
Scenedesmus sp.		74	1		22	33	4	46
Staurastrum sp.	1							
Volvox sp.			4*					
Cyanophyta								
Anabaena sp.								1*

Phytoplankton taxa	Direct impact area			Indirect impact area				
	Lake Cowal		Bland Creek	Lake Cowal				
	LC01	LC02	BC01	LC03	LC04	LC05	LC06	LC07
Cyanothece sp.		1						
Oscillatoria sp.					6*			
Planktolyngbya sp.						4*		
Spirulina sp.		1*	1*			3*	2*	
Euglenozoa								
Euglena sp.		2	1	7			1	8
Phacus sp.	1	2	5		3			13
Diversity	16	19	16	12	16	10	11	16
Abundance	92	186	128	59	168	58	24	206

Notes: * indicates that the representative comprises a colony, chain or filament; green indicates potentially bloom-forming; brown shading indicates taxa is potentially bloom-forming and toxic.

5.4.2. Macrophytes

A total of four macrophytes from four families were recorded at six sites during the November 2020 survey (Table 5-5). No macrophytes were recorded from Bland Creek. All sites in Lake Cowal with exception of LC07 contained macrophytes. The most abundant taxa were a sedge species (*Eleocharis* sp.), recorded from all sites at Lake Cowal except for site LC07 (Table 5-5). *Eleocharis* genus grows in moist habitats and is fairly widespread in NSW (PlantNet, 2006).

Site LC02 had the highest diversity of macrophytes, with a *Chara* sp. and *Myriophyllum* sp. also recorded (Table 5-5). The *Chara* genus is a green alga resembling an aquatic plant and grows in submerged water (Canberra Nature Map, 2023). *Myriophyllum* genus occurs in freshwater and can provide shelter for eggs and juvenile fish (Australian Plants Society NSW, 2020).

The absence of macrophytes at site LC07 may be attributed to the highly ephemeral nature of the waterway. Absence of macrophytes at Bland Creek (BC01) could be due to recent high rainfall and resultant scouring and erosion of the waterway.

Overall, none of the taxa recorded are considered to be threatened or of restricted distribution.

Table 5-5: Macrophyte taxa recorded during the November 2020 field survey

Macrophyte taxa	Direct impact area		Indirect impact area					
	Lake Cowal		Bland Creek	Lake Cowal				
	LC01	LC02	BC01	LC03	LC04	L05	LC06	LC07
Charales								
Characeae								
Chara sp.		✓						
Saxifragales								
Haloragaceae								
Myriophyllum sp.		✓						
Salviniales								
Marsileaceae								
Marsilea sp.		✓						
Poales								
Cyperaceae								
Eleocharis sp.	✓			✓	✓	✓	✓	
Diversity	1	3	0	1	1	1	1	0

5.5. Aquatic Invertebrates

A total of 80 taxa were identified from the aquatic invertebrate assemblage in the surface water at eight sites during the November 2020 field survey (Table 5-6). The most diverse taxa were those belonging to the Diptera (flies and mosquitos) order, recording 17 different species (Table 5-6). Although the most diverse order, Diptera were the sixth most abundant order at sites. The majority of taxa belonged to the Podocopida order (shrimps), recording more than 2,499 specimens. Cyclopoida (copepods) and Cladocera (water fleas) were the next most abundant orders recording between 1,682 and 1,581 specimens each (Table 5-6). The macroinvertebrate condition of the Lachlan River valley is ranked as 'poor to moderate' (Murray-Darling Basin Authority, 2012) however, the results recorded during the November 2020 field survey are considered relatively diverse.

The diversity of aquatic invertebrates was variable within Lake Cowal, ranging between 20 taxa at LC04 and 47 taxa at LC02 (Table 5-6). Diversity was slightly higher on average in Bland Creek than in Lake Cowal, with 33 taxa recorded in Bland Creek compared to 31 taxa in Lake Cowal; however the waterways were comparable. Taxa that occurred across all eight sites included species from the Hemiptera family, a *Corixidae* sp, *Agraptocorixa* sp., and *Anisops* sp. (all water boatmen); as well as a *Cyprididae* sp. (a seed shrimp).

Given that the condition of macroinvertebrate assemblages within the Lachlan River valley are considered 'moderate' (Murray-Darling Basin Authority, 2012) and it is reported that the mean number of taxa present within the valley is 27 families, the fact that Lake Cowal supported only five families suggests that the macroinvertebrate condition within Lake Cowal is 'very poor'. The aquatic invertebrate community of Lake Cowal, while not considered to be of conservation significance, provides the basis of an important food web that supports a diverse and abundance waterbird community during flooding (Murray-Darling Basin Authority, 2019).

Table 5-6: Aquatic invertebrate taxa recorded during the November 2020 field survey.

Aquatic invertebrate taxa	Direct impact area			Indirect impact area				
	Lake Cowal		**Bland Creek**	**Lake Cowal**				
	LC01	LC02	BC01	LC03	LC04	LC05	LC06	LC07
Annelida								
Hirudinida								
Rhynchobdellida								
Glossiphonidae sp.	3							
Oligochaeta								
Lumbriculida								
Lumbriculus sp.		1						
Tubificida								
Naididae sp.								1
Arthropoda								
Arachnida								
Trombidiformes								
Elyias sp.				2		1		
Hydrachna sp.				1		1		
Hydraphantidae sp.	2							
Unionicolidae sp.			1				1	
Wuria sp.				1				
Branchiopoda								
Cladocera								
Chydoridae sp.		65		1				
Cladocera sp.	950					1	8	8
Daphniidae sp.	215			3				
Moinidae sp.			310					
Hexanauplia								
Calanoida								
Centropagidae sp.	740	3	80	26		1	1	
Cyclopoida								

Cyclopidae sp.		950	60	27	15	270	350	10
Insecta								
Coleoptera								
Antiporus sp.	1	1						
Berosus sp.		3	3	3		3	1	
Chrysomelidae sp.			1					
Cybister sp.				1		3		
Dytiscidae sp.		1				1		
Enochrus sp.		1	4	4		3	1	2
Helochares sp.		1		2		1		
Heterocerus sp.			1					
Hydraena sp.		1	5	1				3
Hydrophilidae sp.		12			1		1	
Hyphydrus sp.	2	1	2					
Liodessus sp.	4		2				5	2
Megaporus sp.	1	1	3	1				
Rhantus sp.	1	1						
Diptera								
Ablesmyia sp.		1		1				
Anopheles sp.		1		1				
Bezzia sp.	1	4	1	1	3		3	2
Calopelma sp.		7	8	7	4	8	2	4
Chironominae sp.		6	1		1	10	1	2
Chironomus sp.	2	5			2	1	7	4
Cricotopus sp.		4			2			
Cryptochironomus sp.			1		1			
Culiseta sp.		1						
Dicrotendipes sp.			1	2	2			
Ephydridae sp.							2	
Odontomyia sp.		4	1	2		3		
Orthocladiinae sp.						6		

Polypedilium sp.	1							
Procladius sp.	10	5		1	6		8	4
Stratiomyidae sp.		4						
Tanypodinae sp.		1			3			
Ephemeroptera								
Baetidae sp.		57	2				2	
Cloeon sp.	5	3	7	8	1	2		
Tasmanocoenis sp.	1							
Hemiptera								
Agraptocorixa sp.	1	2	2	1	1	2	2	2
Anisops sp.	1	5	3	4	3	3		4
Corixidae sp.	1	40	3	1	3	19	1	4
Enithares sp.	1							
Micronecta sp.		4		3	1	4	5	7
Micronectidae sp.		25		75	300	27	10	34
Microvelia sp.		2		1				
Notonectidae sp.	1	39	18	12		83	2	44
Ranatra sp.	1							
Odonata								
Austrolestes sp.	1	1						
Diplacodes sp.						1		
Hemianax sp.		2		1		2		
Ischnura sp.		8	4	9	2	6	1	2
Libellulidae sp.						1		
Procordulia sp.		1						
Leptoceridae sp.			6	1				
Oecetis sp.	3	1		1				
Triplectides sp.	9	5	8	8	5	4		3
Zygoptera								
Coenagrionidae sp.		9	2					
Zygoptera sp.						1		

Malacostraca								
Decapoda								
Cherax sp.	1							
Parataya sp.	2							
Ostracoda								
Ostracoda^								
Ostracoda sp.		7		7				1
Podocopida								
Candonidae sp.			1					
Cyprididae sp.	30	700	3	500	500	165	200	85
Notodromadidae sp.				95		220		
Cnidaria								
Hydrozoa								
Hydrozoa^								
Hydrozoa sp.			1					
Mollusca								
Gastropoda								
Hygrophila^								
Glyptophysa sp.	2	3		1				
Isidorella sp.				3				
Lymnaeidae sp.		21						
Physa sp.	3	3	4	1		1		
Planorbidae sp.			1	1				
Abundance	**1996**	**2023**	**550**	**821**	**856**	**854**	**614**	**228**
Diversity	**30**	**47**	**33**	**40**	**20**	**31**	**22**	**21**

Note ^ indicates that Hygrophila, Hydrozoa and Ostracoda are an unranked Clade and not an Order.

5.6. Aquatic Vertebrates

Three aquatic vertebrate fauna taxa (three fish species) were recorded during the November 2020 field survey, including representatives from three families (Table 5-7). Of the three fish taxa, two were exotic species; the Common Carp and the Eastern Gambusia. There was an abundance of gravid female Eastern Gambusia noted at the time of the field survey. The third and only native taxon was a species of native Carp Gudgeon (*Hypseleotris* sp.) (Table 5-7) which comprises part of the fish assemblage that forms the Lowland Lachlan River EEC (Endangered under the FM Act) (Department of Primary Industries, 2006). All taxa were recorded via electrofishing. The results are consistent with fish monitoring data provided by frc environmental from 2011 to 2017, with the Common Carp, Eastern Gambusia and Carp Gudgeon recorded in relatively high abundance across the five years of monitoring (frc environmental 2022). Additional fish species recorded by frc environmental from 2011 – 2017 include: Goldfish, Bony Bream, Australian Smelt and Flathead Gudgeon (frc Environmental, 2022). Bony Bream, Australian Smelt and Flathead Gudgeon also comprise part of the fish assemblage that forms the Lowland Lachlan River EEC (Department of Primary Industries, 2006).

No threatened aquatic species or populations listed under the EPBC Act were recorded, via either electrofishing or eDNA sampling, during the November 2020 field survey.

Table 5-7: Aquatic vertebrate species presence/absence recorded during the November 2020 field survey

Aquatic vertebrate taxa	Impact			Reference				
	Lake Cowal		Bland Creek	Lake Cowal				
	LC01	LC02	BC01	LC03	LC04	LC05	LC06	LC07
Fish								
Cyprinidae								
*Common Carp (*Cyprinus carpio*)			2					
Eleotridae								
^Carp gudgeon species (*Hypseleotris* sp.)	82							
Poeciliidae								
*Eastern Gambusia (*Gambusia holbrooki*)	45		98					
Diversity	**2**	**0**	**2**	**0**	**0**	**0**	**0**	**0**
Abundance	**127**	**0**	**100**	**0**	**0**	**0**	**0**	**0**

Note * indicates exotic species. ^ indicates species comprises the fish assemblage of the Lowland Lachlan River EEC.

6. Ecological values

6.1. Aquatic Ecology

The November 2020 field survey provided background data on the aquatic ecological values within Lake Cowal and Bland Creek. All sites were classified as Type 1 highly sensitive key fish habitat and Class 1 major key fish habitat. Type 1 highly sensitive key fish habitat classifications for all sites were assigned due to the sites containing in-stream snags or native aquatic plants, and the potential for the waterway to provide habitat for threatened aquatic species (ie Olive Perchlet, Southern Purple-spotted Gudgeon and Flathead Galaxias).

During the November 2020 field survey, water and sediment quality varied between sites but was generally consistent in terms of pH, salinity and suspended solids. Turbidity varied between sites (Table 5-2 and Table 5-3). Dissolved oxygen in water was low across all sites. Nutrients and metals were generally below detection limits or below ANZECC and ARMCANZ (2000) trigger values and/or DGVs (Water Quality Australia, 2018) (Table 5-2 and Table 5-3) at all sites. This indicates that the majority of sites are considered to be in moderate condition despite existing adjacent land use and disturbance including ongoimg operation of the Cowal CGO. Aquatic habitat such as macrophytes was typically absent or of low quality at all sites however some low quality habitat for aquatic species was present in the form of large woody debris. Habitat tended to lack the complexity required by many aquatic species and no sites supported habitat *critical* to the survival of a species.

A total of 40 phytoplankton with representatives from four phyla were recorded within the study area, four macrophytes, 81 aquatic invertebrates and three aquatic vertebrate taxa (including two exotic species and one native) were recorded across eight sites within two waterways. Lake Cowal supported a more diverse biological community (121 taxa) with only 51 taxa recorded within Bland Creek however it must be noted that only one site was sampled within Bland Creek whereas seven sites were sampled within Lake Cowal (Table 5-1).

Lake Cowal recorded six phytoplankton genera that have the potential to be bloom forming and/or toxic, albeit typically in very low abundance whereas Bland Creek recorded three species that have the potential to be bloom forming and/or toxic, typically in higher abundance than Lake Cowal (Table 5-4). The occurrence of these taxa can be attributed, in part, to anthropogenic influences; however, external factors such as previous prolonged drought is likely to have contributed to proliferation of some of the bloom forming and/or toxic algae taxa, in particular.

Overall, it is considered that Lake Cowal and the Bland Creek are of low to moderate ecological value due to:

- their classification as Type 1 highly sensitive key fish habitat and Class 1 major key fish habitat;
- the presence of low quality key fish habitat features;

- the presence of a low diversity macroinvertebrate assemblages;
- the lack of threatened aquatic species.

Lake Cowal and Bland Creek are characterised by sufficient key fish habitat features to potentially provide aquatic habitat; however, it is considered to be of low to moderate ecological value due to its highly ephemeral/temporary hydroperiod and low diversity/abundance of aquatic vertebrate biota.

6.2. Environmental Receptors

The primary environmental receptors identified by the aquatic ecology assessment, in relation to potential impacts associated with 3rd order and above waterways, comprise:

- water-dependent bird species (addressed in EMM Consulting Pty Limited (2023a));
- native fish species and native fish habitat (KFH);
- native water-dependent plant communities (macrophytes); and
- surface water and sediment quality;
- the Lowland Lachlan River EEC; and,
- riparian vegetation (addressed in EMM Consulting Pty Limited (2023a)).

Water dependent bird species impacts have been addressed in the BDAR - appended to the EIS (EMM Consulting Pty Limited, 2023a). Native water dependent plant communities consider only the macrophytes as riparian vegetation is addressed in the BDAR (EMM Consulting Pty Limited, 2023a).

Base on the desktop review and the collection of field data (Section 5) the construction and operation of the project has the potential to impact aquatic ecology values (Receptors). Table 6-1 summarises the potential pathways for a project activity to impact identified aquatic values during the different stages of the project, construction (C) and operation (O). These pathways and potential impacts are discussed in detail along with potential mitigations strategies for the various stages of the project in sections 7 through section 13.

Table 6-1: Pathway for impacts and Aquatic Receptors Impacted. Note Project stage O = operation, C = Construction

Pathway	Aquatic Environmental Receptors possibly impacted				Comments
	Native fish and KFH	Macrophytes	Lower Lachlan EEC	Surface water and sediment quality	
Poor Water quality as a result of construction activity	C	C	C	C	Poor water quality from construction activities including turbid water discharges and fuels and oils from machinery. Poor water quality has the potential to impact native fish and KFH during construction. Discharges of turbid water and chemical spills are a risk. Native aquatic vegetation (submerged macrophytes) where present will be susceptible to risk associated with turbid water.
Poor Water quality as a result of dewatering	C	C	C	C, O	There is the potential for decreased water quality to occur within Lake Cowal should any water be released back into the lake with concentrations of metals and physico-chemical parameters higher than background concentrations within Lake Cowal.
Poor Water quality as a result of using primary waste rock	O, C	O	C, O	O	There is the potential for sensitive biota within Lake Cowal to accumulate arsenic, molybdenum and selenium over time.
Loss of KFH	C	C	C		A total of 323.12 ha of KFH will be lost as a result of the proposed action.
Loss of aquatic fauna	C	C	C		There is potential for aquatic fauna to be lost as a result of being trapped within the mine site when the LPB is sealed.

7. Construction and Expansion Impacts

7.1. Lake Protection Bund (LPB) Construction

Evolution's preference is to construct the extended LPB in a dry environment. However due to the current inundation of Lake Cowal and its effect on the schedule for the Project, it is possible that Lake Cowal may still be inundated at the time of construction of the LPB. This section assumes the LPB will be constructed when Lake Cowal is inundated although that may not be the case. Should the LPB be constructed when the lake is dry, it is considered that impacts to water quality will be nil to negligible apart from potential long-term exposure to leachate from primary waste rock which is to be used to construct the bund. Potential impacts due to long term exposure to leachate from the primary waste rock is discussed in section 7.1.4.

The proposed expanded LPB (separating Lake Cowal from the Project area) comprises two components that in plan view form an arc around the expanded Project area, abutting the western lake shoreline. The components consist of an initially constructed temporary isolation bund and ultimately the LPB itself.

7.1.1. Existing Water Management and Lake Isolation System

ATC Williams (2023) states that the current CGO water management system has been designed such that the approved CGO does not impact on the integrity of Lake Cowal. Mine infrastructure and landforms have been constructed within the internal catchment drainage system (ICDS). The ICDS combines with the up-catchment diversion system (UCDS) and lake isolation system to protect Lake Cowal from all CGO development activities (ATC Williams, 2023).The Lake Isolation System comprises a Temporary Isolation Bund (TIB) and a permanent isolation bund (LPB) that provides a permanent barrier between Lake Cowal and the open pit (ATC Williams, 2023). Run-off from areas upslope of the ICDS is diverted via the UCDS, around the CGO to Lake Cowal. Flow from the UCDS is discharged into stilling basins prior to entering Lake Cowal. When the UCDS capacity is exceeded, flow floods out over the adjacent countryside as sheet flow and in drainage lines with the bund preventing water from entering the CGO (ATC Williams, 2023).

7.1.2. Temporary Isolation Bund

A temporary isolation bund (TIB) will be constructed at an early stage of the project to restrict, as much as practicable, inflow from Lake Cowal to the LPB construction area (ATC Williams, 2023). The TIB will be constructed using inert waste rock and will form a bund with a crest level of 206.5 AHD, with batter slopes not exceeding 1(vertical): 2(horizontal) (ATC Williams, 2023). Lower permeability material will be selectively placed within the bund and sheet piling will be used to limit seepage through the bund. Prior to construction, a continuous silt curtain will be erected around the outer perimeter of the TIB to trap fine sediment and control the migration of suspended solids into the lake (ATC Williams, 2023).

Any water captured behind the TIB will undergo water quality testing to confirm suitability for release into Lake Cowal, or treatment if required prior to pumped release back into the lake (ATC Williams, 2023).

7.1.3. Lake Protection Bund

The LPB is to be built in accordance with *Lake Cowal Lake Protection Detailed Design* prepared by SLR Consulting Limited (2022). Evolution Mining (2022) report the following broad construction methodology (Figure 7-1) is to be used:

1) Working in the direction of bank to lake (install custom tapered silt curtains as designed by Chatoyer);
2) Build approximately 100-200m of rock sub-groyne;
3) Place geo-fabric;
4) Place middle groyne;
5) Repeat steps 2 – 4 until full groyne complete;
6) Install sheet piles;
7) Dewater to central treatment dams or over groyne;
8) Build permanent LPB.

The two most likely impacts to Lake Cowal as a result of constructing the LPB are increased turbidity and chemicals and fuel spills. Chemicals and fuels spills are discussed in section 7.1.5. Turbidity is to be managed by the installation of appropriately designed and installed Chatoyer tapered silt curtains which have found widespread use in recent years, including in freshwater lakes and impoundments, and have been effective in controlling turbidity (Chatoyer, 2023).

