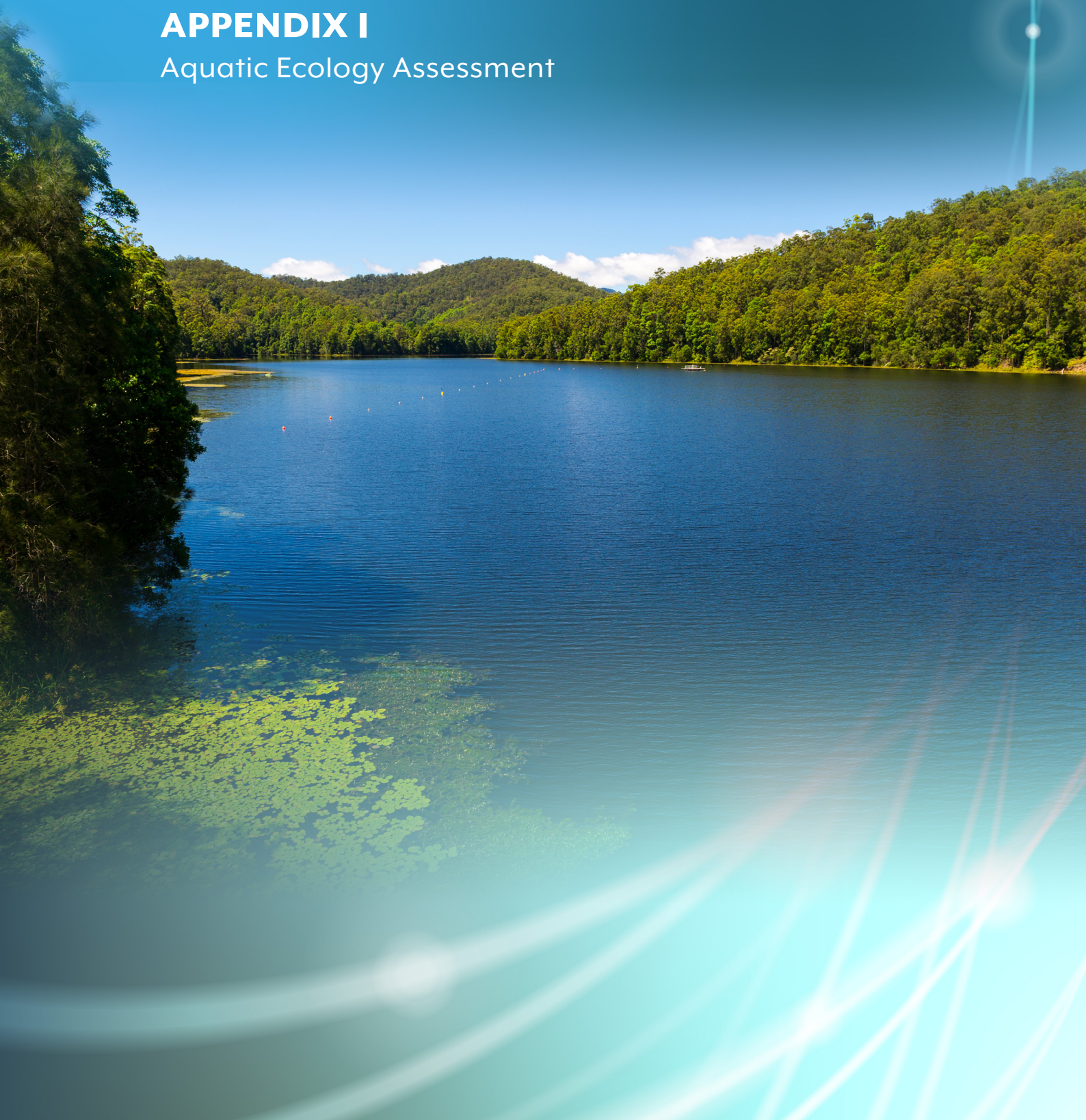


APPENDIX I

Aquatic Ecology Assessment



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Clarrie Hall Dam Raising Environmental Impact Statement: Aquatic Ecology Assessment