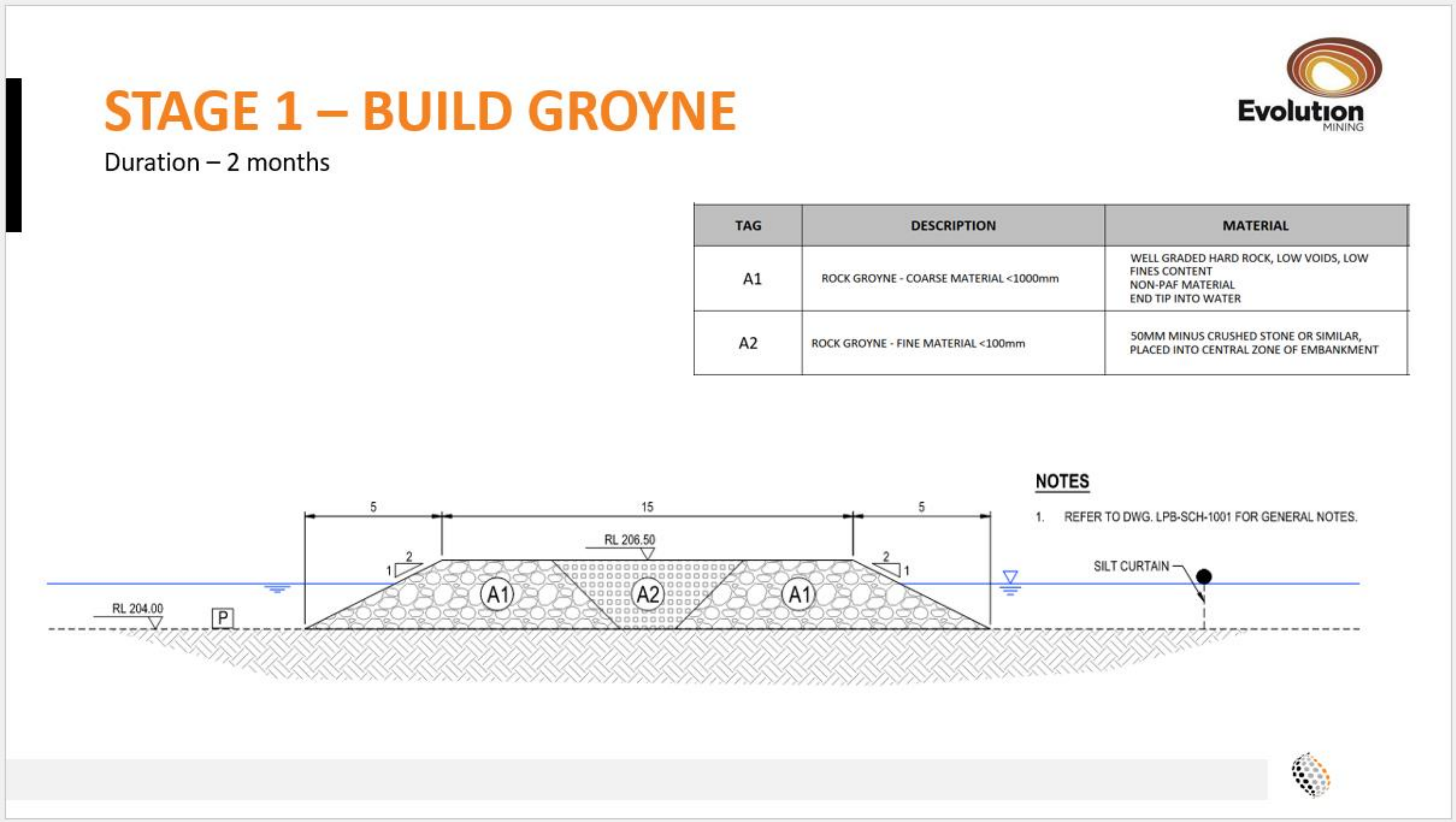

Figure 7-1: LPB (groyne) design (Evolution Mining, 2022)

7.1.4. Use of Primary Waste Rock in LPB

The LPB will comprise a low permeability embankment designed to limit, to negligible magnitudes, inflow from the lake to the Project area for the life of the Project and post-closure (ATC Williams, 2023). It is understood that primary waste rock will be utilised for the construction of the LPB extension as was used on the existing, previously approved lake isolation system (EMM Consulting Pty Limited, 2023c; ATC Williams, 2023). The CGO Open Cut Expansion Project: Lake Protection Bund Waste Rock Management report (2023c) states that the primary waste rock consists of unweathered, mined volcanic waste rock from the open pit (EMM Consulting Pty Limited, 2023c). Geochemical characterisation studies undertaken since the CGO first began operating, report that this primary waste rock is predominately non-acid forming (NAF), slightly alkaline, non-saline and non-sodic (Evolution Mining, 2020). Figure 7-2 shows a standard geochemical acid-base classification plot taken from (EMM Consulting Pty Limited (2023c). The plot shows the geochemical acid-base classification of primary waste rock samples and includes samples from previous geochemical investigations, low grade ore (LGO), and ore samples shown for comparison (EMM Consulting Pty Limited, 2023c). Figure 7-2 clearly shows the majority of the primary waste rock is NAF, with negative net acid production potential (NAPP) and alkaline net acid generation (NAG) pH values (EMM Consulting Pty Limited, 2023c).

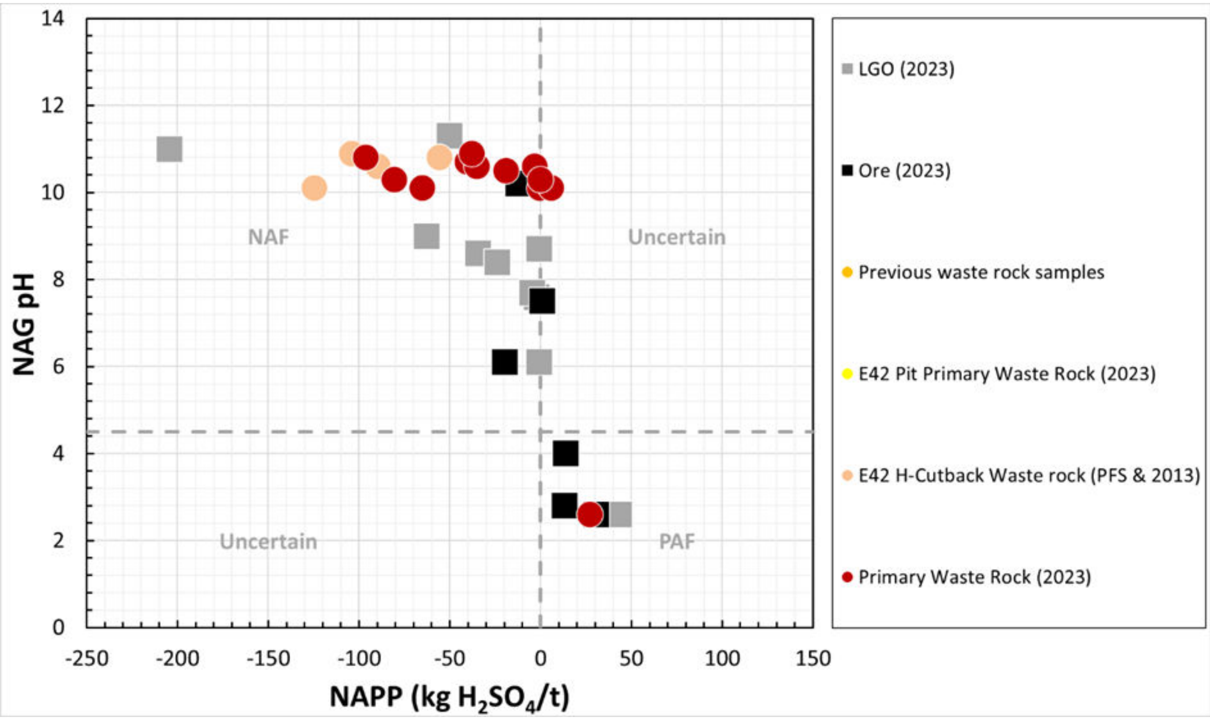

Figure 7-2: NAPP versus NAG pH for primary waste rock and other selected samples (EMM Consulting Pty Limited, 2023c)

The LPB Waste Rock Management report states that whilst the majority of the primary waste rock is expected to be NAF there is potential for leaching of certain metal/metalloids following exposure of the waste rock to ambient conditions. Results of additional testing showed that arsenic, molybdenum and selenium had the potential to be mobilised when in contact with deionised water **(EMM Consulting Pty Limited, 2023c)**.

Results of the additional testing show that most primary waste rock leachate arsenic concentrations remain within the Lake Cowal water quality range and are below ANZECC 80% species protection and stock water protection concentrations (albeit outside the ANZECC guidelines for pH) with two primary waste rock samples falling above Lake Cowal's background upper limit for arsenic (EMM Consulting Pty Limited, 2023c).

The majority of primary waste rock selenium leachate concentrations are reported as falling within Lake Cowal's background selenium concentrations and are also below the ANZECC 95% species protection objective with only one primary waste rock leachate sample falling outside these ranges (EMM Consulting Pty Limited, 2023c).

The results of the molybdenum leachate analysis is of note and is shown below in Figure 7-3. The majority of waste rock molybdenum leachate concentrations lie above Lake Cowal's background molybdenum concentrations however all samples fall below the upper limit for stock protection water quality objective (albeit again at higher pH values) (EMM Consulting Pty Limited, 2023c).

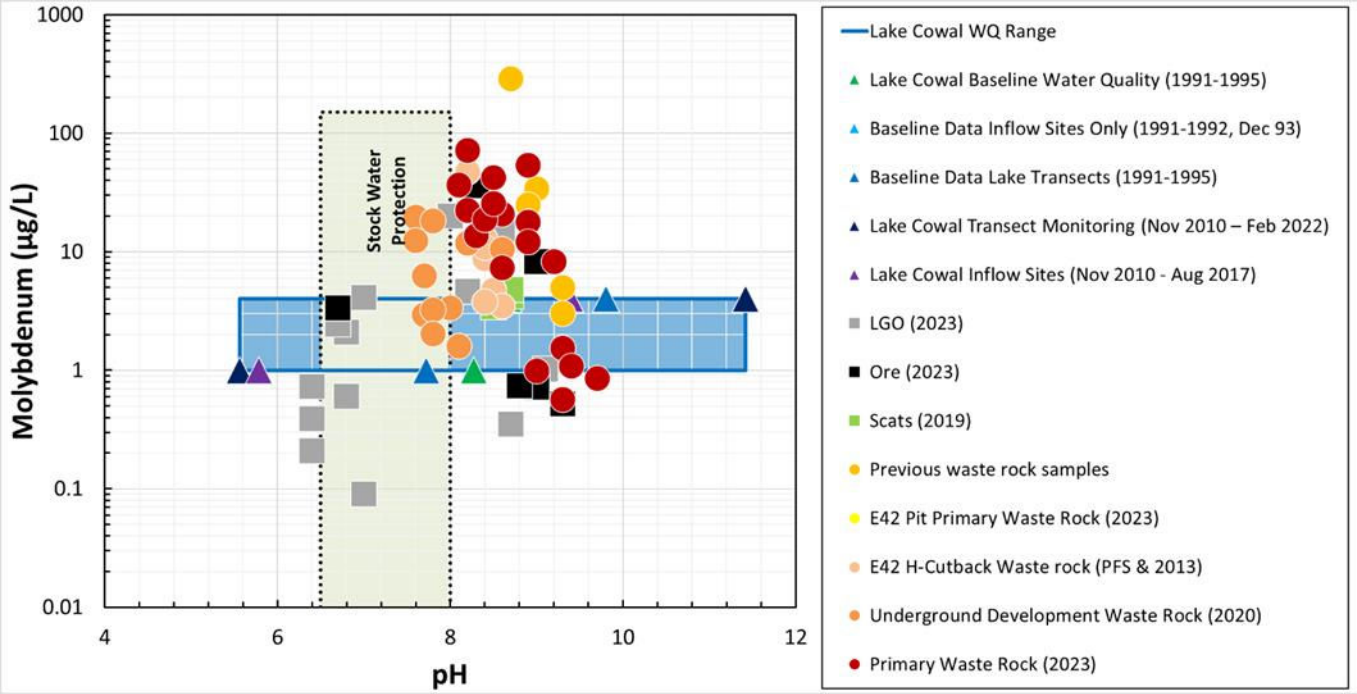

Figure 7-3: Values of pH and Mo in primary waste rock leachate compared to the range in Lake Cowal water quality and water quality objectives (EMM Consulting Pty Limited, 2023c)

The report states that a similar analysis was undertaken for primary waste rock leachate concentrations for cadmium, copper, iron, lead, manganese, mercury, zinc and nickel; however, all leachate concentrations were found to lie within the Lake Cowal water quality range and water quality objectives for each parameter **(EMM Consulting Pty Limited, 2023c)**.

The effects of molybdenum on aquatic ecosystems are understudied relative to other metals however a review of available literature revealed a small number of studies looking at the effect of increased molybdenum levels on aquatic biota. Small concentrations of molybdenum are essential for aquatic ecosystems to function correctly and molybdenum is actively added to water in many aquarium and aquaculture facilities however studies of the effects of higher concentrations on zooplankton and phytoplankton, the drivers of food webs in aquatic ecosystems, show that molybdenum accumulates over time resulting in detrimental effects to sensitive biota such as decreased growth rates, disorders of growth and development, and cessation of growth in sensitive phytoplankton (Hrytsyniak, Yanovych, & Shvets, 2016). Toxic effects at higher concentrations have also been shown in a range of bony fish species (Hrytsyniak, Yanovych, & Shvets, 2016). It is important to note that toxic effects are seen in aquatic biota only when exposed to concentrations significantly higher than concentrations shown to be leaching from the primary waste rock (Heijerick, Regoli, & Carey, 2012; Regoli, Tilborg, Heijerick, Stubblefield, & Carey, 2012) (Figure 7-3) however it is possible that an extended period of exposure to high concentrations of molybdenum will have a negative impact on aquatic biota and there is no current understanding of the toxic effects of molybdenum on avian species relevant to the project such as water fowl (US Fish and Wildlife Service, 1989). Molybdenum has also been shown to be toxic to cattle when consumed in ranges of 20-100 mg/kg dry weight diet when combined with a diet that is low in copper (US Fish and Wildlife Service, 1989) however it is important to note that molybdenum leachate concentrations for the primary waste rock fall below the upper limit for stock protection water quality objective (albeit again at higher pH values) (EMM Consulting Pty Limited, 2023c). Given that the same primary waste rock was used existing, previously approved lake isolation system (EMM Consulting Pty Limited, 2023c; ATC Williams, 2023) it is considered unlikely that construction of the proposed LPB using the same primary waste rock will create new negative impacts to water quality within Lake Cowal beyond those changes in water quality seen once the existing lake isolation system was built.

7.1.5. Chemicals and Fuel Spills

Chemical spills or low-level exposure of the aquatic environment to chemicals (e.g. run-off from machinery, including potential vehicle accidents) would most likely involve hydrocarbon products such as fuels and lubricants. The most likely areas for spills to originate are within the bund construction and expansion footprint during refuelling procedures or from an equipment failure (fuel leak or hydraulic hose failure) during the construction works. Spills will predominantly be a risk only when the lake is full.

Storage and containment of fuels and chemicals on site will meet all required standards and include measures to contain accidental spills such as appropriate bunding for the volumes of material stored on site. Potential accidental release in uncontrolled areas (via a collision within the construction footprint for example) is possible and emergency spill response procedures will be necessary and detailed in the construction environmental management plan (CEMP). All refuelling and servicing activities of equipment is to be completed outside of waterways and drainage lines.

7.1.6. Water Quality

7.1.6.1. Historical Water Quality

The surface water assessment undertaken by ATC Williams (2023) utilises baseline data collected prior to the CGO mine becoming operational, between 1991 and 1995 and includes 34 monitoring locations spanning four transects across Lake Cowal (ATC Williams, 2023). Additional water quality monitoring was undertaken (when the lake re-filled) from November 2010 through to July 2014, from August 2016 to July 2018 and from December 2021 to February 2022 when the mine was operational (ATC Williams, 2023). This section of the aquatic ecology EIS compares baseline (pre mine operation) transect water quality data to transect water quality data collected while the mine was operational to determine whether historical operations negatively impacted water quality within Lake Cowal. Given the Project will expand the life of the mine rather than increase existing maximum ore processing rates or tailings disposal methods, (ATC Williams, 2023) future water quality parameters and metals concentration are predicted to be relatively consistent with historical water quality readings. The following data is taken from Table 6 in ATC Williams (2023).

Average total nitrogen concentrations increased substantially after the CGO mine became operational (Figure 7-4). Average total nitrogen concentrations between 1991 – 1995 were calculated to be 136 µg/L, 214 µg/L below the default trigger values for SE Australia Freshwater Lakes and Reservoirs (ATC Williams, 2023). Average total nitrogen concentrations for the 2010-2023 monitoring period were calculated to be 671 µg/L, 321 µg/L over the default trigger values for SE Australia Freshwater Lakes and Reservoirs (ATC Williams, 2023).

Average total phosphorous concentrations decreased significantly after the CGO mine became operational (Figure 7-5). Average total phosphorous concentrations between 1991 – 1995 were calculated to be 1 667 µg/L whereas average total phosphorous concentrations for the 2010-2023 monitoring period were calculated to be 386 µg/L. Average total phosphorous concentrations exceeded the default trigger values for SE Australia Freshwater Lakes and Reservoirs for both monitoring periods (ATC Williams, 2023).

Average pH decreased after the CGO mine became operational (Figure 7-6). Average pH between 1991 – 1995 was calculated to be 8.48 which is considered to be alkaline (Foged, 1978) whereas pH for the 2010-2023 monitoring period was calculated to be 8.01. Still considered alkaline but to a lesser degree (Foged, 1978). pH exceeded the upper default trigger values for SE Australia Freshwater Lakes and Reservoirs for both monitoring periods (ATC Williams, 2023).

Average conductivity decreased after the CGO mine became operational (Figure 7-7). Average conductivity between 1991 – 1995 was calculated to be 881 µS/cm which is considered to be fresh water (Hammer, 1986) whereas average conductivity for the 2010-2023 monitoring period was calculated to be 382 which can be considered very fresh (Hammer, 1986). Average conductivity exceeded the upper default trigger values for SE Australia Freshwater Lakes and Reservoirs for both monitoring periods (ATC Williams, 2023).

Average turbidity increased substantially after the CGO mine became operational (Figure 7-8). Average turbidity between 1991 – 1995 was calculated to be 111 NTU which is considered to be highly turbid (Datastream, 2022) whereas average turbidity for the 2010-2023 monitoring period was calculated to be 287 NTU which can also be considered highly turbid (Datastream, 2022). Average turbidity exceeded the upper default trigger values for SE Australia Freshwater Lakes and Reservoirs for both monitoring periods (ATC Williams, 2023).

Average total arsenic concentrations increased after the CGO mine became operational (Figure 7-9). Average total arsenic concentrations between 1991 – 1995 was calculated to be 2.6 µg/L whereas average total arsenic concentrations for the 2010-2023 monitoring period was calculated to be 5.4 µg/L. Average total arsenic concentrations exceeded the upper default trigger values for 99% protection levels for aquatic ecosystems for both monitoring periods (ATC Williams, 2023).

Average total cadmium concentrations increased after the CGO mine became operational (Figure 7-10). Average total cadmium concentrations between 1991 – 1995 was calculated to be 0.06 µg/L whereas average total cadmium concentrations for the 2010-2023 monitoring period was calculated to be 0.1 µg/L. Average total cadmium concentrations met the upper default trigger values for 99% protection levels for aquatic ecosystems for both monitoring periods prior to the CGO mine becoming operational and exceeded the upper default trigger values for 99% protection levels for aquatic ecosystems once the mine became operational (ATC Williams, 2023).

Average total copper concentrations increased slightly after the CGO mine became operational (Figure 7-11). Average total copper concentrations between 1991 – 1995 was calculated to be 5.8 µg/L whereas average total copper concentrations for the 2010-2023 monitoring period was calculated to be 7.5 µg/L. Average total copper concentrations exceeded the upper default trigger values for 99% protection levels for aquatic ecosystems for both monitoring periods, prior to the CGO mine becoming operational and once the mine became operational (ATC Williams, 2023).

Average total lead concentrations increased slightly after the CGO mine became operational (Figure 7-12). Average total lead concentrations between 1991 – 1995 was calculated to be 2.7 µg/L whereas average total lead concentrations for the 2010-2023 monitoring period was calculated to be 4.1 µg/L. Average total lead concentrations exceeded the upper default trigger values for 99% protection levels for aquatic ecosystems for both monitoring periods (ATC Williams, 2023).

Average total mercury concentrations decreased significantly after the CGO mine became operational (Figure 7-13). Average total mercury concentrations between 1991 – 1995 was calculated to be 0.13 µg/L whereas all total mercury concentrations for the 2010-2023 monitoring period were below the detectable limit. Average total mercury concentrations exceeded the upper default trigger values for 99% protection levels for aquatic ecosystems prior to the mine becoming operational (ATC Williams, 2023).

Average total zinc concentrations increased after the CGO mine became operational (Figure 7-14). Average total zinc concentrations between 1991 – 1995 was calculated to be 11.7 µg/L whereas average total zinc concentrations for the 2010-2023 monitoring period was calculated to be 17.8 µg/L. Average total zinc concentrations exceeded the upper default trigger values for 99% protection levels for aquatic ecosystems for both monitoring periods (ATC Williams, 2023).