- Aquatic Ecology Assessment
- August 2024

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Clarrie Hall Dam Raising Environmental Impact Statement: Aquatic Ecology Assessment

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Executive Summary

This executive summary summarises the results of all aquatic investigations undertaken in support of the proposed Clarrie Hall Dam raising Proposal. The results of all investigations were used to identify and document potential impacts to key aquatic values known to occur within the footprint of the Clarrie Hall Dam raising Proposal, which includes Doon Doon Creek, Clarrie Hall Dam, the Tweed River and associated tributaries and waterways.

A desktop assessment and comprehensive literature review were undertaken in 2023 to determine potential listed species and associated habitat, threatened ecological communities (TECs) and groundwater-dependent ecosystems (GDEs) that may be impacted by the Proposal. The results of the desktop assessment indicated that no TECs occur within, or downstream of the Proposal footprint and no TECs would be impacted by the Proposal.

The desktop assessment indicated that a total of 4 threatened aquatic species listed under the *Fisheries Management Act 1994* (FM Act) and/or the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and the platypus (*Ornithorhynchus anatinus*) have the potential to occur in waterways within 50 km of Clarrie Hall Dam. Aquatic species in addition to the platypus include: southern purple-spotted gudgeon (*Mogurnda adspersa*), eastern freshwater cod (*Maccullochella ikei*), Mary River cod (*Maccullochella mariensis*) and Oxleyan pygmy perch (*Nannoperca oxleyana*). Only the platypus has been recorded within the Proposal footprint or downstream of the Proposal area.

An assessment into potential impacts to GDEs was undertaken by EMM Consulting Pty Limited. The report states “with the exception of a stand of River Oak in the construction footprint, impacts to potential GDEs are not anticipated due to the Proposal. The risk ranking for all potential groundwater impacts is low” (EMM Consulting Pty Limited, 2024b). The report also states that “a Water Management Plan (WMP) will be developed for the Proposal” (EMM Consulting Pty Limited, 2024b).

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, macroinvertebrate analysis (AUSRIVAS SIGNAL score), eDNA analysis of fish and platypus, and electrofishing and netting for aquatic vertebrates. Surveys were undertaken by Austral, and results were also taken from surveys undertaken by the Department of Primary Industries (DPI) Fisheries within Clarrie Hall Dam.

Aquatic surveys were undertaken at a total of 15 sites in September 2023 by Austral. DPI Fisheries undertook fish surveys at 8 sites within Clarrie Hall Dam in September 2023. Additional targeted Oxleyan pygmy perch surveys were undertaken by Austral at 13 sites in January 2024 in response to an unidentified positive detection of *Nannoperca* sp. that

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was recorded via eDNA analysis. Surveys were undertaken in Clarrie Hall Dam, Doon Doon Creek, Big Creek, Commissioners Creek and the Tweed River. Targeted Oxleyan pygmy perch surveys also included sites within tributaries of the Tweed River and associated wetlands downstream of Clarrie Hall Dam.

Waterways ranged from the third to the seventh (Strahler) order, with all sites being classified as Type 1 highly sensitive key fish habitat and Class 1 major key fish habitat.

Surface water quality analysis was undertaken at each of the 15 sites surveyed by Austral. Sites were located within Clarrie Hall Dam, Doon Doon Creek (including McCabes Bridge), the Tweed River, Commissioners Creek and Big Creek. A range of parameters including conductivity, dissolved oxygen, turbidity, nitrogen, chromium, copper and nickel were higher than the recommended guideline values across a number of waterways.