A total of two physico-chemical parameters (pH and Conductivity), concentration of one nutrient (TP) and concentrations of one metal (mercury) improved once the mine became operational. All three physico-chemical parameters remained above the default trigger values for SE Australia Freshwater Lakes and Reservoirs whilst mercury dropped well below the 99% protection levels for aquatic ecosystems. A total of two physico-chemical parameters increased once the mine became operational and five metal concentrations increased once the mine became operational. Nitrogen levels only exceeded the default trigger values for SE Australia Freshwater Lakes and Reservoirs once the mine became operational whilst turbidity exceeded the default trigger values for SE Australia Freshwater Lakes and Reservoirs prior to the mine becoming operational. All five metals that increased in concentration once the mine became operational either met or exceeded the 99% protection levels for aquatic ecosystems prior to the mine becoming operational. Further study is required to determine the factors driving the changes in physico-chemical parameters and metals concentrations however it is possible that changes in land use in the immediate surroundings of Lake Cowal and Lake water levels at the time of sampling are factors. Given that the Project will expand the life of the mine rather than increase existing maximum ore processing rates or tailings disposal methods, (ATC Williams, 2023) it is considered unlikely that the proposed action will create new negative impacts to water quality within Lake Cowal beyond those changes in water quality seen once the mine became operational.

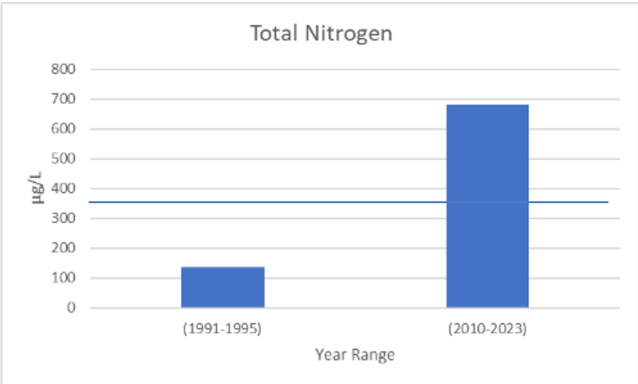

Figure 7-4: Comparison of average total nitrogen concentrations (1991-1995 and 2010-2023) (- = default trigger values for SE Australia Freshwater Lakes and Reservoirs)

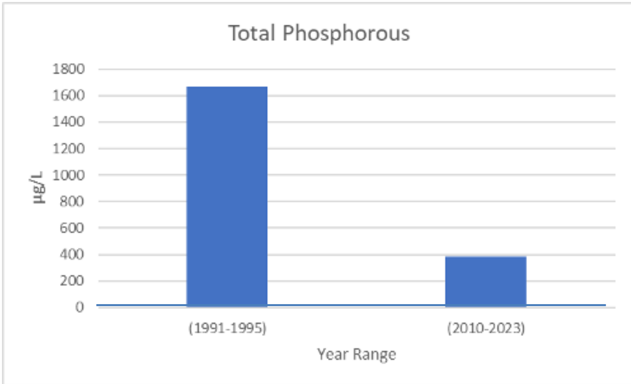

Figure 7-5: Comparison of average total phosphorous concentrations (1991-1995 and 2010-2023) (- = default trigger values for SE Australia Freshwater Lakes and Reservoirs)

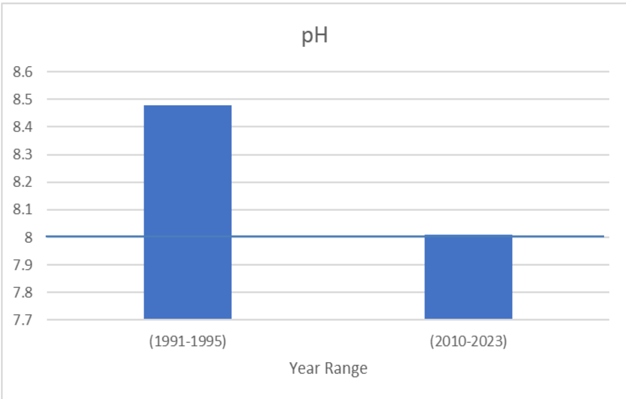

Figure 7-6: Comparison of average pH readings (1991-1995 and 2010-2023) (- = upper trigger value for SE Australia Freshwater Lakes and Reservoirs)

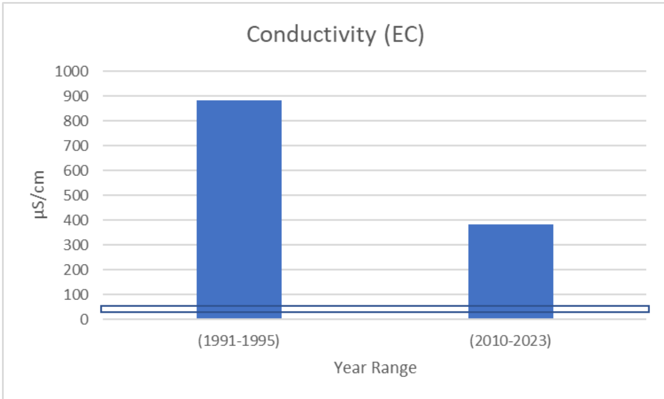

Figure 7-7: Comparison of average conductivity readings (1991-1995 and 2010-2023) (- = default trigger values for SE Australia Freshwater Lakes and Reservoirs)

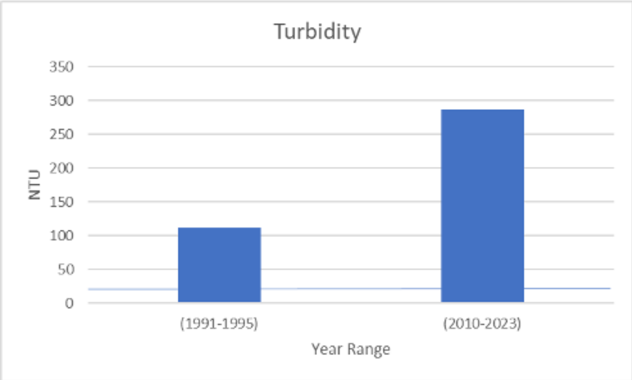

Figure 7-8: Comparison of average conductivity readings (1991-1995 and 2010-2023) (- = default trigger values for slightly disturbed ecosystems – lakes)

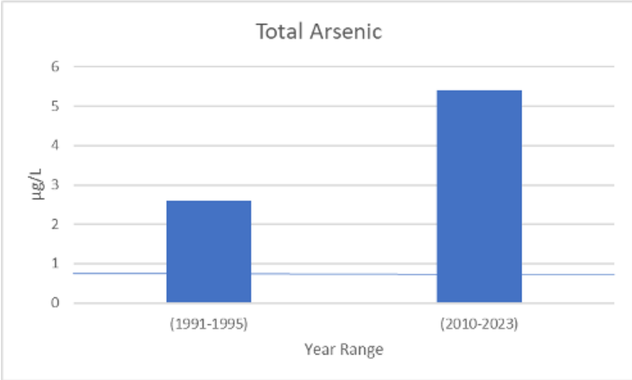

Figure 7-9: Comparison of average total arsenic concentrations (1991-1995 and 2010-2023) (- = 99% protection levels for aquatic ecosystems)

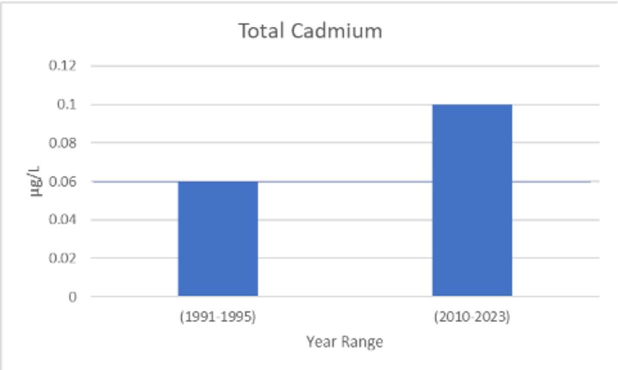

Figure 7-10: Comparison of average total cadmium concentrations (1991-1995 and 2010-2023) (- = 99% protection levels for aquatic ecosystems)

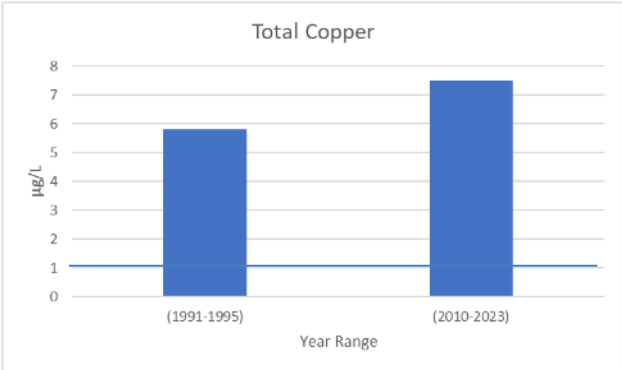

Figure 7-11: Comparison of average total copper concentrations (1991-1995 and 2010-2023) (- = 99% protection levels for aquatic ecosystems)

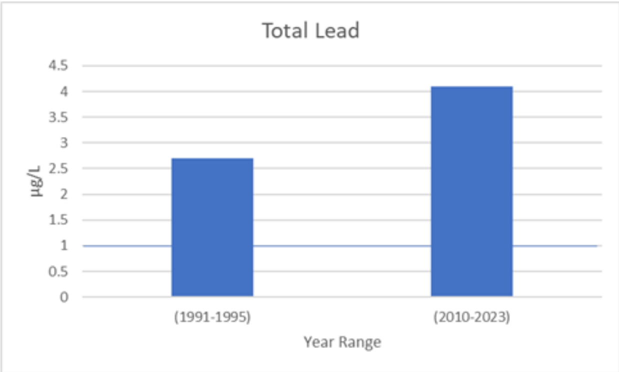

Figure 7-12: Comparison of average total lead concentrations (1991-1995 and 2010-2023) (- = 99% protection levels for aquatic ecosystems)

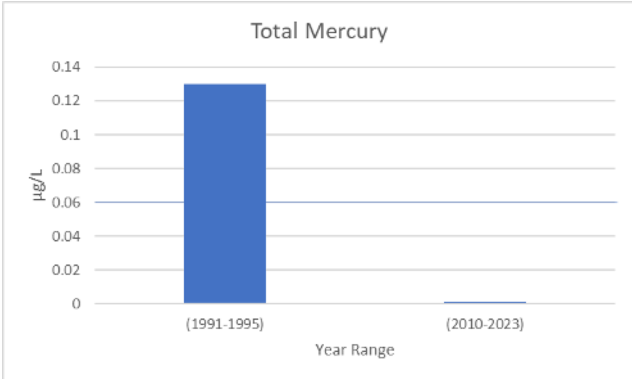

Figure 7-13: Comparison of average total mercury concentrations (1991-1995 and 2010-2023) (- = 99% protection levels for aquatic ecosystems)

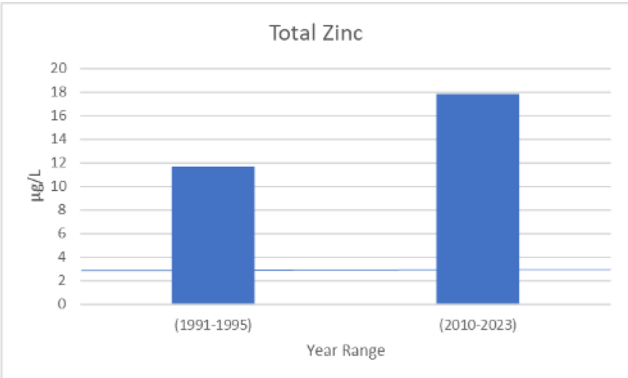

Figure 7-14: Comparison of average total zinc concentrations (1991-1995 and 2010-2023) (- = 99% protection levels for aquatic ecosystems)

7.1.7. Loss of KFH due to Expansion and New Bund Construction

Water levels within Lake Cowal fluctuate significantly and at the time of the surveys Lake Cowal was only partially full and limited aquatic habitat was present. While an assessment of KFH was undertaken in accordance with *Policy and guidelines for fish habitat conservation and management* (Department of Primary Industries, 2013) and a detailed description of each survey site is provided as justification of the assignation of waterway type and waterway class no detailed mapping of aquatic vegetation or significant aquatic habitat features was undertaken.

An Offsets strategy is provided in *Cowal Gold Operations Open Pit Continuation Project Biodiversity Development Assessment Report* (EMM Consulting Pty Limited, 2023a). Given the high variability of water levels within Lake Cowal and the significant periods of time in which the lake is dry it has been determined that areas plant community types (PCTs) strongly correlate with surveyed areas of KFH to be impacted by the Project (Figure 7-15; Figure 7-16) (EMM Consulting Pty Limited, 2023a). The proposed offset strategy states that areas of PCT 17 and 53 mapped within the lake would be classified as KFH and that these areas are bounded by PCT 249 which fringes Lake Cowal. Table 7-1: Key fish habitat offset requirements is taken from *Cowal Gold Operations Open Pit Continuation Project Biodiversity Development Assessment Report* (EMM Consulting Pty Limited, 2023a) and shows that if PCTs 17 and 53 are considered KFH a total of 323.12 ha of KFH are to be impacted by the Project and will require to be offset appropriately. It should be noted that Evolution own sufficient land within Lake Cowal to establish stewardship sites that will meet both terrestrial and aquatic ecology offset requirements.

Table 7-1: Key fish habitat offset requirements

PCT	Area Impacted (ha)	Offset Area required at 2:1 (ha)
17	12.04	24.08
53	311.08	646.24
Totals	**323.12**	**646.24**
249 (buffer only)	51.97	103.94

Figure 7-15: KFH impacted by the Project

Figure 7-16: Lake Cowal when dry

7.1.8. Assessment of Geomorphic Stability of areas of KFH within the Development

Two areas of KFH were assessed within the development proper (LC01 and LC02) however this section will address all areas of KFH assessed within Lake Cowal (Figure 3-1). Long term Compensatory Wetland Monitoring has shown that while the hydrology of Lake Cowal is highly variable, showing regular, significant changes in flow and water levels over time the banks of Lake Cowal are highly stable showing little to no movement over time (DnA Environmental, 2018; DnA Environmental, 2019; DnA Environmental, 2020; DnA Environmental, 2021; DnA Environmental, 2022). Figure 7-18 illustrates the geomorphic characteristics within the Project (development) when Lake Cowal is fully inundated. While the banks of Lake Cowal are highly stable, the presence of macrophytes and other biotic characteristics of KFH fluctuate and are driven by the presence or absence of water and can also be considered highly variable. In summation, areas of KFH within the development are highly geomorphically stable while the hydrology and water dependent fish habitat can be considered highly variable or unstable. The Project will have no impact on the geomorphic stability of Lake Cowal.

7.1.9. Impacts to Hydrology

Impacts of the Project on the hydrology of Lake Cowal are discussed in *Cowal Gold Operations Open Pit Continuation Environmental Impact Statement Surface Water Assessment* (ATC Williams, 2023). The report states that given the proposed expansion of the CGO into Lake Cowal the following direct effects can be expected:

- A small reduction in the catchment area of Lake Cowal and hence a potential effect on the long term lake water balance; and,
- A small reduction in the lake storage capacity and hence a potential effect on lake peak flood levels.

The report states that the current catchment of the ICDS is estimated at approximately 14 km^2 and will increase to approximately 22.7 km^2 by Year 2 of the Project (ATC Williams, 2023). The approximate pre-CGO catchment of Lake Cowal equates to 9 760 km^2 therefore the existing area intercepted by the ICDS is equal to approximately 0.14 percent of the Lake Cowal catchment. This is estimated to increase to 0.23 percent should the Project proceed, an increase of approximately 0.09 percent (ATC Williams, 2023). The expanded LPB is expected to decrease the lake surface area (at its spill level to Nerang Cowal) by approximately 1.7 percent and its capacity by approximately 1.9 percent (ATC Williams, 2023).

Peak flood level modelling undertaken by ATC Williams (2023) are shown in Figure 7-17. The increase in predicted peak flood level was considered small with an average change of 0.013 m for the 1 percent Annual Exceedance Probability (AEP), 0.014 m for the 0.1 percent AEP and 0.010 m for the Probable Maximum Flood (PMF) (ATC Williams, 2023) (Figure 7-17).

Given the small area that the Project occupies when compared to the overall size of Lake Cowal, outside of a small increase in predicted flood levels is it considered unlikely that the Project will have any impacts to hydrology within Lake Cowal.

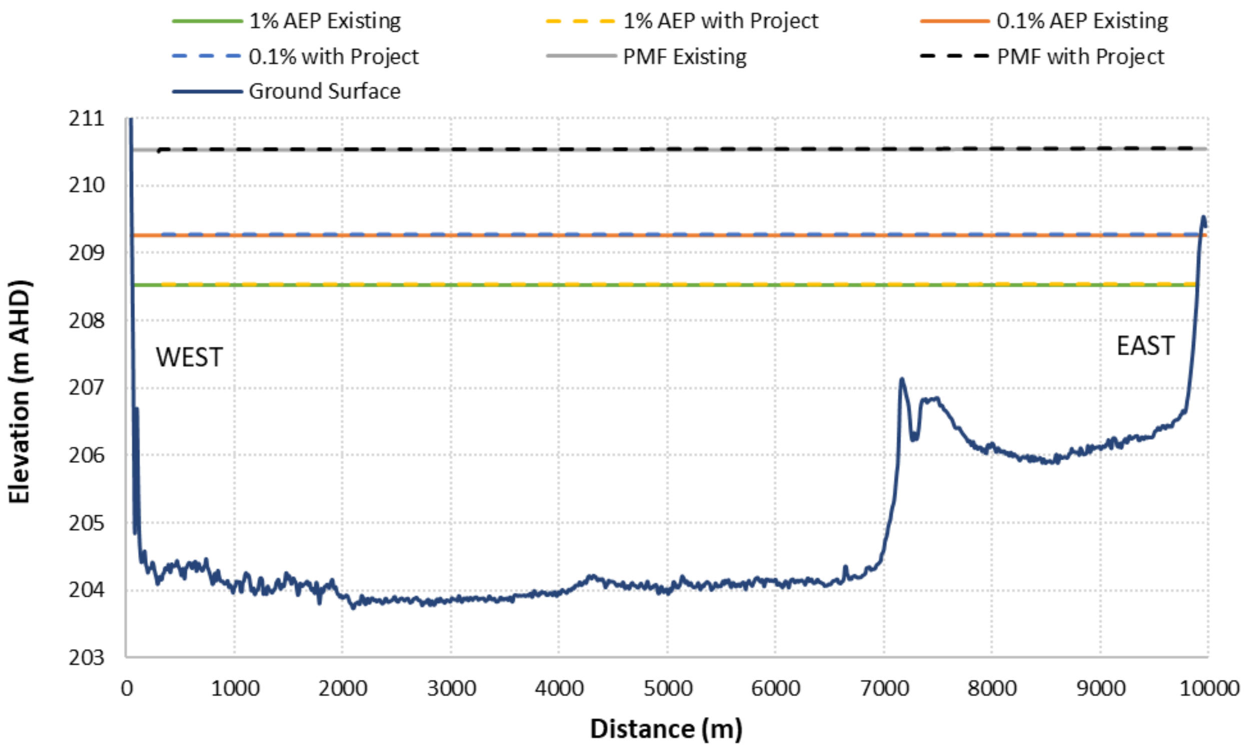

Figure 7-17: Modelled Lake Cowal Peak Flood Levels (ATC Williams, 2023)

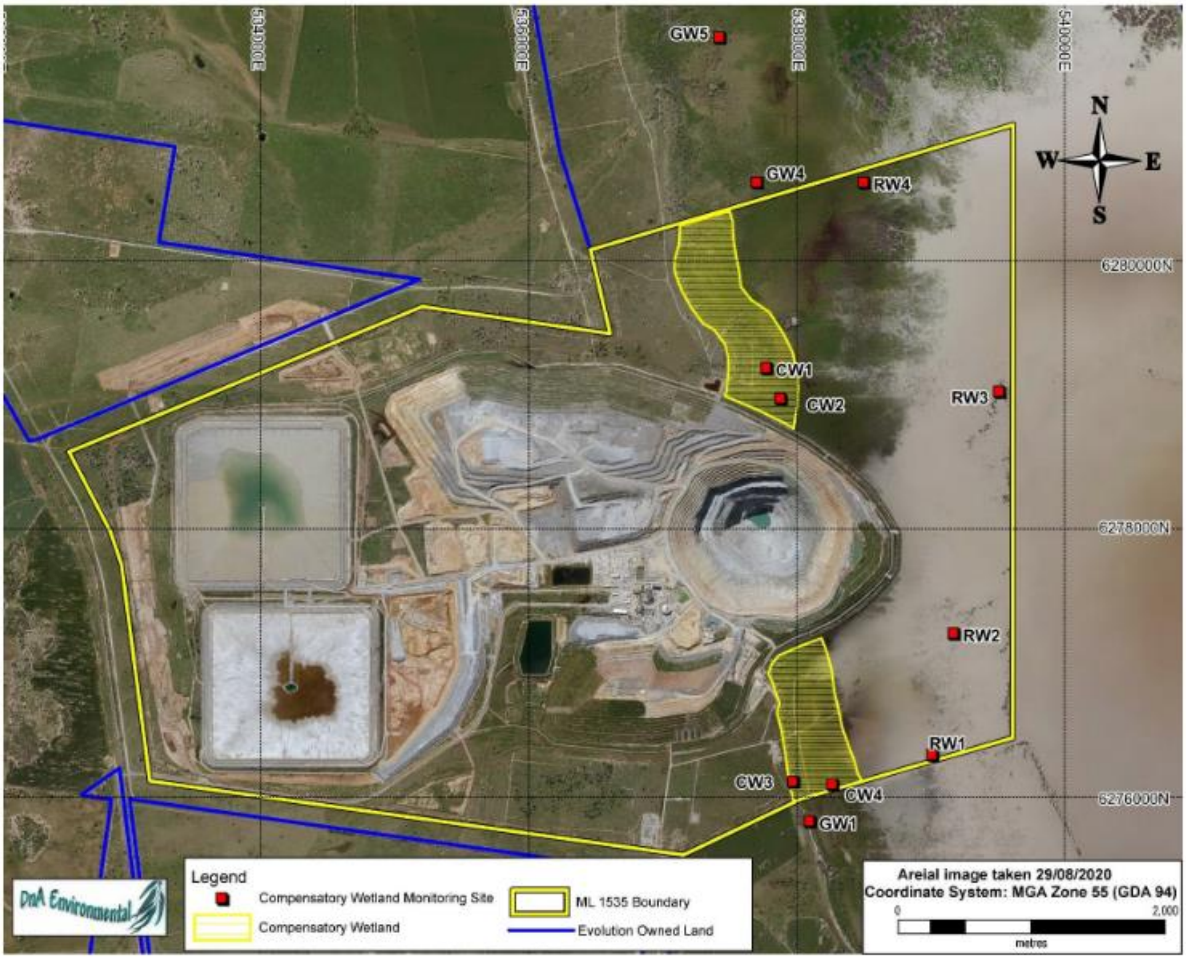

Figure 7-18: Geomorphic features within the development (DnA Environmental, 2022)

7.1.10. Impacts to GDEs

A detailed Groundwater Impact Assessment report was prepared by EMM Consulting Pty Limited and will be appended to the EIS. The following section draws on information provided in the Groundwater Impact Assessment report and potential impacts have been assessed solely on the information provided in the Groundwater Impact Assessment report.

The Groundwater Impact Assessment report states that there is a clear difference in hydro-chemical signatures within the Lake Cowal surface water system and all groundwater systems assessed within the study area (EMM Consulting Pty Limited, 2023b). The reported groundwater level trend analysis showed that all groundwater systems are strongly influenced by rainfall trends and that no sampled bores were primarily influenced by either lake levels or CGO borefield groundwater pumping trends (EMM Consulting Pty Limited, 2023b). The report also states that there is clear hydrochemical separation between lake samples and ground water (Lachlan Formation) samples showing that these populations are hydraulically separated with no overlap. Reviews of depths to groundwater indicate there is a slight groundwater mounding emanating under Lake Cowal potentially indicating that the Lake system is a losing and disconnected system, with groundwater receiving gradual long-term seepage from the lake when full. This is ultimately restricted by the Lacustrine Clay layer which overlays the alluvial groundwater systems (EMM Consulting Pty Limited, 2023b). The report also states that there is clear segregation of water quality signature between the lake and the more saline Cowra Formation and weathered bedrock (which includes the bores around the mining area). Underground mine water samples are compatible with the Cowra Formation and weathered bedrock and show no compatibility with the lake. The separation of surface water systems is hypothesised, within the report, to be due to the very low hydraulic conductivity properties of the Lacustrine Clay layer overlying the alluvial groundwater systems. Based on this analysis the report states the following:

1) There is no definitive evidence of hydraulic connection between the lake and the bores around the open pit and underground; and,
2) There is no evidence of hydraulic connection between the palaeochannel and the lake, or the palaeochannel and the open pit or underground.

Based on the information provided in the Groundwater Impact Assessment report it is understood that a minimal amount of seepage from Lake Cowal into shallow groundwater systems may occur when lake levels are high which occurs infrequently. This shallow groundwater system is restricted by the Lacustrine Clay layer which will restrict the permeation of Lake water into deeper groundwaters thus protecting local GDEs (EMM Consulting Pty Limited, 2023b). As such, the Project will have little to no impact on Aquatic Groundwater Dependent Ecosystems in the vicinity of the project.

7.1.11. Fauna Passage During Bund Construction

If Lake Cowal is inundated during the construction of the LPB there is potential for the movement of aquatic fauna to be restricted once the LPB is joined, sealing off the CGO mine footprint from Lake Cowal and trapping aquatic fauna within the CGO mine footprint. Fish species comprising part of the fish assemblage that forms the Lowland Lachlan River EEC have the potential to be trapped once the LPB is sealed however appropriate fauna salvage undertaken at this stage, capturing and releasing native fish species into Lake Cowal will negate negative impacts to fish species comprising the Lowland Lachlan River EEC. No other listed aquatic species outside of those species comprising the Lowland Lachlan River EEC have been detected during any surveys.

7.1.12. Dewatering Impacts

The LPB is to be constructed in accordance with the *Lake Cowal Lake Protection Detailed Designs* as prepared by SLR Consulting Limited (2022). Should Lake Cowal be fully inundated at the point where the LPB is sealed there is potential for a significant volume of lake water to be trapped within the Project footprint. At this point fauna salvage and dewatering will be required. All waters are to be discharged into Lake Cowal and it is expected that the dewatering process will take approximately four months. Should the water be stored within the project footprint (groyne) for a significant amount of time there is potential for a decrease in water quality to occur such as increased salinity due to evaporation or leaching/spills from the mine site. Currently there are three dewatering options in place:

1. Discharge straight to Lake Cowal with water treatment protocols in place;
2. Collect the water and treat in dams prior to release back into Lake Cowal; and,
3. Maintain water quality then release into Lake Cowal.

Ongoing treatment and discharge of water may be required if seepage into the mine site occurs after the main body of water has been released back into Lake Cowal.

It is not possible to determine the impacts of water that is to be discharged into Lake Cowal until the water has been tested and treated prior to release. As such, an Adaptive Management Strategy is required and is discussed further in section 13.2 Dewatering Adaptive Management Strategy.

8. Operation Impacts

It is understood from the Surface Water Assessment prepared by ATC Williams (2023) that the Project will not change existing maximum ore processing rates or methods, tailings disposal methods, main site access, water supply sources or hours of operation. Based on this information it is unlikely that continued operation of the CGO mine with the proposed expansion will have any new, negative impacts on aquatic receptors.

9. Cumulative Impacts

No cumulative impacts are expected as a result of the Project commencing. Cumulative impacts are limited to:

- Extension of the mine life by two years. There will be no change to the rate of mining or ore processing. There is no expected change in ore quality and there for water quality changes are not anticipated.

No new significant impacts are expected due to cumulative impacts.

10. Impact Assessment

10.1. Impacts to Aquatic Ecology

The potential exists for direct and indirect impacts on aquatic and riparian ecology receptors to occur during construction and operation phases as a result of the proposed Project expansion, including:

- Direct impacts: Direct loss of 323.12 ha of KFH due of the proposed expanded location disturbance footprint;
- Indirect impacts: Decreased water quality due to pit dewatering. Potential for impacts to aquatic ecology due to prolonged exposure to low levels of molybdenum; and,
- Both direct and indirect: Lower Lachlan River EEC

10.2. Risk Assessment for the Project

Table 10-1 outlines the risk matrix adopted when assessing Project impacts.

Table 10-2 outlines the consequence criteria for the construction impacts and Table 10-3 presents the risk assessment undertaken for the construction impacts.

Table 10-1: Risk matrix adopted for the Risk assessment for Construction Impacts

		Likelihood				
		Almost Certain	Likely	Possible	Unlikely	Rare
Consequence	Insignificant	M	L	L	L	L
	Minor (Mi)	M	M	L	L	L
	Moderate (Mo)	H	H	M	M	L
	Major (Ma)	E	H	H	M	M
	Catastrophic	E	E	H	H	M

Table 10-2: Consequence Criteria adopted for the Risk assessment for the Construction Impacts

	Insignificant	Minor (Mi)	Moderate (Mo)	Major (Ma)	Catastrophic

	Minimal, if any, impact which have an overall negligible net effect	Localised, reversible short term reversible event with minor effects which are contained to an onsite level	Localised long term but reversible event with moderate impacts on a local level	Extensive, long term, but reversible event with high impacts on a regional level	Long term, extensive, irreversible with high level impacts at potential state wide levels
Species Specific (state or nationally listed species)	No detectable permanent impacts on population of a listed species; AND/OR short term removal of >1% of the site population but <1% of the local, regional or state population of a listed species	Permanent removal of >1% of the site population but <1% of the local, regional or state population of a listed species; AND/OR short term removal of >1% of the local population but <1% of the regional or state population of a listed species	Permanent removal of >1% of the local population but <1% of the regional or state population of a listed species; AND/OR short term removal of >1% of the regional population but <1% of the state population of a listed species	Permanent removal of >1% of the regional population but <1% of the state population of a listed species; AND/OR short term removal of >1% of the state or national population of a listed species	Permanent removal of >1% of the state or national population of a listed species
Lower Lachlan EEC	No detectable permanent impacts to the listed EEC	Permanent removal of <1% of the EEC habitat at the local site; AND/OR Short term removal of <1% habitat or known total EEC.	Permanent removal of 1-5% of the EEC habitat at the local site; AND/OR Short term removal of 1-5% habitat or known total EEC	Permanent removal of >5% of the EEC habitat at the local site; AND/OR Short term removal of >5% habitat or known total EEC	Permanent removal of >5% of the state EEC in area or known population
Species Specific Interactions- Aquatic Ecology	No measurable permanent impacts on aquatic ecology values	Minor short term impacts, life cycle may be disrupted but for less than a year. Annual recruitment should still occur. Short and long term viability of individual species not impacted	Medium term (1-2 year) impacts, life cycle disrupted and resulting in no recruitment for a year. Short term viability of individual species impacted recovery within 1 -5 years. Long term viability of species not impacted	Long term (2-5 year) impacts, life cycle significantly disrupted no recruitment for successive years. Short term and long term viability individual species impacted recovery time frame (5-10 years)	Loss of species and population. Minimal possibility of recovery

Surface Water - Water Quality	No measurable change to surface water quality or quality changes are not measurable	Changes to Surface Water quality during the activity, no further changes noted once activity is finished	Changes to Surface Water quality due to activity, recovery up to 1 year	Changes to Surface Water Quality due to activity, recovery 1-2 years	Changes to Surface water quality, where water becomes toxic, or permanent changes to quality, recovery is greater than 2 years
GDE	No detectable change in groundwater levels or quality	Local short term changes in ground water level (>2m change).	Local long term changes in ground water levels (<2m change) or short term regional changes in water level of (>2m change).	Regional long term changes to groundwater levels (>2m change).	Regional long term changes to groundwater levels (<2m change).
Geomorphic stability	No Measurable or noticeable change in geomorphic stability	Negligible change in stability, negligible loss of geomorphic stability due to natural processes AND/OR modification of natural landform limited. ie low densite grazing,	Moderate change in stability, Moderate loss of geomorphic stability due to natural processes AND/OR modification of natural landform limited. ie high density grazing,	Major change in stability, some loss of geomorphic stability due to natural processes AND/OR some modification of natural landform. ie small scale mining, intensive agriculture such as cropping	Substantial change in stability, complete loss of geomorphic stability due to natural processes AND/OR extensive modification of natural landform. ie large scale mining,

Table 10-3: Risk assessment for the Project Impacts

Project Phase	Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments including Uncertainty
Construction – LPB Construction	Surface Water - Water Quality	Construction activities	Increased turbidity within Lake Cowal	Appropriate sediment and erosion control measures (i.e. silt curtain) Assumes CEMP developed and measures in place for all construction activities.	Mo	U	M	Poor water quality due to increased turbidity possible if silt curtain fails Risk lowered if all mitigation and management measures followed including ongoing water quality monitoring
Construction – LPB Construction	Surface Water - Water Quality	Use of primary waste rock	Prolonged release of Molybdenum into Lake Cowal	Assumes testing procedures and thresholds for rock use detailed in EMM Consulting Pty Limited (2023c) are adhered to.	-	-	-	Unknown due to insufficient data
Construction - LPB Construction	Surface Water - Water Quality	Chemicals and Fuel spills	Decrease in water quality due to contamination with hydrocarbons etc	Assumes CEMP developed and measures in place for all construction activities. Appropriate bunding for stored materials and appropriate spill kits in place.	Mo	R	L	Chemical and fuel spills will be rare if all mitigation measures are followed.
Construction	GDE	Excavation of pits or construction of LPB	Temporary dewatering may be required.	No Proposed mitigation measures in place	IN	R	L	GDEs are isolated from the mine pit and Lake Cowal. No risk to GDEs.
Construction	Aquatic fauna	Construction of the LPB	Fauna salvage and dewatering required	Management plans and mitigation measures in place	Mi	P	L	Provided Management plans and mitigation measures are adhered to it is considered that risks to native fauna are minimal. It is

Project Phase	Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments including Uncertainty
								considered unlikely that listed aquatic species will be impacted by the Project.
Construction	Surface Water - Water Quality	Dewatering of groyne/Project area	Decreased water quality within Lake Cowal	A dewatering management plan (DMP) has been prepared detailing monitoring, water treatment and mitigation measures to be implemented during dewatering	Mo	U	M	Assuming the DMP is implemented and appropriate monitoring, treatment and mitigation measures are in place risks to Lake Cowal are considered unlikely.
Construction and operation	Geomorphic stability	Construction of the LPB and continued operation of the CGO	Changes to geomorphic stability	CEMP and Management plans in place	Mo	R	L	Lake Cowal is geomorphically stable. KFH within the proposed footprint is scheduled for complete removal. No risks to geomorphic stability.
Construction and operation	EEC	Construction and operation of the LPB and continued operation of the CGO	Loss of area supporting regional site Lower Lachlan EEC (Lake Cowal)	No mitigation measures in place as the area will be lost to the EEC	Mo	AC	H	Construction of bund and mine expansion will result in a loss of habitat within the Lower Lachlan EEC at the site. Loss of less than 2% of surface area of Lake Cowal which is an ephemeral lake with limited long term habitat values. Loss of KFH to be addressed with offsets.
Construction and operation	EEC	Construction and operation of the LPB and continued operation of the CGO	Loss of area supporting Lower Lauchlan EEC	No mitigation measures in place as the area will be lost to the EEC	Mi	AC	M	Construction of bund and mine expansion will result in a loss of habitat within the Lower Lachlan EEC of less than 1% of the known total habitat area. Loss of KFH to be addressed with offsets.

Project Phase	Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments including Uncertainty
Operation	Surface Water - Water Quality	Continued operation of the CGO	Changes to physico-chemical parameters and metals concentrations within Lake Cowal	CGO will continue to operate with historical safety measures in place	MA	R	M	CGO mine operations will continue with no new changes other than an extension to the life of the mine. Molybdenum levels in the waste rock to be used for the LPB are low. However, it is unclear if there is likely to be any concentrating effects of Molybdenum in Lake Cowal. Molybdenum should be added to the Lake Cowal monitoring program. No new impacts expected.
Construction and Operation	Surface Water - Water Quality	Expansion of the Project footprint	Changes to hydrology within Lake Cowal	A surface water assessment has been undertaken to assess impacts to hydrology	MA	R	M	Predicted changes to peak flood level are minimal.

10.2.1. Direct

In terms of direct impacts, the expansion of the Project will result in the removal of aquatic habitat (KFH) due to the proposed location of the proposed pits and associated surface infrastructure including the LPB. This has the potential to reduce the area of habitat available to aquatic biota however it is considered unlikely that listed aquatic species will be impacted. The expansion will also result in the reduction of the extent of Lake Cowal, a nationally important wetland. However, the total area of aquatic disturbance is 323.12 ha, which equates to less than two percent of the total area of Lake Cowal (16 150 ha). In addition, following the completion of the desktop assessment and November 2020 field survey, it is considered unlikely that threatened aquatic species inhabit Lake Cowal during large inundation events where Lake Cowal is filled via the Bland Creek sub catchment. It is more likely that threatened aquatic species would migrate into the lake during major filling events where Lake Cowal is flooded via increased run off, Bland Creek and the Lachlan River; however, this tends to occur relatively infrequently. While unlisted aquatic biota will be impacted by the proposed expansion, the desktop assessment and November 2020 field survey indicate that exotic species tend to be the dominant aquatic biota present within Lake Cowal. It is likely that any impact to native unlisted aquatic biota will be remediated by inflows of biota that will result in the recolonisation of any disturbed areas of the lake. Existing habitat modification and anthropogenic influences have also caused the degradation of the lake surface, further decreasing the likelihood that viable populations of listed aquatic species thrive within Lake Cowal. Overall, it is considered unlikely that the proposed expansion would impact extensively on local habitat or listed aquatic fauna. As the proposed expansion is located on the southwest margin of the lake, there will not be any impacts to fish passage.

Direct loss of area classified as Lower Lachlan EEC is addressed below in the section 10.3.

Direct impacts to Lake Cowal water quality will occur if the LPB is constructed during a wet phase via three pathways,

1) The construction process will result in the disturbance of the lakebed and interaction between the material being used for the LPB and the lake water. These activities are likely to result in the generation of turbidity during the construction process. Lake depth at the time of construction is likely to be minimal with a maximum depth of unknown due the likelihood of fluctuating water levels. The minor depth of water and absence of flow is unlikely to result in widespread turbidity impacts across Lake Cowal. Turbidity impacts as a result of the construction of the LPB will be limited to the vicinity of the LPB.

2) The construction of the LPB and entrapment of Lake water within the CGO mine site that will require dewatering. The quality of the water will be determined by the period of inundation. The quality of the water will also be determined by the properties of the primary

waste rock and materials used to construct the LPB. The material being used to the construct the LPB is the same material that has been used on site previously the resultant water quality is not anticipated to be significantly different (ATC Williams, 2023; EMM Consulting Pty Limited, 2023c). A Dewatering Management Plan (DMP) has been prepared and will manage the process.

10.2.2. Indirect

Indirect impacts will primarily be potential impacts from changes to water quality as a result of the construction and ingoing operation of the CGO. The indirect impacts will be as a result of direct water flow off the LPB and the potential for the leaching of pollutants into Lake Cowal. The LPB will be constructed from the same waste rock and site material that has been used on site in the past. And long term indirect impacts of run off interacting with the LPB rock.

10.3. Threatened Habitats, Ecological Communities, Species and Populations

In accordance with section 221ZV of the FM Act and Matters of National Environmental Significance Significant impact guidelines 1.1 (EPBC Act) (Department of the Environment 2013), an assessment was undertaken to determine whether the Project is likely to significantly impact listed habitats, communities, populations and/or species. Assessments of the following habitats, communities, populations and/or species are presented in full in Appendix H (FM Act) and Appendix I (EPBC Act), and brief summaries are provided below. Habitats, communities, populations and/or species that were considered to be unlikely to occur within, or downstream of, Lake Cowal (Appendix C), have not been considered further.

Assessments of significance have been provided for:

- Habitat and communities:
    - Lower Lachlan River EEC; and
    - Lake Cowal.
- Populations and species:
    - Western population of Olive Perchlet;
    - Flathead Galaxias; and
    - Southern Purple-spotted Gudgeon.

10.3.1. FM Act

I. Lower Lachlan River EEC

Implementation of the Project condition will not have a significant direct or indirect impact on the Lowland Lachlan EEC as:

- the Lowland Lachlan River EEC covers an area of approximately 7 198 511.17 ha
- The Project proposes to take an area of 323.12 ha of KFH which can aslo be considered as the Lower Lachlan River EEC (EMM Consulting Pty Limited, 2023a);
- A total of 0.0045 percent of the Lower Lachlan River EEC is to be lost should the Project proceed;
- Outside of the direct loss of KFH it is considered unlikley the Project will pose any new negative impacts to Lake Cowal or the Lower Lachlan River EEC;

In terms of indirect ongoing impacts, there is the potential for molybdenum leachate from the primary waste rock which is to be used in the construction of the LPB to have a negative impact on the aquatic environment due to prolonged exposure however all tested leachate samples from the primary waste rock revealed that concentrations were below the stock water protection level (EMM Consulting Pty Limited, 2023c). More information is required to determine the impacts of long term exposure to low levels of molybdenum. Molybdenum should be added to the existing water quality monitoring program for Lake Cowal to monitor for any concentrating impacts in the longer term. The Project is unlikely to cause a significant impact to the Lower Lachlan River EEC.

II. Western population of Olive Perchlet

Construction and operation of the Project is unlikely to significantly impact on the Western population of Olive Perchlet, given that:

- it is unlikely that the Lake Cowal supports a population of the Western population of Olive Perchlet;
- No public records for the Western population of Olive Perchlet were reported within the Lachlan Catchment (Department of Environment and Heritage, 2023);
- it is not considered that extensive areas of suitable habitat occur within Lake Cowal or the surrounding waterways, sufficient to support the species;
- Lake Cowal is unlikely to contain suitable habitat for sufficient periods to enable the establishment of local populations; and

- exotic fish species known to impact the Olive Perchlet are already widespread throughout the local catchment.