Sediment analysis was undertaken at the same waterways where water quality analysis was undertaken. A total of 8 parameters were detected in concentrations higher than the default guideline values (DGVs) for the protection of 80% of species representative of highly disturbed systems at one or more sites (aluminium, total chromium, trivalent chromium, cobalt, copper, lead, vanadium and zinc).

A total of 77 taxa were identified from the phytoplankton (free-floating algae) assemblage in the surface water across 15 sites during the September 2023 survey. Samples were collected from Clarrie Hall Dam, Doon Doon Creek, Big Creek, Commissioners Creek and the Tweed River. A number of potentially toxic, bloom-forming algae were detected via laboratory analysis of the samples. None of the taxa recorded during the survey was considered to be threatened or of restricted distribution.

A total of 22 macrophytes from 13 families were recorded across 15 sites during the September 2023 survey. A total of 17 native species of macrophyte and 5 exotic species of macrophyte were recorded across all sites. Exotic species were more common in Clarrie Hall Dam; however, all waterways except Commissioners Creek and Big Creek supported exotic species. Weeds of National Significance (WoNS) were detected in multiple waterways during surveys. None of the taxa recorded are considered to be threatened or of restricted distribution.

Macroinvertebrates were assessed at riffle and edge habitats within the Tweed River, Big Creek, Doon Doon Creek and Commissioners Creek during the September 2023 field survey. Overall, none of the taxa recorded are considered to be threatened or of restricted distribution. Results were pooled and the SIGNAL2 score and taxa richness assessed. The results showed that the assessed waterways can be considered healthy relative to an urban or heavily polluted stream.

Aquatic vertebrate surveys were undertaken by Austral at 15 sites in September 2023 and included electrofishing, fyke netting, bait netting and dip netting. eDNA analysis was undertaken at all sites. The only listed threatened fauna species detected by Austral during

the initial surveys was the platypus. All other species were considered common or exotic. The platypus was considered prevalent throughout the study area. eDNA analysis revealed one detection for an unidentified *Nannoperca* sp. (pygmy perch) considered likely to be Oxleyan pygmy perch given their historical distribution.

DPI Fisheries undertook fish surveys at 8 sites within Clarrie Hall Dam in September 2023. No listed threatened species were detected during the surveys.

Targeted Oxleyan pygmy perch surveys were undertaken by Austral in January 2024 in response to the positive *Nannoperca* sp. detection obtained via eDNA analysis. Oxleyan pygmy perch was not detected during the targeted surveys. All species recorded during the targeted surveys were considered common or exotic.

A range of existing impacts on aquatic values are present in the Proposal area. These include river regulation, cold water pollution (CWP), agricultural impacts, exotic species, stock access and agricultural impacts, erosion and fish passage. Impacts resulting from the construction and operation of the Proposal are considered to be minimal.

Construction impacts may include a decrease in water quality downstream of the dam wall and direct loss of KFH. These impacts can be minimised and mitigated by preparing a comprehensive Construction Environmental Management Plan (CEMP) which would include mitigation measures detailed within this report. Loss of KFH would be offset accordingly at a 2:1 ratio.

Construction of the raised dam wall would increase the capacity of Clarrie Hall Dam, which would result in an increased inundation area. Some loss of KFH would occur within creeks and tributaries that flow into Clarrie Hall Dam. Loss of platypus habitat will occur as water levels rise; however, it is expected that the platypus will readily construct new burrows as the water level rises.

Impacts from the operation of the raised dam wall are expected to be minimal. Depth within riffle habitat within Doon Doon Creek downstream of the dam wall is modelled to increase by 0.1 m approximately 20% of the time when water levels would typically sit at 0.5 m to 0.6 m (EMM Consulting Pty Limited, 2024b). Changes to pool depth are considered to be nil to negligible. No impacts to surface water within the Tweed River is expected although there will be minor increases in times of flood under the Proposal (EMM Consulting Pty Limited, 2024b).