III. Flathead Galaxias

Construction and operation of the Project is unlikely to significantly impact on the Flathead Galaxias given that:

- it is unlikely that the Lake Cowal supports a population of the Flathead Galaxias;
- No public records for the Flathead Galaxias were reported within the Lachlan Catchment (Department of Environment and Heritage, 2023);
- it is not considered that extensive areas of suitable habitat occur within Lake Cowal or the surrounding waterways, sufficient to support the species;
- Lake Cowal is unlikely to contain suitable habitat for sufficient periods to enable the establishment of local populations; and
- exotic fish species known to impact the Flathead Galaxias are already widespread throughout the local catchment.

IV. Southern Purple-spotted Gudgeon

Construction and operation of the Project is unlikely to significantly impact on the Southern Purple-spotted Gudgeon, given that:

- it is unlikely that the Lake Cowal supports a population of the the Southern Purple-spotted Gudgeon;
- No public records for the the Southern Purple-spotted Gudgeon were reported within the Lachlan Catchment (Department of Environment and Heritage, 2023);
- it is not considered that extensive areas of suitable habitat occur within Lake Cowal or the surrounding waterways, sufficient to support the species;
- Lake Cowal is unlikely to contain suitable habitat for sufficient periods to enable the establishment of local populations; and
- exotic fish species known to impact the the Southern Purple-spotted Gudgeon are already widespread throughout the local catchment.

10.3.2. EPBC Act

I. Lake Cowal (Wetland of National Importance)

The expansion of the CGO Project is unlikely to significantly impact on Lake Cowal, given that:

- The Project proposes to take only 2 percent (323.12 ha) of the KFH available within Lake Cowal;
- Whilst the effects of long term exposure to Molybdenum are unknown, the Project is unlikely to pose any new, negative impacts to water quality beyond those impacts that occurred once the mine became operational;
- No fauna is to be taken from Lake Cowal;
- The Lake Foreshore is to be rehabilitated once construction of the LPB is complete;

The rehabiliated area has the potential to provide valuable spawning ground for aquatic fauna.

II. Flathead Galaxias

The expansion of the CGO Project is unlikely to significantly impact on the Flathead Galaxias, given that:

- it is unlikely that populations of the species occur within Lake Cowal;
- the area of potential habitat disturbance is minimal, and habitat is unlikely to be critical to the survival of the species;
- Lake Cowal is unlikely to provide sufficient suitable habitat for the species during a “typical” year due to its ephemeral hydroperiod, excluding an area of “permanently” inundated lake surface; and
- exotic fish species known to impact the species are already widespread throughout the local catchment.

In terms of direct impacts, the expansion of the CGO project disturbance footprint area will reduce the availability of potential low quality habitat within Lake Cowal by an area of 323.12 ha, attributed to the expansion of one existing pit and the excavation of three new pits of the Project mine, as well as the construction of associated infrastructure including the LPB on the lake surface. However, the total area of impact is 323.12 ha, which equates to less than 2 percent of the total area of Lake Cowal (16,150 ha when fully inundated).

In terms of indirect ongoing impacts, there is the potential for molybdenum leachate from the primary waste rock which is to be used in the construction of the LPB to have a negative impact on the aquatic environment over time however all leachate samples from the primary waste rock revealed that concentrations were below the stock water protection level (EMM Consulting Pty Limited, 2023c). More information is required to determine the impacts of long term exposure to low levels of molybdenum.

While suitable habitat for the Flathead Galaxias likely occurs within Lake Cowal, it is considered unlikely that the species occurs, except potentially during major flood events when connectivity to the Lachlan River occurs. In addition, suitably inundated conditions are not considered a regular occurrence, with the majority of native aquatic fauna likely to be transient within this system due to the lakes partly ephemeral hydroperiod and particularly given the anthropogenic impacts currently affecting the lake. Therefore, it is unlikely that implementation of the CGO Project will result in significant impact to the EPBC Act listed species.

11. Rehabilitation Strategy

Progressive rehabilitation has been undertaken at the CGO since the commencement of mining operations and includes portions of the Northern Waste Rock Emplacement (NWRE), Southern Waste Rock Emplacement (SWRE) and Perimeter Waste Rock Emplacement (PWRE), Northern Tailings Storage Facilities (NTSF) and Southern Tailings Storage Facilities (STSF), the new Lake Cowal foreshore and other water infrastructure areas such as outer dam walls and water diversion structures (EMM Consulting Pty Limited, 2023d). A rehabilitation strategy has been developed by Evolution Mining (Evolution Mining, 2023; EMM Consulting Pty Limited, 2023d) whereby the lake foreshore will be reinstated and the downstream toe of the LPB (Lake Foreshore) will be landscaped when lake levels permit. The landscaped area will be approximately 19.5 ha with a length of 6.5 km and will merge with the existing lakebed area and will partially rely on endemic vegetation and seedbank. Supplementary planting with appropriate flora species will be undertaken as needed in order to rehabilitate the LPB toe. In addition to existing and planted vegetation aquatic fauna habitat in the form of tree logs (range of sizes), various sized rocks and boulders and other organic material will be installed (Evolution Mining, 2023). This serves both the purpose of providing important aquatic habitat but also provides structure and stability that will allow plants to become established. Two additional areas are being considered for rehabilitation in a similar manner:

- The Temporary Isolation Bund:
  - Approximate length: 6.5 km
  - Approximate height: 206.5 RL – slope length 5.6 m
  - Indicative area: 36.4 ha
- LPB Embankment:
  - Approximate length: 6.5 km
  - Approximate embankment height (Centre): 209.64 RL - Slope length 7m
  - Approximate embankment height (North and South): 208.9 RL
  - Indicative Area: 45.5 ha

- The LPB embankment area will not support flora species with deep roots planted (i.e. trees) as this will potentially cause piping of the clay zone.

Following construction of the LPB and once water levels recede sufficiently, landscaping and reinstatement of the Lake Cowal foreshore will be carried out. The earthworks and landscaping, using primarily lakebed soils, will occur during the LPB construction if the lakebed is dry. Should the lakebed still be wet/semi-inundated then construction would be delayed until the conditions were suitable. From the toe of the LPB the landscaping will extend approximately 30 m horizontally into the lake.

Reinstatement of the lake foreshore around the extended LPB will generally follow the concepts approved in the existing Compensatory Wetland Management Plan and will include microvariations in slope and elevation to provide complex habitats for terrestrial and aquatic ecosystems.

Following the contouring of the new Lake Foreshore, rehabilitation will involve both active and passive rehabilitation techniques with the existing seedbank in the lakebed soils anticipated to provide natural revegetation of disturbed areas. The works will include placement of rock material and appropriate biomaterial to create water retaining elements."

It is understood that the current design will allow for water to remain for a period of time even when lake levels recede. With careful planning and design these shallow, revegetated, inundated areas have the potential to become important spawning habitat for native fish species present within Lake Cowal.

12. Aquatic Offsets

In accordance with Biodiversity Offsets Policy for Major Projects Fact sheet: Aquatic biodiversity (Department of Primary Industries, 2014) aquatic offsets are required wherever direct or indirect impacts to key fish habitat occur (i.e. impacts to water quality, sediment, direct removal).

EMM Consulting Pty Limited (2023a) have determined an offset strategy which is detailed in the *Cowal Gold Operations Open Pit Continuation Project Biodiversity Development Assessment Report* with the relevant section pertaining to aquatic offsets included below.

"*Lake Cowal is mapped as "key fish habitat" in the Fisheries Spatial Data Portal, "Type 1 – Highly Sensitive Key Fish Habitat"* (Department of Primary Industries, 2013)*. A 50–100 m buffer to Type 1 or 2 habitats or Class 1 to 3 waterways measured from the top of the bank/drainage also apply* (Department of Primary Industries, 2013)*.*

PCT 17 and 53 occur in Lake Cowal and would be classified as key fish habitat. PCT 249 fringes Lake Cowal; it is considered that this is not key fish habitat but would occur within the key fish habitat buffer zone. The area of the three vegetation communities is provided in Table 7-1 (noting that PCT 249 is considered to be a buffer only and to not require offset under the FM Act).

Further discussions are required to finalise an appropriate offsets strategy. All offsets should be secured prior to commencing the project unless otherwise approved with the relevant authority.

13. Summary and Recommendations

13.1. Summary

Evolution Mining (Cowal) Pty Limited is proposing to expand the size and life of Cowal Gold Operations. The implementation of the Project will extend the total mine life by approximately two years to 2042. The Project will not change existing ore processing rates or methods, tailings disposal methods, main site access, water supply sources or hours of operation. The Project will also retain the existing open pit mining workforce.

Potential impacts to Lake Cowal and the Lower Lachlan River EEC are expected to be minimal,

Potential impacts are:

- Decreased water quality within Lake Cowal due to the construction of the LPB. Turbidity is to be mitigated by the installation of a silt curtain which has historically been shown to be effective in controlling turbidity in freshwater environments;
- Decreased water quality within Lake Cowal due to use of primary waste rock in construction of the LPB. Primary waste rock was used in the existing, approved lake protection system and changed to water quality within Lake Cowal beyond those seen when the CGO became operational are considered unlikely. Risks associated with long-term exposure to low levels of molybdenum are unknown however, when analysed, molybdenum levels within the leachate from the primary waste rock were below stock protection levels;
- A total of 323.12 ha of KFH equating to PCTs 53 (311.08 ha) and 17 (12.04) will be lost if the Project proceeds. An indicative offsets pathway to offset this loss has been proposed;
- No impacts to aquatic GDEs are expected;
- Impacts associated with dewatering the mine post sealing of the LPB are to mitigated by the implementation of a DMP;
- Impacts to geomorphic stability are predicted to be minimal and isolated, relating only to the direct loss of KFH within the mine footprint;

- Impacts to hydrology within Lake Cowal are predicted to be small and are limited to minor increases in water levels in times of peak flood;

- Impacts to the Lower Lachlan River EEC are expected to be minimal and are likely limited to the loss of 0.0045 percent of the overall Lower Lachlan River EEC. The area to be lost is considered low quality habitat for those species that comprise the Lower Lachlan River EEC.

In summation, minor impacts to Lake Cowal and the Lower Lachlan River EEC are expected should the Project proceed. An approved offsets pathway should be finalised to offset the loss of 323.12 ha of KFH prior to the Project commencing. Mitigation measures must be finalised and in place prior to the commencement of the Project. Implementation of the Project will not have a significant impact to any matter listed under the FM Act or MNES listed under the EPBC Act.

13.2. Dewatering Management

It is not possible to determine whether water will be trapped within the mine site prior to construction of the LPB, nor is it possible to determine water quality of any trapped water prior to commencing the project. A Dewatering Management Plan has been prepared by ENV Solutions (2022) and will ensure that best practise procedures are undertaken when dewatering.

13.3. Mitigation Measures

- A Fauna Management Plan (FMP) should be prepared detailing best practices for capturing and releasing aquatic fauna back into Lake Cowal. The FMP should include that fauna salvage should be undertaken by experienced and qualified aquatic ecologists and discuss capture and release methods.

- A detailed De-watering Plan (DWP) has been prepared prior to constructing the bund (ENV Solutions, 2022). The DWP includes leading practices with regard to the dewatering of the CGO mine site including the option for additional treatment measures if water quality does not meet the standards for discharge.

- Ongoing testing of primary waste rock to be used in construction of the LPB is required in accordance with EMM Consulting Pty Limited (2023c).

- An indicative offsets pathway has been proposed to mitigate the loss of KFH (EMM Consulting Pty Limited, 2023a). An offsets pathway will be confirmed prior to the Project commencing.

14. References

ANZECC and ARMCANZ. (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Volume 1, The Guidelines (Chapters 1-7).* Canberra: Environment Australia.

ATC Williams. (2023). *Cowal Gold Operations Open Pit Continuation Environmental Impact Statement Surface Water Assessment.* Unpublished.

Australian Museum. (2022). *Platypus*. Retrieved 2022, from https://australian.museum/learn/animals/mammals/platypus/

Australian Plants Society NSW. (2020). *Myriophyllum species Water Milfoils*. Retrieved from https://resources.austplants.com.au/plant/myriophyllum-species/#:~:text=Myriophyllums%20are%20freshwater%20aquatic%20plants,form%20on%20the%20same%20plant.

Bino, G., Kingsford, R. T., Archer, M., Connolly, J. H., Day, J., Dias, K., . . . Whittington, C. (2019). The platypus: evolutionary history, biology, and an uncertain future. *Journal of Mammalogy*, 308-327.

Bureau of Meteorology. (2022a). *Climate statistics for Australian locations*. Retrieved from Bureau of Meteorology: http://www.bom.gov.au/climate/averages/tables/cw_050017.shtml

Bureau of Meteorology. (2022b). *Monthly rainfall: West Wyalong Airport AWS*. Retrieved from http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=139&p_display_type=dataFile&p_startYear=&p_c=&p_stn_num=050017

Canberra Nature Map. (2023). *Chara sp. (genus)*. Retrieved from https://canberra.naturemapr.org/species/2785

Chatoyer. (2023). *Custom Tapered Silt Curtains*. Retrieved from https://chatoyer.com.au/silt-curtains/custom-tapered-silt-curtains/

CSIRO. (2008). *Water availability in the Lachlan.* Australia: CSIRO.

Datastream. (2022). *A Monitor's Guide to Water Quality*. Retrieved from https://datastream.org/en/guide/turbidity#:~:text=Turbidity%20values%20less%20than%2010,be%20more%20than%20100%20NTU.

Department of Climate Change, Energy, the Environment and Water. (2019). *Lake Cowal/Wilbertroy Wetlands - NSW040*. Retrieved from Directory of Important Wetlands: https://www.environment.gov.au/cgi-bin/wetlands/report.pl

Department of Climate Change, Energy, the Environment and Water. (2020). *Revised provisional list of animals requiring urgent management intervention*. Retrieved from https://www.dcceew.gov.au/environment/biodiversity/bushfire-recovery/bushfire-impacts/priority-animals

Department of Climate Change, Energy, the Environment and Water. (2021). *Australia's bioregions (IBRA)*. Retrieved from https://www.dcceew.gov.au/environment/land/nrs/science/ibra#ibra

Department of Climate Change, Energy, the Environment and Water. (2021). *Wetlands Australia 32: Protecting the biodiversity of the Great Cumbung*. Retrieved from https://www.dcceew.gov.au/water/wetlands/publications/wetlands-australia/national-wetlands-update-february-2020/great-cumbung

Department of Climate Change, Energy, the Environment and Water. (2023). *Protected Matters Search Tool*. Retrieved from https://pmst.awe.gov.au/#/map?lng=131.50634765625003&lat=-28.671310915880834&zoom=5&baseLayers=Imagery

Department of Environment and Heritage. (2023). *NSW Bionet*. Retrieved from https://www.environment.nsw.gov.au/atlaspublicapp/ui_modules/atlas_/atlassearch.aspx

Department of Industry. (2018). *Guidelines for controlled activities on waterfront land: Riparian corridors*. Retrieved from https://water.nsw.gov.au/__data/assets/pdf_file/0003/367392/NRAR-Guidelines-for-controlled-activities-on-waterfront-land-Riparian-corridors.pdf

Department of Land and Water Conservation. (2002). *The NSW State Groundwater Dependent Ecosystems Policy.* Department of Land and Water Conservation.

Department of Planning and Environment. (2016). *Waterbirds flock to Great Cumbung Swamp*. Retrieved from https://www.environment.nsw.gov.au/news/waterbirds-flock-to-great-cumbung-swamp

Department of Primary Industries. (2006). *Primefact 145: Aquatic ecological community in the natural drainage.* New South Wales: Department of Primary Industries.

Department of Primary Industries. (2012). *NSW Aquifer Interference Policy.* Retrieved 2022, from https://www.industry.nsw.gov.au/__data/assets/pdf_file/0005/151772/NSW-Aquifer-Interference-Policy.pdf

Department of Primary Industries. (2012). *Risk assessment guidelines for groundwater dependent ecosystems - Volume 1: The conceptual framework .* Sydney: Department of Primary Industries.

Department of Primary Industries. (2013). *Policy and guidelines for fish habitat*. Retrieved from https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/634694/Policy-and-guidelines-for-fish-habitat.pdf

Department of Primary Industries. (2014). *NSW Biodiversity Offsets Policy for Major Projects Fact Sheet: Aquatic Biodiversity.* Retrieved 2022, from https://www.environment.nsw.gov.au/resources/biodiversity/14817aqoffs.pdf

Department of Primary Industries. (2017). *Primefact 185: Trout Cod Maccullochella macquariensis.* Department of Primary Industries Threatened Species Unit.

Department of Primary Industries. (2017). *Primefact: Southern Purple Spotted Gudgeon – Mogurnda adspersa.* Online: Threatened Species Unit.

Department of Primary Industries. (2019). *Degradation of riparian vegetation*. Retrieved from https://www.dpi.nsw.gov.au/fishing/habitat/threats/removal-and-degradation-of-riparian-vegetation

Department of Primary Industries. (2020). *Threatened species distribution maps*. Retrieved from NSW Department of Primary Industries: https://www.dpi.nsw.gov.au/fishing/threatened-species/threatened-species-distributions-in-nsw

Department of Primary Industries. (2023a). *Fisheries NSW Spatial Data Portal*. Retrieved from https://webmap.industry.nsw.gov.au/Html5Viewer/index.html?viewer=Fisheries_Data_Portal

Department of Primary Industries. (2023b). *Fish stocking*. Retrieved from https://www.dpi.nsw.gov.au/fishing/recreational/resources/stocking

Department of Primary Industries. (2023c). *Redfin perch*. Retrieved from https://www.dpi.nsw.gov.au/fishing/aquatic-biosecurity/pests-diseases/freshwater-pests/finfish-species/redfin-perch

Department of Primary Industries. (2023d). *Eastern Gambusia*. Retrieved from https://www.dpi.nsw.gov.au/fishing/aquatic-biosecurity/pests-diseases/freshwater-pests/finfish-species/gambusia

Department of Primary Industries. (2023e). *Southern Purple Spotted Gudgeon*. Retrieved from https://www.dpi.nsw.gov.au/fishing/threatened-species/what-current/endangered-species2/purple-spotted-gudgeon

Department of Primary Industries. (2023f). *Priorities Action Statement - Actions for Western Population of Olive Perchlet*. Retrieved from https://www.dpi.nsw.gov.au/fishing/threatened-species/what-current/endangered-populations2/olive-perchlet/priorities-action-statement-actions-for-western-population-of-olive-perchlet

Department of Sustainability, Environment, Water, Population and Communities. (2011). *Survey guidelines for Australia's threatened fish: Guidelines for detecting fish listed as threatened under the EPBC Act.* Retrieved 2022, from https://www.dcceew.gov.au/environment/epbc/publications/survey-guidelines-australias-threatened-fish

Department of the Environment. (2013). *Matters of National Environmental Significance: Significant impact guidelines.* Canberra: Department of the Environment.

Department of the Environment. (2013). *Significant Impact Guidelines 1.1 - Matters of National Environmental Significance*. Retrieved from https://www.dcceew.gov.au/environment/epbc/publications/significant-impact-guidelines-11-matters-national-environmental-significance

DnA Environmental. (2018). *2017 Compensatory Wetland Monitoring Report.* Cowal Gold Operations Evolution Mining (Cowal) Pty Ltd.

DnA Environmental. (2019). *2018 Compensatory Wetland Monitoring Report.* Cowal Gold Operations Evolution Mining (Cowal) Pty Ltd.

DnA Environmental. (2020). *2019 Compensatory Wetland Monitoring Report.* Cowal Gold Operations Evolution Mining (Cowal) Pty Ltd.

DnA Environmental. (2021). *2020 Compensatory Wetland Monitoring Report.* Cowal Gold Operations Evolution Mining (Cowal) Pty Ltd.

DnA Environmental. (2022). *2021 Compensatory Wetland Monitoring Report.* Cowal Gold Operations Evolution Mining (Cowal) Pty Ltd.

EMM Consulting Pty Limited. (2020). *Cowal Gold Operations (CGO) Underground Development: Biodiversity Development Assessment Report.* Online: Evolution Mining (Cowal) Pty Ltd.

EMM Consulting Pty Limited. (2023a). *Cowal Gold Operations Open Pit Continuation Project Biodiversity Development Assessment Report.* Unpublished.

EMM Consulting Pty Limited. (2023b). *Cowal Gold Operation - Open Pit Continuation Project: Groundwater Impact Assessment.* Unpublished.

EMM Consulting Pty Limited. (2023c). *CGO Open Cut Expansion Project: Lake Protection Bund Waste Rock Management.* Unpublished.

EMM Consulting Pty Limited. (2023d). *Mine Closure and Rehabilitation Strategy: Cowal Gold Operations Open Pit Continuation Project.* Unpublished.

Entwistle, T., & Skinner, S. (2002). Non-marine algae of Australia: 4. Floristic survey of some colonial green macroalgae (Chlorophyta). *Telopea*, DOI:10.7751/telopea20024010.

Entwistle, T., Sonneman, J., & Lewis, S. (1997). *Freswater Algae in Australia: A guide to conspicuous genera.* Sainty and Associates.

ENV Solutions. (2022). *Dewatering Managment Plan (DMP): Cowasl Lake Protection Bund Dewatering .* Unpublished.

Evolution Mining. (2020). *Cowal Gold Operations Mining Operations Plan 1st July 2020 to June 2021.*

Evolution Mining. (2022). *Cowal Lake Protection Bund (LPB) Construction Methodology.* Unpublished.

Evolution Mining. (2022). *Environmental Monitoring Data.* Online: Evolution Mining.

Evolution Mining. (2023). *Cowal Gold Operation Open Pit Continuation Project:CGO OPC Finish/Rehab LPB Construction Sequence and disturbance boundaries.* Unpublished.

Foged, N. (1978). Diatoms in Eastern Australia. *Bibliotheca Phycologica, 41* , 1-242.

frc Environmental. (2022). *Cowal Gold Mine: Compensatory Wetland Habitat and Fish Investigation .* Cleveland, Qld: Unpublished report for Evolution Mining.

Gell, P. A., Sluiter, I. R., & Fluin, J. (2002). Seasonal and interannual variations in diatom assemblages in Murray River connected wetlands in north-west Victoria, Australia. *Marine and Freshwater Research*, 981-992.

Gilligan, D., Jess, L., McLean, G., Asmus, M., Wooden, I., Hartwell, D., . . . Bell, K. (2010). *Identifying and implementing targeted carp control options for the Lower Lachlan Catchment.* Cronulla: NSW Department of Primary Industries.

Grant, T., & Temple-Smith, P. D. (2003). Conservation of the Platypus, Ornithorhynchus anatinus : Threats and Challenges. *Aquatic Ecosystem Health and Management* , 5-18.

Green, D. L., Petrovic, J., Burrell, M., & Moss, P. (2011). *Water resources and management overview: Lachlan catchment.* Sydney: Office of Water.

Hammer, U. T. (1986). *Saline Lake Ecosystems of the World.* Dordrecht: Dr. W. Junk Publishers.

Hazelton, P., & Murphy, B. (2007). *Interpreting Soil Test Results: What Do All The Numbers Mean?* 10.1071/9780643094680.

Heijerick, D. G., Regoli, L., & Carey, S. (2012). The toxicity of molybdate to freshwater and marine organisms. II. Effects assessment of molybdate in the aquatic environment under REACH. *Science of the Total Environment*, doi: 10.1016/j.scitotenv.2012.05.075.

Hrytsyniak, I. I., Yanovych, D. O., & Shvets, T. M. (2016). The biogical role and toxic effect of molybdenum in hydroecosystems (overview). *Science of Ukraine*, http://dx.doi.org/10.15407/fsu2016.03.032 UDC 556.114:[628.394.17:546.77.

John, J. (1983). *The diatom flora of the Swan River estuary, Western Australia .* Bibliotheca phycologica.

John, J. (2000). *A guide to diatoms as indicators of urban stream health. National River Health Program, Urban Sub Program, Report No. 7.* Canberra: Land and Water Resources and Development Corporation.

Lachlan Riverine Working Group. (2014). *Lachlan Environmental Water Management Plan Summary.* Lachlan Riverine Working Group.

Lintermans, M. (2017). *Fishes of the Murray-Darling Basin: An introductory guide.* Canberra: Murray-Darling Basin Authority.

McCarthy, P. M. (2013). *Census of Australian Marine Diatoms. Australian Biological Resources Study.* Retrieved from Http://www.anbg.gov.au/abrs/Marine_Diatoms/index.html

Murray-Darling Basin Authority. (2012). *Sustainable Rivers Audit 2: The ecological health of rivers in the Murray–Darling Basin at the end of the Millennium Drought (2008–2010).* Canberra: Murray-Darling Basin Authority.

Murray-Darling Basin Authority. (2019). *Basin-wide environmental watering strategy.* Online: Murray-Darling Basin Authority.

NSR Environmental Consultants Pty Ltd. (1995). *Lake Cowal Gold Project Environmental Impact Statement: Volume 2 Fauna Impact Statement & Fauna and Flora Studies.* Abbotsford: Unpublished report for Evolution Mining.

NSW National Parks and Wildlife Service. (2003). *The Bioregions of New South Wales: their biodiversity, conservation and history .* Hurstville: NSW National Parks and Wildlife Service .

Ockden, M. C., Deasy, C., Quinton, J. N., Surridge, B., & Stoate, C. (2014). Keeping agricultural soil out of rivers: Evidence of sediment and nutrient accumulation within field wetlands in the UK. *Journal of Environmental Management*, 54-62.

PlantNet. (2006). *NEW SOUTH WALES FLORA ONLINE: Eleocharis acuta R.Br.* Retrieved from https://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&lvl=sp&name=Eleocharis~acuta

Regoli, L., Tilborg, W. V., Heijerick, D., Stubblefield, W., & Carey, S. (2012). The bioconcentration and bioaccumulation factors for molybdenum in the aquatic environment from natural environmental concentrations up to the toxicity boundary. *Science of the Total Environment*, doi: 10.1016/j.scitotenv.2012.06.020.

Shaheen, S. M., Abdelrazek, M. A., Elthoth, M., Moghanm, F. S., Mohamed, R., Hamza, A., . . . Rinklebe, J. (2019). Burullus coastal lagoon at North Nile Delta, Egypt: A survey and risk assessment. *Science of The Total Environment*, 1237-1249.

Sheridan, J. M., Lowrance, R., & Bosch, D. D. (1999). Management Effects on run-off and sediment transport in riparian forest buffers. *American Society of Agricultural and Biological Engineers*, 55-64.

Simpson, R., & Jackson, P. (1996). *The Mary River Cod Research and Recovery Plan.* Brisbane: Queensland Department of Primary Industries - Fisheries Group.

SLR Consulting Limited. (2022). *Lake Cowal Lake Protection Detailed Design.* Unpublished.

Strahler, A. (1952). Dynamic Basis of Geomorphology. *Geological Society of America Bulletin, 63*, 923-938.

Sydney Catchment Authority. (2010). *Cyanobacteria Risk Profile.* Sydney: NSW Government.

Turak, E., Waddell, N., & Johnstone, G. (2004). *New South Wales (NSW) Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual .* Sydney: Department of Environment and Conservation.

US Fish and Wildlife Service. (1989). *Molybdenum hazards to fish, wildlife and invertebrates: A synoptic view.* US Fish and Wildlife Service.

Vestjens, W. J. (1977). *CSIRO Division of Wildlife Research Technical Memorandum No. 12: Status, habitats and food of vertebrates at Lake Cowal, NSW.* Canberra: CSIRO.

Water Quality Australia. (2018). *Australian and New Zealand Guidelines for Fresh & Marine Water Quality*. Retrieved from https://www.waterquality.gov.au/anz-guidelines

15. Appendix A – Database Search Summary

Table A-15-1: BioNet database search results (Lachlan River catchment)

	Vernacular	Species	# Records
Fish			
Cyprinidae	*Common Carp	*Cyprinus carpio*	4
Galaxiidae	Mountain Galaxias	*Galaxias olidus*	169
Percichthyidae	Golden Perch	*Macquaria ambigua*	1
Percichthyidae	Macquarie Perch	*Macquaria australasica*	22
Percichthyidae	Murray Cod	*Maccullochella peelii*	1
Poeciliidae	*Eastern Gambusia	*Gambusia holbrooki*	15
Retropinnidae	Australian Smelt	*Retropinna semoni*	2
Terapontidae	Silver Perch	*Bidyanus bidyanus*	1
Crustacean			
Parastacidae	Common Yabby	*Cherax destructor*	61
Mammal			
Ornithorhynchidae	Platypus	*Ornithorhynchus anatinus*	178
Reptile			
Chelidae	Broad-shelled Turtle	*Chelodina expansa*	2
Chelidae	Eastern Long-necked Turtle	*Chelodina longicollis*	168
Chelidae	Macquarie Turtle	*Emydura macquarii*	7

Table A-15-2: PMST database search results

Family	Common Name	Scientific Name	Conservation status: EBPC Act	Potential distribution
Habitats				
-	Banrock Station Wetland Complex	-	Wetlands of International Importance	600-700 km downstream of Lake Cowal
-	Hattah-Kulkyne Lakes	-	Wetlands of International Importance	400-500 km downstream of Lake Cowal
-	Riverland	-	Wetlands of International Importance	500-600 km downstream of Lake Cowal
-	The Coorong, Lake Alexandrina, Albert Wetland	-	Wetlands of International Importance	700-800 km downstream of Lake Cowal
Fish				
Galaxiidae	Flathead Galaxias	*Galaxias rostratus*	CE	Species or species habitat may occur within area
Percichthyidae	Macquarie Perch	*Macquaria australasica*	E	Species or species habitat may occur within area
Percichthyidae	Trout Cod	*Maccullochella macquariensis*	E	Species or species habitat may occur within area
Percichthyidae	Murray Cod	*Maccullochella peelii*	V	Species or species habitat known to occur within area

16. Appendix B - Literature Review Summary

Table B.1 Literature review results (aquatic ecology – Lachlan River catchment; subterranean ecology – <200 km)

Reference	Report title	General	Impacts	Aquatic Flora & Riparian Vegetation	Aquatic Invertebrates	Aquatic Vertebrates (non-threatened)	Threatened species^	Aquifer Geology & Water Quality	Stygofauna Taxa
Aquatic ecology									
(Green, Petrovic et al. 2011)	Water resources and management overview: Lachlan catchment	-	Impact to native aquatic environment due to agriculture, water regulation and fish passage barriers	-	River snail	-	Silver Perch, Southern Purple-spotted Gudgeon, Olive Perchlet, Macquarie Perch (*Macquaria australasica*), Southern Pygmy Perch	majority of groundwater is extracted from alluvial aquifers which spread across the western part of the catchment from Lake Cargelligo to beyond Hillston	-
(Lachlan Riverine Working Group 2014)	Lake Cowal and Wilbertroy Wetlands	Lake Cowal/Wibertroy Wetlands are included on the Directory of Important Wetlands, and the National Trust has listed Lake Cowal as a 'Landscape	-	-	Common Yabby (*Cherax destructor*)	Golden perch (*Macquaria ambigua ambigua*),	Silver perch, Macquarie perch and Murray cod (*Maccullochella peelii peelii*), Freshwater catfish (*Tandanus tandanus*)	-	-

Reference	Report title	General	Impacts	Aquatic Flora & Riparian Vegetation	Aquatic Invertebrates	Aquatic Vertebrates (non-threatened)	Threatened species^	Aquifer Geology & Water Quality	Stygofauna Taxa
		Conservations Area'.							
(EMM Consulting Pty Limited 2020)	Cowal Gold Operations (CGO) Underground development Biodiversity Development Assessment Report	Lake Cowal is a large ephemeral wetland and is listed in the Directory of Important Wetlands in Australia.	-	In the lake bed, existing vegetation is mostly drought tolerant, exotic grass species of varying levels of abundance	Common Yabby, Hanley's River Snail	Exotic - Redfin, European Carp Native – Golden Perch,	Olive Perchlet (western population) Southern Purple Spotted Gudgeon, Flathead Galaxias, Murray Cod, Macquarie Perch, Southern Pygmy Perch, Basin population), Eel-tailed Catfish, Silver Perch	High potential aquatic GDE is identified at Lake Cowal. The CGO site lies within the Lake Cowal Volcanics, which comprise massive and stratified non-welded pyroclastic debris, overlying a partly brecciated lava sequence, overlying volcanic conglomerate interbedded with siltstone and mudstone. Within the Lake Cowal Volcanic Complex are	-

Reference	Report title	General	Impacts	Aquatic Flora & Riparian Vegetation	Aquatic Invertebrates	Aquatic Vertebrates (non-threatened)	Threatened species^	Aquifer Geology & Water Quality	Stygofauna Taxa
								diorite and gabbro intrusions, one of which is intersected by the CGO open pit. Within the ore body, there are several north-south oriented, near-vertically dipping faults and fractured dykes. Overlying the Ordovician host rock (Saprock and Primary) is a Tertiary age laterite (Saprolite), which averages about 20 metres and varies in thickness across the CGO site from 15 metres to 55 metres.	

a u s t r a l

research and consulting

Reference	Report title	General	Impacts	Aquatic Flora & Riparian Vegetation	Aquatic Invertebrates	Aquatic Vertebrates (non-threatened)	Threatened species^	Aquifer Geology & Water Quality	Stygofauna Taxa
								Quarternary age sediments of predominantly lacustrine clay (Transport Alluvium) characteristically cover the Tertiary laterite. The depth of sediments across the CGO site and surrounds ranges from 10 to 55 metres (10.6 to 20.5 metres thick in the area of the underground mine).	
(Lintermans 2017)	Fishes of the Murray-Darling Basin: An introductory guide	-	Flow regulation, habitat degradation, lowered water quality, barriers,	-	-	Native - Short-headed lamprey (*Mordacia mordax*), Bony herring (*Nematalosa erebi*), Australian	Olive Perchlet, Flat-headed galaxias, Freshwater catfish, Murray cod, Silver perch,	-	-

Reference	Report title	General	Impacts	Aquatic Flora & Riparian Vegetation	Aquatic Invertebrates	Aquatic Vertebrates (non-threatened)	Threatened species^	Aquifer Geology & Water Quality	Stygofauna Taxa
			exotic species, disease, exploitation, translocation and stocking.			smelt (*Retropinna semoni*), Un-specked hardyhead (*Craterocephalus stercusmuscarum fulvus*), Murray-Darling rainbowfish (*Melanotaenia fluviatilis*), Golden perch, Carp gudgeons (*Hypseleotris* spp.). Exotic - Common carp, Goldfish, Tench (*Tinca tinca*), Eastern gambusia, Redfin Perch,			
(Murray-Darling Basin Authority 2012)	Sustainable Rivers Audit 2: The ecological health of rivers in the Murray–Darling Basin at the end of	Lachlan catchment considered in "moderate" hydrological condition, "good" physical form condition,	Habitat modification, degradation and fragmentation of aquatic and riparian habitat.	Vegetation condition within the Lachlan catchment is considered to be "poor"	Lachlan catchment is considered to be 'moderate' in terms of the macroinvertebrate community	Lachlan catchment considered 'extremely poor' in terms of fish community health, average biomass (kg)/site	-	-	-

Reference	Report title	General	Impacts	Aquatic Flora & Riparian Vegetation	Aquatic Invertebrates	Aquatic Vertebrates (non-threatened)	Threatened species^	Aquifer Geology & Water Quality	Stygofauna Taxa
	the Millennium Drought (2008–2010): Volume 1	and 'very poor' in terms of ecosystem health				higher for exotic fish compared to native fish.			
(Department of Primary Industries 2018)	Lachlan Water Resource Plan Surface water resource description	This report is a detailed description of the surface water resources of the Lachlan Water Resource Plan Area (SW10) to provide an understanding of the region and the resources covered by the plan. It describes the location and physical attributes and provides background information on the hydrology, environmental assets and	Dams and associated impacts, barriers to fish passage.	-	-	-	Olive Perchlet, , Freshwater catfish, Murray cod, Silver perch, Southern Pygmy Perch, Macquarie Perch, Lachlan EEC)	Water quality 'poor to good'	-

Reference	Report title	General	Impacts	Aquatic Flora & Riparian Vegetation	Aquatic Invertebrates	Aquatic Vertebrates (non-threatened)	Threatened species^	Aquifer Geology & Water Quality	Stygofauna Taxa
		water quality characteristics relevant to these water sources.							
(Department of Planning, Industry and Environment 2020)	Lachlan Long Term Water Plan Part A: Lachlan catchment	Overall, the fish community in the Lachlan is in poor to very poor health	Headwater dams, weirs and large-scale floodplain irrigation	The western portion of the Lachlan catchment supports extensive areas of floodplain woodlands and wetlands, dominated by river red gum with grassy understorey that occur along the river and the effluent creeks	Seven crustacean species	Australian smelt, carp gudgeon, flat-headed gudgeon, bony herring, Murray-Darling rainbowfish, unspecked hardyhead, Golden Perch	purple-spotted gudgeon, silver perch, Murray cod, Macquarie perch, trout cod, Southern pygmy perch, flathead galaxias, freshwater catfish, olive perchlet and a small gastropod, Hanley's river snail	-	-
(Commonwealth of Australia 2011)	Environmental Water	This document has been prepared to	Barriers to fish passage, River	-	-	-	Macquarie perch, trout cod, southern pygmy	-	-

Reference	Report title	General	Impacts	Aquatic Flora & Riparian Vegetation	Aquatic Invertebrates	Aquatic Vertebrates (non-threatened)	Threatened species^	Aquifer Geology & Water Quality	Stygofauna Taxa
	Delivery Lachlan River	provide information on the environmental assets and potential environmental water use in the Lachlan River catchment	regulation, land management practices (e.g. riparian clearing) and species introductions,				perch and purple-spotted gudgeon, freshwater river snail		
(Murray-Darling Basin Authority, 2019)	Basin-wide environmental watering strategy	The implementation of the Basin Plan is seeking to alleviate some of the adverse effects of river regulation and consumptive use of water in a way that also provides water users with security and supports communities.	-	about 360,000 hectares of river red gum; 409,000 ha of black box; 310,000 ha of coolibah forest and woodlands; and existing large communities of lignum	-	Golden Perch	Murray Cod	-	-

Reference	Report title	General	Impacts	Aquatic Flora & Riparian Vegetation	Aquatic Invertebrates	Aquatic Vertebrates (non-threatened)	Threatened species^	Aquifer Geology & Water Quality	Stygofauna Taxa
(Gilligan, et al., 2010)	Identifying and implementing targeted carp control options for the Lower Lachlan Catchment	Discusses impacts of Common Carp in the Lachlan River catchment.	Impacts to biological and abiotic components	-	20 macroinvertebrate families collected across 25. 5 collected in Lake Cowal	Common Carp	-	-	-

17. Appendix C - Likelihood of Occurrence

Table C-1 Likelihood of occurrence assessment for the Project (Lachlan River catchment & PMST listings)

Family	Common name	Scientific name	Data source				Conservation status	LoO	Rationale for likelihood of occurrence	Habitat requirements
			DPI	BioNet	PMST	Lit.	EPBC Act			
Habitats & Communities										
-	Banrock Station Wetland Complex - 63	-	-	-	✓	-	Wetland of International Importance	Unlikely	PMST: 600-700km downstream of Lake Cowal	-
-	Hattah-Kulkyne Lakes - 16	-	-	-	✓	-	Wetland of International Importance	Unlikely	PMST: 400-500km downstream of Lake Cowal	-
-	Riverland - 29	-	-	-	✓	-	Wetland of International Importance	Unlikely	PMST: 500-600km downstream of Lake Cowal	-
-	The Coorong, and Lakes Alexandrina and Albert Wetland - 25	-	-	-	✓	-	Wetland of International Importance	Unlikely	PMST: 700-800km downstream of Lake Cowal	-
-	Lake Cowal / Wilbertroy Wetlands - NSW040	-	-	-	✓	-	Wetland of National Importance	Known	PMST: Within Project area	-
-	Lake Brewster - NSW048	-	-	-	-	✓	Wetland of National Importance	Unlikely	Literature: More than 140 km downstream of Lake Cowal	-
-	Booligal Wetlands - NSW043	-	-	-	-	✓	Wetland of National Importance	Unlikely	Literature: More than 200 km downstream of Lake Cowal	-
-	Great Cumbung Swamp - NSW045	-	-	-	-	✓	Wetland of National Importance	Unlikely	Literature: More than 200 km downstream of Lake Cowal	-
-	Lake Merrimajeel / Murrumbidgil Swamp - NSW049	-	-	-	-	✓	Wetland of National Importance	Unlikely	Literature: More than 200 km downstream of Lake Cowal	-
-	Lachlan Swamp (Part of mid Lachlan Wetlands) - NSW047	-	-	-	-	✓	Wetland of National Importance	Unlikely	Literature: More than 200 km downstream of Lake Cowal	-

Family	Common name	Scientific name	Data source				Conservation status	LoO	Rationale for likelihood of occurrence	Habitat requirements
			DPI	BioNet	PMST	Lit.	EPBC Act			
-	Merrowie Creek (Cuba Dam to Chillichil Swamp) - NSW051	-	-	-	-	✓	Wetland of National Importance	Unlikely	Literature: More than 200 km downstream of Lake Cowal	-
Fish										
Galaxiidae	Flathead Galaxias	*Galaxias rostratus*	✓	-	✓	-	CE / PL	Possible	DPI Fisheries: Predicted distribution indicates that the species has the potential to occur within, and immediately upstream of, Lake Cowal within Bland Creek and Barmedman Creek, as well as downstream within Bogandillon Creek and the Lachlan River (~30 km away). BioNet: n/a PMST: Species or species habitat may occur within area. Literature: frc Environmental lists the species in a likelihood of occurrence table but does not indicate that it has been historically recorded in Lake Cowal. Records for the species before 1980 exist in the Lachlan Valley.	The species is generally found mid-water in still and gently moving waters of small streams, lakes, lagoons, billabongs and backwaters. Its habitat consists of coarse sand or mud substrate and aquatic vegetation, where it feeds on aquatic insects and crustaceans. The Flathead Galaxias is endemic to the southern tributaries of the Murray-Darling River system, particularly the Murray, Murrumbidgee and Lachlan rivers and their tributaries, and the upper Macquarie-Bogan rivers catchment. The Flathead Galaxias has experienced significant declines in distribution and abundance in all river systems in NSW. Extensive scientific sampling over the last two decades has recorded extremely few specimens. The last record in the Murrumbidgee River is from 1971, and it is thought that the species may be locally extinct from the lower Murray, Murrumbidgee, Macquarie and Lachlan rivers. In addition, only very small numbers of specimens have been sampled from wetlands of the Murray River floodplain between Hume Dam and Lake Mulwala and the upper Murray River near Tintaldra. During periods of major flooding and inundation, muddy substrates and aquatic vegetation may be present within Lake Cowal and this may provide suitable habitat for this species. It should be noted that the Flathead Galaxias was added to the Department of Climate Change, Energy, the Environment and Water (2020) provisional list of animal species that have been identified as requiring immediate urgent management intervention, following the 2019/2020 bushfire season in southern and eastern Australia.
Percichthyidae	Murray Cod	*Maccullochella peelii*	✓^	✓	✓	✓	V	Unlikely	DPI Fisheries: Stocking data indicates the species was stocked in Gum Bend Lake (Condobolin) in 2015/2016 (more than 60 km downstream of Lake Cowal within an impoundment).	The Murray Cod's natural distribution extends throughout the Murray-Darling basin ranging west of the divide from south east Queensland, through NSW into Victoria and South Australia. It is found in the waterways of the Murray–Darling Basin in a wide range of warm water habitats that

Family	Common name	Scientific name	Data source				Conservation status	LoO	Rationale for likelihood of occurrence	Habitat requirements
			DPI	BioNet	PMST	Lit.	EPBC Act			
									BioNet: One specimen record from downstream of the Booligal Weir (>200 km downstream of Lake Cowal). PMST: Species or species habitat known to occur within area (likely attributed to DPI Fisheries stocking). Literature: frc Environmental lists the species as historically occurring in Lake Cowal, albeit with no reference source, but are now considered unlikely to occur. Murray Cod formerly contributed to commercial yield, likely entering from the Lachlan River; however, Lake Cowal is unlikely to provide suitable habitat to maintain a breeding population.	range from clear, rocky streams to slow flowing turbid rivers, billabongs and large deep holes. Murray Cod is entirely a freshwater species and will not tolerate high salinity.
Percichthyidae	Macquarie Perch	*Macquaria australasica*	✓	✓	✓	✓	E / PL	Unlikely	DPI Fisheries: Predicted distribution indicates that the species has the potential to occur within the Lachlan River and Abercrombie River more than 200 km upstream of Lake Cowal. BioNet: Recorded from the Abercrombie River and Retreat River. PMST: species or species habitat may occur within area. Literature: Decline correlates with proliferation of Redfin Perch. A small population occurs near Wyangala Dam and a substantial population is known from the Abercrombie River.	Macquarie Perch are found in the Murray-Darling Basin, particularly within upstream reaches of the Lachlan, Murrumbidgee and Murray rivers, and parts of south-eastern coastal NSW, including the Hawkesbury River and Shoalhaven River catchments. Macquarie Perch are found in both river and lake habitats, especially the upper reaches of rivers and their tributaries. The species feed on shrimps and small benthic aquatic insect larvae and in lake habitats cladocerans can also be a significant dietary item. Competition from introduced fish species such as Redfin Perch and other exotic species, which are confirmed from the upland zone of the Macquarie River, are thought to have significant contributions to its decline. It is unlikely that suitable habitat is available in Lake Cowal (when inundated). In addition, the lake is dry for the majority of the time and/or has limited connectivity to the Lachlan River and its upstream tributaries. It should be noted that the Macquarie Perch was added to the the Department of Climate Change, Energy, the Environment and Water (2020) provisional list of animal species that have been identified as requiring immediate urgent management intervention, following the 2019/2020 bushfire season in southern and eastern Australia.
Terapontidae	Silver Perch	*Bidyanus bidyanus*	✓	✓	✓	✓	CE	Unlikely	DPI Fisheries: Predicted distribution indicates that the species has the potential to occur within Bogandillon Creek, Wallamundry Creek, Wallaroi Creek, and the Lachlan River	Silver Perch are endemic to the Murray-Darling system (including all states and sub-basins). Within its natural range, Silver Perch are known to occupy cool clear water of the upper reaches and highlands, to the lower turbid slow flowing

Family	Common name	Scientific name	Data source				Conservation status	LoO	Rationale for likelihood of occurrence	Habitat requirements
			DPI	BioNet	FMST	Lit.	EPBC Act			
									approximately 30 km downstream of Lake Cowal. BioNet: One record within Lake Curlew more than 100 km downstream of Lake Cowal (sighting note - interview with local fisherman). FMST: n/a Literature: frc Environmental lists the species as historically occurring in Lake Cowal, albeit with no reference source, but are now considered unlikely to occur. Silver Perch formerly contributed to commercial yield, likely entering from the Lachlan River; however, Lake Cowal is unlikely to provide suitable habitat to maintain a breeding population.	rivers of the west (Department of Primary Industries 2017). It is thought that they prefer fast flowing conditions around rapids (Merrick and Schmida 1984) as they have been observed congregating below rapids and weirs (Allen, Midgley et al. 2002). However, this may be coincidental and may coincide with fish encountering a barrier as they attempt to migrate upstream, rather than a preference for flowing water, as evidenced by a lack of fast flowing water within the area of the last known naturally occurring population. It is also suggested that they prefer open water rather than areas of snags and debris (Cadwallader and Backhouse 1983) demonstrated by visual observation within impoundments; however, DPI Fisheries data indicates that most individuals are caught near snagged habitat. There is limited information available on their habitat requirements and preferences for particular habitat components. Hatchery-bred Silver Perch are stocked out of their range in several dams on east coast river systems; however, reproduction does not appear to occur. One self-sustaining population of Silver Perch occurs in Cataract Dam in the Hawkesbury Nepean catchment. Silver Perch are an omnivorous species, with a diet including insects, small crustaceans and vegetation. Interaction with exotic fish is likely to be a threat to the species, as well as river regulation and thermal pollution.
Mammals										
Ornithorhynchidae	Platypus	*Ornithorhynchus anatinus*	-	✓	-	-	P,L	Unlikely	DPI Fisheries: n/a BioNet: One record of the Platypus in 1997 at Lake Cowal; however, majority of the remaining records are from a substantial distance upstream and downstream of Lake Cowal. FMST: n/a Literature: n/a	The Platypus is a semi-aquatic mammal that depends entirely on freshwater systems, exhibiting a preference for aquatic habitats comprising a riparian zone with consolidated earth banks stabilised by large trees, overhanging vegetation, abundant in-stream organic matter, coarse woody debris, and coarse channel substrates, as well as a combination of wide stream sections and shallow pools (Bino, Kingsford et al. 2019). Foraging is undertaken in both low flow pools and high flow riffle habitat within streams, preferably at depths of less than 5 m and with coarse bottom substrates (Bino, Kingsford et al. 2019). Studies conducted by the Australian Platypus Conservancy (Serena and Williams 2010) indicates that a statistically

Family	Common name	Scientific name	Data source				Conservation status	LoO	Rationale for likelihood of occurrence	Habitat requirements
			DPI	BioNet	PMST	Lit.	EPBC Act			
										significant relationship between platypus numbers and foraging activity and the presence of higher numbers of indigenous trees within the riparian zone exists. A similar relationship was demonstrated for the amount of cover provided by vegetation and lower-growing plants overhanging the water. The Platypus may occur within Lake Cowal following high rainfall and major flooding, but it is unlikely to occur during "normal" conditions and will obviously not occur during dry conditions. It should be noted that the Platypus was added to the Department of Climate Change, Energy, the Environment and Water (2020) provisional list of animal species that have been identified as requiring immediate urgent management intervention, following the 2019/2020 bushfire season in southern and eastern Australia.

Note ^indicates DPI Fisheries fish stocking data; LoO = Likelihood of occurrence; E = Endangered, V = Vulnerable, EP = Endangered population, PL = Department of Climate Change, Energy, the Environment and Water (2000) provisional management list.

18. Appendix D - Site Photographs, November 2020

Table D-1 Site photographs taken during the November 2020 field survey showing upstream, downstream, riverbed and riverbank profiles

Site	Upstream	Downstream	Bed	Banks
LC01				
LC02				

Site	Upstream	Downstream	Bed	Banks
LC03				
LC04				

Site	Upstream	Downstream	Bed	Banks
LC05				
LC06				

Site	Upstream	Downstream	Bed	Banks
LC07				
BC01				

19. Appendix E - DPI Fisheries Key Fish Habitat Assessment Proforma

Table E-1 Key fish habitat – waterway type assessment

Component	Present?	Component	Present?	Component	Present?
Type 1 - Highly sensitive key fish habitat		Type 2 – Moderately sensitive key fish habitat		Type 3 – Minimally sensitive key fish habitat	
Posidonia australis (a seagrass)		*Zostera*, *Heterozostera*, *Halophila* and *Ruppia* species of seagrass beds <$5m^2$ in area		Unstable or unvegetated sand or mud substrate, coastal and estuarine sandy beaches with minimal or no in-fauna	
*Zostera/*Heterozostera/*Halophila/Ruppia* species of seagrass beds >$5m^2$ in area		Mangroves		Coastal and freshwater habitats not included in TYPES 1 or 2	
Coastal saltmarsh >$5m^2$ in area		Coastal saltmarsh <$5m^2$ in area		Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	
Coral communities		Marine macroalgae such as *Ecklonia* and *Sargassum* species		Notes: For the purposes of these policy and guidelines the following are not considered key fish habitat:	
Coastal lakes and lagoons that have a natural opening and closing regime (i.e. are not permanently open or artificially closed or are subject to one off unauthorised openings)		Estuarine and marine rocky reefs		First and second order streams on gaining streams (based on the Strahler method of stream ordering)	

Component	Present?	Component	Present?	Component	Present?
Type 1 - Highly sensitive key fish habitat		Type 2 – Moderately sensitive key fish habitat		Type 3 – Minimally sensitive key fish habitat	
Marine park, an aquatic reserve or intertidal protected area		Coastal lakes and lagoons that are permanently open or subject to artificial opening via agreed management arrangements (e.g. managed in line with an entrance management plan)		Farm dams on first and second order streams or unmapped gullies	
SEPP 14 coastal wetlands, wetlands recognised under international agreements (e.g. Ramsar, JAMBA, CAMBA, ROKAMBA wetlands), wetlands listed in the Directory of Important Wetlands of Australia		Aquatic habitat within 100 m of marine park, aquatic reserve or intertidal protected area		Agricultural and urban drains	
Freshwater habitats that contain in-stream gravel beds, rocks greater than 500 mm in two dimensions, snags greater than 300 mm in diameter or 3 m in length, or native aquatic plants		Stable intertidal sand/mud flats, coastal and estuarine sandy beaches with large populations of in-fauna		Urban or other artificial ponds (e.g. evaporation basins, aquaculture ponds)	
Any known or expected protected or threatened species habitat or area of declared ‘critical habitat’ under the FM Act		Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1		Sections of stream that have been concrete-lined or piped (not including a waterway crossing)	
Mound springs		Weir pools and dams up to full supply level where the weir or dam is across a natural waterway		Canal estates	

Table E-2 Key fish habitat – waterway class assessment

Classification	Characteristics of waterway class	Present?
Class 1 – major key fish habitat	Marine or estuarine waterway or permanently flowing or flooded freshwater waterway (e.g. river or major creek), habitat of a threatened or protected fish species or 'critical habitat'.	
Class 2 – moderate key fish habitat	Generally named intermittently flowing stream, creek or waterway with clearly defined bed and banks, semi-permanent to permanent water in pools or in connected wetland areas. Freshwater aquatic vegetation is present. Type 1 and Type 2 habitats present.	
Class 3 – minimal key fish habitat	Named or unnamed waterway with intermittent flow and sporadic refuge, breeding or feeding areas for aquatic fauna (e.g. fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or other Class 1-3 fish habitats.	
Class 4 – unlikely key fish habitat	Generally unnamed waterway with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free-standing water or pools post-rain events (e.g. dry gullies, shallow	

		floodplain depressions with no aquatic flora).	

20. Appendix F - In Situ Water Quality, November 2020

Table F-1 In situ water quality parameters recorded during the November 2020 field survey

Waterway	Site	Habitat type	Hydroperiod	pH (units)	EC (uS/cm)	DO (%)	Turbidity (NTU)	Temp. (°C)	Depth (m)	Anoxic layer (cm)
Impact										
Lake Cowal	LC01	Dam	Inundated	7.7	449.0	51.4	1.0	26.6	0.5	0
Lake Cowal	LC02	Lake	Intermittent pools	8.8	502.0	89.8	7.8	35.6	0.1	0
Lake Cowal	LC07	Lake	Intermittent pools	8.3	403.0	15.5	1,196	21.9	0.1	0
Reference										
Bland Creek	BC01		Inundated	7.9	475.0	83.0	70.0	27.6	0.5	0
Lake Cowal	LC03	Lake	Inundated	7.8	557.0	20.8	11.8	22.7	0.2	0
Lake Cowal	LC04	Lake	Intermittent pools	8.8	566.0	123.8	87.2	39.0	0.2	0
Lake Cowal	LC05	Lake	Intermittent pools	8.0	571.0	108.0	3.5	35.8	0.2	0
Lake Cowal	LC06	Lake	Intermittent pools	9.0	1,160	159.0	5.6	28.9	0.1	0

21. Appendix G - Electrofisher Settings, November 2020

Table G-1 Electrofisher settings, November 2020

Waterway	Site	Volts	Frequency (Hz)	Duty cycle (%)	Seconds on time
Impact					
Lake Cowal	LC01	350	120	12	1202
Lake Cowal	LC02	250	120	12	459
Reference					
Bland Creek	BC01	300	120	12	1156
Lake Cowal	LC03	250	120	12	660
Lake Cowal	LC04	Water temperature too high for electrofishing			
Lake Cowal	LC05	Water temperature too high for electrofishing			
Lake Cowal	LC06	Water temperature too high for electrofishing			
Lake Cowal	LC07	Water temperature too high for electrofishing			

22. Appendix H - FM Act Significant Impact Assessments

Table H-1 Significant impact criteria (threatened ecological community) – Lowland Lachlan River EEC

Criteria	Discussion
(a) in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,	Not applicable
(b) in the case of an endangered population, whether the proposed development or activity is likely to have an adverse effect on the life cycle 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,	Not applicable
(c) in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity, (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	The expansion of the Project will impact on the extent of the Lowland Lachlan River EEC, which Lake Cowal forms part of, attributed to the expansion of one existing pit and the excavation of three new pits, as well as the construction of associated infrastructure including exclusion bunds on the lake surface. However, the total area of impact is 323.12ha, which equates to 2% of the total area of Lake Cowal (16,150ha) and approximately 0.0045 % of its total area of the Lower Lachlan River EEC. Consequently, it is not anticipated that implementation of the Project is likely to have an adverse effect on the extent of the Lower Lachlan River EEC, such that its local occurrence is placed at risk of extinction.
(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,	The composition of the Lower Lachlan River EEC (fish community) is limited in Lake Cowal. Lake Cowal is ephemeral and supports a fish community intermittently. The only native species (part of the Lower Lachlan EEC) detected across all surveys was Carp Gudgeon Bony

	Bream, Australian Smelt and Flathead Gudgeon. The only species detected during the most recent surveys were Carp Gudgeon which were detected within the proposed mine footprint and during dewatering activities. These fish will be lost or translocated into Lake Cowal. The loss or translocation does not place the Lower Lachlan EEC at a risk of extinction.
(d) 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 proposed development or activity, and	The total area of direct impact is 323.12ha, which equates to 2% of the total area of Lake Cowal (16,150ha). This equates to approximately 0.0045 % of the total area of the Lower Lachlan River EEC.
	A total of 323.12ha of area will be modified or removed as part of the Project.
(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,	The composition of the Lower Lachlan River EEC (fish community) is limited in Lake Cowal. Lake Cowal is ephemeral and supports a fish community intermittently. The only native species (part of the Lower Lachlan EEC) detected during surveys were Carp Gudgeon, Bony Bream, Australian Smelt and Flathead Gudgeon. The Carp Gudgeon were detected within the proposed mine footprint and during dewatering activities these fish will be lost or translocated into Lake Cowal. The loss or translocation does not place the Lower Lachlan EEC at a risk of extinction.
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the threatened species, population or ecological community in the locality,	The habitat to be removed is not considered critical to the long-term survival of the Lower Lachlan EEC.
e) whether the proposed development or activity is likely to have an adverse effect on any critical habitat (either directly or indirectly),	The habitat and area to be directly and indirectly impacted is unlikely to affect critical habitat for the Lower Lachlan River EEC. While the habitat in Lake Cowal is mapped as Type 1 highly sensitive key fish habitat and Class 1 major key fish habitat. Type 1 highly sensitive key fish habitat the

	actual habitat values are ephemeral and not considered critical habitat based on the absence of the majority of the species that represent the Lower Lachlan River EEC.
(f) whether the proposed development or activity is consistent with a Priorities Action Statement,	The project would result in the removal of 2% of the Lake as part of the Lower Lachlan River EEC . The project would result the loss of 0.0045% of the total mapped area of the Lower Lachlan EEC. that is mapped and includes Lake Cowal. The habitat in Lake Cowal is not considered key or critical habitat that will be lost if the project proceeds. The loss of habitat contradicts the Medium priority of the Priority Action Statement. These impacts may be addressed via an agreed offsets and rehabilitation plans.
(g) whether the proposed development 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.	The installation of the LPB could be considered a barrier that prevents natural flow regimes and fish passage. However, the low value of the habitat to be removed is unlikely to be a significant impact and the fish that make up the EEC have not been found to be present in Lake Cowal with the exception of Carp Gudgeon, Bony Bream, Australian Smelt and Flathead Gudgeon.
Conclusion	The delivery of the Project will have a direct impact and result in the loss of 0.0045% of the Lower Lachlan EEC habitat. The habitat value of the area that will be lost as a result of the project is considered low based on the findings of the desktop study, field investigations and the species present. It has been concluded that the delivery of the Project would not result in or contribute significantly to impacts to the Lower Lachlan River EEC primarily based on the poor representation of the aquatic community in Lake Cowal.

Table H-2 Significant impact criteria (endangered populations) – Western population of Olive Perchlet

Criteria	Discussion
(a) in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,	No known population of Olive Perchlet in Lake Cowal. Water quality impacts as a result of the Project are not considered to be at the levels or concentrations of pollutants that will impact the life cycle of fish based on the findings of the surface water assessment.
(b) in the case of an endangered population, whether the proposed development or activity is likely to have an adverse effect on the life cycle 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,	Not applicable
(c) in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity-- (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
(d) 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 proposed development or activity, and	The total area of direct impact is 323.12ha, which equates to 2% of the total area of Lake Cowal (16,150ha).
(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

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the threatened species, population or ecological community in the locality,	Habitat proposed to be removed as part of the Project is considered of low quality due to the ephemeral nature of Lake Cowal. Physical habitat attributes such as macrophyte beds and large woody debris are minimal or absent. Removal of 323.12 ha of low quality, ephemeral habitat will not pose a significant impact to the species.
(e) whether the proposed development or activity is likely to have an adverse effect on any critical habitat (either directly or indirectly),	No critical habitat for the Western Population of Olive Perchlet is present within Lake Cowal. Aquatic habitat values within Lake Cowal are considered poor due to the ephemeral nature of the water body and the absence of those habitat values associated with the Western Population of Olive Perchlet. Complex structure such as overhanging vegetation, aquatic macrophyte beds and large woody debris are absent. The Project will not have an adverse impact to critical habitat.
(f) whether the proposed development or activity is consistent with a Priorities Action Statement,	There are a number of recovery actions stipulated for the Western population of Olive Perchlet, with one potentially being of relevance to the project: *Undertake priority rehabilitation, restoration and enhancement work (e.g. rehabilitating riparian vegetation, cold water pollution reduction measures, reinstating large woody debris, removal of barriers to fish passage, removal of willows from riverbanks, sediment and erosion control measures) at key sites known to support*

	Olive Perchlet populations (Low priority). (Department of Primary Industries, 2023f). The Project proposes to rehabilitate the Lake Foreshore post construction of the LPB as detailed in EMM Consulting Pty Limited (2023d) and in section 11 of this document. The proposed rehabilitation will result in higher quality habitat values than is currently present within Lake Cowal. It is also important to note that it is considered unlikely that Olive Perchlet is present within Lake Cowal and that multiple surveys did not detect the species. The project will be implemented in a manner that does not contradict relevant Priorities Action Statements, as far as practicable.
(g) whether the proposed development 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.	Of the key threatening processes listed under the FM Act, two may be relevant to the project with regard to the Western Population of Olive Perchlet: *Degradation of native riparian vegetation along New South Wales water courses*; Overall, there is a lack of contiguous native riparian vegetation present along Lake Cowal approximately 6.5 km of highly modified shoreline is proposed to be impacted. The Project proposes to rehabilitate the Lake

	Foreshore post construction of the LPB as detailed in EMM Consulting Pty Limited (2023e) and in section 11 of this document. The proposed rehabilitation will result in higher quality habitat values than is currently present within Lake Cowal. *Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams*; and While the Project will impact hydrology within Lake Cowal however impacts are predicted to be minimal. Hydrological impacts are predicted to be restricted to minimal increases to peak flood levels as detailed in ATC Williams (2023). Lake Cowal is highly ephemeral and flooding rarely occurs. No other impacts to the hydrology of Lake Cowal are expected.
Conclusion	Construction and operation of the Project is unlikely to significantly impact the Western Population of Olive Perchlet given that: • The species was not detected within Lake Cowal during any aquatic surveys; • The Project proposes to take only 2 percent of the aquatic habitat present within Lake Cowal; • While KFH within Lake Cowal is designated Type 1, Class 1, it is of low quality due to the ephemeral nature of Lake Cowal and the absence of key aquatic habitat values such as extensive

	macrophyte beds, large woody debris, trailing vegetation and boulders. Additionally, exotic species associated with the decline of the Western Population of Olive Perchlet are prevalent throughout Lake Cowal. Impacts to water quality, hydrology, geomorphic stability are all considered to be minimal. It is not known whether long term exposure to low levels of molybdenum will negatively impact aquatic fauna however concentrations of molybdenum within primary waste rock leachate are below approved stock protection levels.

Table H-2 Significant impact criteria (critically endangered species) – Flathead Galaxias

Criteria	Discussion
(a) in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,	A review of all available desktop resources revealed that no records for Flathead Galaxias occur within the Lachlan Catchment. A number of surveys were drawn on to inform this EIS including surveys undertaken as part of the EIS process and Flathead Galaxias was not detected. The Project will not impact Flathead Galaxias such that a viable local population of the species is likely to be placed at risk of extinction.
(b) in the case of an endangered population, whether the proposed development or activity is likely to have an adverse effect on the life cycle 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,	Not Applicable

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity-- (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.
(d) 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 proposed development or activity, and	A review of all available desktop resources revealed that no records for Flathead Galaxias occur within the Lachlan Catchment. A number of surveys were drawn on to inform this EIS including surveys undertaken as part of the EIS process and Flathead Galaxias was not detected. A total of 323.12 ha of KFH classed as Type 1, Call 1 habitat will be removed should the project proceed. Despite the above classification aquatic habitat within Lake Cowal is considered of low quality given the ephemeral nature of the lake and the absence of key aquatic habitat values such as complex structures such as macrophyte beds, large woody debris, trailing vegetation and boulders.
(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
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the threatened species, population or ecological community in the locality,	A review of all available desktop resources revealed that no records for Flathead Galaxias occur within the Lachlan Catchment. A number of surveys were drawn on to inform this EIS including surveys undertaken as part of the EIS process and Flathead Galaxias was not detected. While all KFH within Lake Cowal is considered Type 1, Class 1 habitat, aquatic habitat within Lake Cowal is considered of low quality due to the ephemeral nature of the lake and the absence of key habitat

	characteristics such extensive aquatic macrophyte beds and large woody debris. Overall, it is unlikely that Lake Cowal is considered to be “important habitat” in its current condition, and therefore any potential impacts to Lake Cowal are unlikely to affect the Flathead Galaxias
(e) whether the proposed development or activity is likely to have an adverse effect on any critical habitat (either directly or indirectly),	There is no declared critical habitat listed under the FM Act for the Flathead Galaxias.
(f) whether the proposed development or activity is consistent with a Priorities Action Statement,	There are a number of recovery actions stipulated for the Flathead Galaxias, with one potentially being of relevance to the project: *Undertake priority rehabilitation, restoration and enhancement work (e.g. rehabilitating riparian vegetation, cold water pollution reduction measures, reinstating large woody debris, removal of barriers to fish passage, removal of willows from riverbanks, sediment and erosion control measures) at key sites known to support Flathead Galaxias populations (High priority).* While the Project will impact hydrology within Lake Cowal however impacts are predicted to be minimal. Hydrological impacts are predicted to be restricted to minimal increases to peak flood levels as detailed in ATC Williams (2023). Lake Cowal is highly ephemeral and flooding rarely occurs. No other impacts to the hydrology of Lake Cowal are expected. Cold water pollution will not occur as part of the project.
(g) whether the proposed development 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.	Of the key threatening processes listed under the FM Act, one may be relevant to the project with regard to the Macquarie Perch, Trout Cod and/or Southern Purple-spotted Gudgeon: *Degradation of native riparian vegetation along New South Wales water courses*;
Conclusion	Construction and operation of the Project is unlikely to significantly impact the Flathead Galaxias given that: • The species was not detected within Lake Cowal during any aquatic surveys;

	• The Project proposes to take only 2 percent of the aquatic habitat present within Lake Cowal; • While KFH within Lake Cowal is designated Type 1, Class 1, it is of low quality due to the ephemeral nature of Lake Cowal and the absence of key aquatic habitat values such as extensive macrophyte beds, large woody debris, trailing vegetation and boulders. Additionally, exotic species associated with the decline of the Flathead Galaxias are prevalent throughout Lake Cowal. Impacts to water quality, hydrology, geomorphic stability are all considered to be minimal. It is not known whether long term exposure to low levels of molybdenum will negatively impact aquatic fauna however concentrations of molybdenum within primary waste rock leachate are below approved stock protection levels.

Table H-3 Significant impact criteria (endangered species) – Southern Purple-spotted Gudgeon

Criteria	Discussion
(a) in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,	The Southern Purple-spotted Gudgeon is currently considered to be extremely rare in inland NSW however, DPI Fisheries habitat mapping indicates it is possible that it is present within the vicinity of Lake Cowal more broadly. Overall, it is unlikely that the project will have an adverse effect on the life cycle of the, Southern Purple-spotted Gudgeon that a viable local population of the species is likely to be placed at risk of extinction, because a viable local population is likely absent from Lake Cowal.
(b) in the case of an endangered population, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a	Not applicable

viable local population of the species is likely to be placed at risk of extinction,	
(c) in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity-- (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
(d) 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 proposed development or activity, and	A review of all available desktop resources revealed that no records for Southern Purple-spotted Gudgeon occur within the Lachlan Catchment. A number of surveys were drawn on to inform this EIS including surveys undertaken as part of the EIS process and Southern Purple-spotted Gudgeon was not detected. A total of 3232.12 ha of KFH classed as Type 1, Call 1 habitat will be removed should the project proceed. Despite the above classification aquatic habitat within Lake Cowal is considered of low quality given the ephemeral nature of the lake and the absence of key aquatic habitat values such as complex structures such as macrophyte beds, large woody debris, trailing vegetation and boulders.
(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
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the threatened species, population or ecological community in the locality,	With regard to the Southern Purple-spotted Gudgeon, the species prefers slow-flowing or still water with a substantial amount of macrophyte coverage and/or a rocky benthos. Overall, it is unlikely that the Lake Cowal is considered to be “important habitat” in its current condition, and

	therefore any potential impacts are unlikely to be Southern Purple-spotted Gudgeon.
(e) whether the proposed development or activity is likely to have an adverse effect on any critical habitat (either directly or indirectly),	There is no declared critical habitat listed under the FM Act for the, Southern Purple-spotted Gudgeon.
(f) whether the proposed development or activity is consistent with a Priorities Action Statement,	There are a number of recovery actions stipulated for and/or Southern Purple-spotted Gudgeon, with three potentially being of relevance to the project: *Allocate and manage environmental water flows in regulated rivers to restore natural seasonal flow patterns, and to reduce the impact of cold water downstream of dams (High priority)* While the Project will impact hydrology within Lake Cowal however impacts are predicted to be minimal. Hydrological impacts are predicted to be restricted to minimal increases to peak flood levels as detailed in ATC Williams (2023). Lake Cowal is highly ephemeral and flooding rarely occurs. No other impacts to the hydrology of Lake Cowal are expected. Cold water pollution will not occur as part of the project. The project will be implemented in a manner that does not contradict relevant Priorities Action Statements, as far as practicable.
(g) whether the proposed development 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.	Of the key threatening processes listed under the FM Act, two may be relevant to the project with regard to the SouthernPurple-spotted Gudgeon: *Degradation of native riparian vegetation along New South Wales water courses*; Overall, there is a lack of contiguous native riparian vegetation present along Lake Cowal approximately 6.5 km of highly modified shoreline is proposed to be impacted. The Project proposes to rehabilitate the Lake Foreshore post construction of the LPB as detailed in EMM Consulting

	Pty Limited (2023e) and in section 11 of this document. The proposed rehabilitation will result in higher quality habitat values than is currently present within Lake Cowal. *Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams*; and While the Project will impact hydrology within Lake Cowal however impacts are predicted to be minimal. Hydrological impacts are predicted to be restricted to minimal increases to peak flood levels as detailed in ATC Williams (2023). Lake Cowal is highly ephemeral and flooding rarely occurs. No other impacts to the hydrology of Lake Cowal are expected. The project will be implemented in a manner that does not contradict key threatening processes, as far as practicable.
Conclusion	Construction and operation of the Project is unlikely to significantly impact the Southern Purple-spotted Gudgeon given that: • The species was not detected within Lake Cowal during any aquatic surveys; • The Project proposes to take only 2 percent of the aquatic habitat present within Lake Cowal; • While KFH within Lake Cowal is designated Type 1, Class 1, it is of low quality due to the ephemeral nature of Lake Cowal and the absence of key aquatic habitat values such as extensive macrophyte beds, large woody debris, trailing vegetation, and boulders. Additionally, exotic species associated with the decline of the Southern Purple-spotted Gudgeon are prevalent throughout Lake Cowal. Impacts to water quality, hydrology, geomorphic stability are all considered to be minimal. It is not known whether long term exposure to low levels of molybdenum will negatively impact aquatic fauna however

	concentrations of molybdenum within primary waste rock leachate are below approved stock protection levels.

23. Appendix I - EPBC Act Significant Impact Assessments

There are no specific significant impact criteria to assess impacts to Nationally Important Wetlands. As such, we have elected to use the significant impact criteria for Wetlands of international Importance (Department of the Environment, 2013) noting that Lake Cowal is **not** a Wetland of international Importance.

Table I-1 Significant impact criteria – Wetlands of national significance

Nationally important wetland assessed	**Lake Cowal**
Criteria	Discussion
Areas of the wetland being destroyed or substantially modified	The Project proposes to take 323.12 or 2 percent of Lake Cowal however Lake Cowal is **not a Wetland of international Importance.**
A substantial and measurable change in the hydrological regime of the wetland, for example, a substantial change to the volume, timing, duration and frequency of ground and surface water flows to and within the wetland	The expansion of the Project is predicted to result in a small increase in peak flood level. Eg a predicted average change of 0.013 m for the 1 percent AEP, 0.014 m for the 0.1 percent AEP and 0.010 m for the Probable Maximum Flood (PMF) (ATC Williams, 2023). No other impacts hydrology, ground or surface water flows have been predicted.
The habitat or lifecycle of native species, including invertebrate fauna and fish species, dependant upon the wetland being seriously affected	The Project will 'take' 323.12 ha of KFH. Provided all mitigation measures are adhered to the habitat or lifecycle of native species, including invertebrate fauna and fish species, dependant upon the wetland will not be seriously affected.
A substantial and measurable change in the water quality of the wetland – for example, a substantial change in the level of salinity, pollutants, or nutrients in the wetland, or water temperature which may adversely impact on biodiversity, ecological integrity, social amenity or human health, or	Assuming all management plans and mitigation measures are adhered to the Project will not result in a substantial and measurable change in the water quality of the wetland
An invasive species that is harmful to the ecological character of the wetland being	Aquatic surveys reveal that a number of invasive species are present within Lake Cowal. The Project will not result in any new invasive species being introduced to the wetland.

established (or an existing invasive species being spread) in the wetland.	
Conclusion	The Project will **not** have a significant impact on a Nationally Important Wetland

Table I-2 Significant impact criteria – Critically endangered species

Species assessed	**Flathead Galaxias**
Criteria	**Discussion**

Lead to a long-term decrease in the size of a population	The DPI Fisheries predicts that the Flathead Galaxias has the potential to occur within Lake Cowal immediately upstream (Bland Creek, Barmedman Creek) and downstream (Bogandillon Creek, Lachlan River), supported by the PMST ("species or species habitat may occur within area"), and literature suggests that the species has occurred within Lake Cowal historically; however, there is no recent evidence that demonstrates occurrence within Lake Cowal or its tributaries in recent years (<10 years). Lintermans indicates that records for the species exist prior to 1980 within the Lachlan River catchment. Sampling undertaken during the November 2020 field survey and prior monitoring completed by Evolution further indicate that the species is unlikely to be present within the lake. Limited suitable habitat for the Flathead Galaxias likely occurs within Lake Cowal during persistent large-scale flood events, it is considered unlikely that the species occurs, particularly given the current agricultural land use of the lake and the presence of a number of weirs along Bland Creek, Bogandillon Creek, Wallamundry Creek, Wallaroi Creek and the Lachlan River, potentially presenting a barrier to the movement of Flathead Galaxias into Lake Cowal. Consequently, it is not anticipated that implementation of the Project will lead to a long-term decrease in the size of a population of the Flathead Galaxias as it is not considered that the species occurs within Lake Cowal, except potentially during major flood events when connectivity to the Lachlan River occurs. It is more likely that existing anthropogenic influences have resulted in the local absence of the species.
Reduce the area of occupancy for of the species	In terms of direct impacts, the expansion of the Project area will reduce available habitat within Lake Cowal, attributed to the expansion of one existing pit and the excavation of three new pits, as well as the construction of associated infrastructure including the LPB on the lake surface. However, the total area of impact is 323.12 ha, which equates to approximately two percent of the total area of Lake Cowal (16 150 ha). In terms of indirect ongoing impacts, it is not possible to determine the likelihood ofnegative impacts associated with long term exposure to low levels of molybdenum which has been detected in leachate from the primary waste rock that is proposed to be used in the construction of the LPB. It is important to note that molybdenum concentrations within samples of primary waste rock leachate were below the approved stick protection levels. In addition, the surface of Lake Cowal is already subject to a number of anthropogenic impacts that affect aquatic habitat including agricultural practises.

	Consequently, it is not anticipated that implementation of the Project will adversely affect the area of occupancy available for the Flathead Galaxias. It is more likely that existing, historic impacts to Lake Cowal (agricultural practises, etc.) have reduced habitat available to the species.
Fragment an existing population into two or more populations	It is unlikely that populations of the Flathead Galaxias occur within Lake Cowal, therefore the Project is unlikely to result in the fragmentation of a population into two or more populations.
Adversely affect habitat critical to the survival of a species	No information was available as to the formal listing of habitat critical to the survival of the Flathead Galaxias. The species prefers still and slow-moving waters of small streams, lakes, lagoons, billabongs and backwaters, with habitat consisting of coarse sand or mud substrate and aquatic vegetation. During periods of major flooding and inundation, muddy substrates, aquatic vegetation and a sufficient depth of water may be present within Lake Cowal and this may provide suitable habitat for this species. However, it is not considered that the species occurs within Lake Cowal, except potentially during major flood events when connectivity to the Lachlan River occurs. In addition, suitabily inundated conditions are unlikely to occur during a “typical” year when Lake Cowal is not fully inundated with the majority of native aquatic fauna likely to be transient within this system. In terms of direct impacts, the expansion of the Project area will reduce available habitat within Lake Cowal by 323.12 ha, attributed to the expansion of one existing pit and the excavation of three new pits, as well as the construction of associated infrastructure including the LPB on the lake surface. However, the total area of impact is 323.12 ha, which equates to approximately two percent of the total area of Lake Cowal (16 150 ha). In terms of indirect ongoing impacts, there is the potential for negative impacts to occur associated with the long term exposure of low levels of molybdenum which may leach from the primary waste rock which is to be used in the construction of the LPB. There is some uncertainty in this area given the lack of knowledge on the effect of long term exposure of low levels of molybdenum on aquatic biota. It is important to note that molybdenum concentrations detected with leachate from primary waste rock samples were below the approved stock protection levels but above the background concentrations found within Lake Cowal. In addition, the surface of Lake Cowal is already subject to a number of anthropogenic impacts that affect aquatic habitat including agricultural practises.

	Overall, it is considered unlikely that Lake Cowal contains habitat critical to the survival of the species, due to its ephemeral nature, and it is also unlikely that the species occurs within Lake Cowal during a "typical" year, therefore it is unlikely that implementation of the Project will impact upon survival of the species.
Disrupt the breeding cycle of a population	It is unlikely that populations of the Flathead Galaxias occur within Lake Cowal, therefore the Project is unlikely to result in the disruption of the breeding cycle of a population.
Modify, destroy, remove, isolate or decrease the availability habitat to the extent that the species is likely to decline	The species prefers still and slow-moving waters of small streams, lakes, lagoons, billabongs and backwaters, with habitat consisting of coarse sand or mud substrate and aquatic vegetation. During periods of major flooding and inundation, muddy substrates, aquatic vegetation and a sufficient depth of water may be present within Lake Cowal and this may provide suitable habitat for this species. However, it is not considered that the species occurs within Lake Cowal, except potentially during major flood events when connectivity to the Lachlan River occurs. In addition, suitability inundated conditions are unlikely to occur during a "typical" year, with the majority of native aquatic fauna likely to be transient within this system. In terms of direct impacts, the expansion of the Project area will remove 323.12 ha of low quality habitat, which equates to approximately two percent of the total area of Lake Cowal (16 150 ha), attributed to the expansion of one existing pit and the excavation of three new pits, as well as the construction of associated infrastructure including the LPB on the lake surface. However, the total area of impact is 323.12 ha, which equates to approximately two percent of the total area of Lake Cowal (16 150 ha). In terms of indirect ongoing impacts, there is the potential for negative impacts to occur associated with the long term exposure of low levels of molybdenum which may leach from the primary waste rock which is to be used in the construction of the LPB. There is some uncertainty in this area given the lack of knowledge on the effect of long term exposure of low levels of molybdenum on aquatic biota. It is important to note that molybdenum concentrations detected with leachate from primary waste rock samples were below the approved stock protection levels but above the background concentrations found within Lake Cowal. In addition, the surface of Lake Cowal is already subject to a number of anthropogenic impacts that affect aquatic habitat including agricultural practises.

	Overall, it is considered unlikely that the expansion of the Project area will significantly modify, destroy, remove, isolate or decrease the availability habitat to the extent that the Flathead Galaxias is likely to decline
Result in invasive species that are harmful to a critically endangered species becoming established in the critically endangered species' habitat	Exotic aquatic fauna species already known from the Lachlan River catchment, and/or Lake Cowal specifically, include the Brown Trout, Common Carp, Eastern Gambusia, Goldfish, Rainbow Trout and Redfin Perch. Therefore, the Project will not result in invasive species becoming established within Lake Cowal as they already exist and/or have the potential to become established during major flood events.
Introduce disease that may cause the species to decline	While not considered to be introduced diseases, the chlorophytes *Aphanocapsa* sp. and *Pediastrum* sp., the cyanophyte Anabaena sp., and the euglenophytes *Euglena* sp. and *Phacus* sp. were recorded from Lake Cowal, with *Euglena* sp. and *Phacus* sp. also recorded from Bland Creek. *Pediastrum* sp. and *Phacus* sp. are considered to be potentially bloom-forming; however, *Aphanocapsa* sp., *Anabaena* sp. and *Euglena* sp. have the potential to be both bloom-forming and toxic, producing either the microcystin, nodularin, anatoxin or euglenophycin toxin. Therefore, they have the potential to be toxic to aquatic biota when blooming. However, it is highly unlikely that that implementation of the Project will result in the introduction of disease such that it causes the decline of the Flathead Galaxias.
Interfere substantially with the recovery of the species	It is unlikely that populations of the Flathead Galaxias occur within Lake Cowal and are more likely to be limited to transient individuals during major flood events where the lake is connected to the Lachlan River. Therefore, it is unlikely that the Project will interfere significantly with the recovery of the species.

Conclusion	The expansion of the Project is unlikely to result in a significant impact to the Flathead Galaxias as it is unlikely that populations of the species occur within Lake Cowal and are more likely to be limited to transient individuals during major flood events when there is connectivity to the Lachlan River, although this is also considered unlikely due to the significant contraction of the species distribution. In terms of direct impacts, approximately two percent of the total area of Lake Cowal will be disturbed. In terms of indirect ongoing impacts, there is the potential for negative impacts to occur associated with the long term exposure of low levels of molybdenum which may leach from the primary waste rock which is to be used in the construction of the LPB. There is some uncertainty in this area given the lack of knowledge on the effect of long term exposure of low levels of molybdenum on aquatic biota. It is important to note that molybdenum concentrations detected with leachate from primary waste rock samples were below the approved stock protection levels but above the background concentrations found within Lake Cowal.