Modelling indicates that CWP impacts are expected to decrease (EMM Consulting Pty Limited, 2024b). The magnitude of CWP releases is modelled to decrease by 2°C; however, the frequency of these releases is modelled to increase by 10%.

The Tweed Shire Council is currently in discussions with DPI Fisheries to determine an appropriate offsets pathway to offset the direct loss of KFH. The Proposal triggers Section 218 (Fishways to be provided in construction of dams and weirs) of the FM Act, which states

that a public authority that proposes to construct, alter or modify a dam, weir or reservoir on a waterway must notify the Minister of the Proposal, and must, if the Minister so requests, include as part of the works for the dam, weir or reservoir, or for its alteration or medication, a suitable fishway or fish by-pass. DPI Fisheries assessed the scope of the Proposal and has recommended the application of Section 218, which requires the provision of suitable fish passage.

Section 4.8 (Fish Passage Trade-Offs) of the *NSW Policy and guidelines for fish habitat conservation and management* (2013) provides provisions for transferring Section 218 fish passage requirements to alternative high priority sites. DPI Fisheries proposed that Section 218 fish passage requirements for Clarrie Hall Dam be transferred to the construction of a suitable fish passage at Bray Park Weir. Tweed Shire Council viewed the proposal favourably, and the Bray Park Weir is to be upgraded and will include the construction of an appropriate fish passage as proposed by DPI Fisheries.

A 7-part-test was undertaken for southern purple-spotted gudgeon. Based on the impact assessment and 7-part-test it is considered unlikely that the Proposal would result in a significant impact on southern purple-spotted gudgeon.

A test of significance was undertaken for the platypus. Based on the impact assessment and test of significance it is considered unlikely that the Proposal would result in a significant impact on the platypus.

Overall, it is considered unlikely that the Proposal would result in a significant impact on any aquatic ecology values.

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16. Appendix Q – EPBC Act Significant Impact Assessments

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Abbreviations

The following abbreviations have been used:

AHD	Australian Height Datum
ALA	Atlas of Living Australia
ANZECC	Australian and New Zealand Environment Conservation Council
ANZG	Australian and New Zealand Guidelines for Fresh & Marine Water Quality
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AUSRIVAS	Australian River Assessment System
Austral	Austral Research and Consulting
AWQC	Australian Water Quality Centre
BC	Biodiversity Conservation
BDAR	Biodiversity Development Assessment Report
BoM	Bureau of Meteorology
BPW	Bray Park Weir
CEMP	Construction Environmental Management Plan
cfu	colony forming units
cm	centimetre
CWP	Cold water pollution
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DGV	default guideline values
DNA	deoxyribonucleic acid
DO	dissolved oxygen
DPE	Department of Planning and Environment
DPI	Department of Primary Industries
DPE	Department of Planning, Industry and Environment
eDNA	environmental deoxyribonucleic acid
EEC	Endangered ecological communities
EIS	Environmental Impact Statement
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
FFMP	Flora and Fauna Management Plan
FM Act	Fisheries Management Act 1994
FSL	full supply level
GDEs	groundwater-dependent ecosystems
ha	hectare
Hz	hertz
IBRA	Interim Biogeographic Regionalisation for Australia
IPC	internal positive control

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KFH	Key fish habitat
kg	kilogram
km	kilometre
kV	kilovolt
kW	kilowatt
LoO	likelihood of occurrence
m	metre
m ²	square metre
m ³	cubic metre
mg	milligram
mg/L	milligram per litre
ml	millilitre
ML	megalitre
mm	millimetre
MNES	matters of national environmental significance
No.	number
NSW	New South Wales
NTU	nephelometric turbidity units
OTU	operational taxonomic units
PCR	polymerase chain reaction
PL	provisional management list.
PMF	probable maximum flood
PMST	Protected Matters Search Tool
ppt	parts per thousand
PWA	NSW Public Works Advisory
qPCR	quantitative polymerase chain reaction
RL	reduced level
SEARs	Secretary's Environmental Assessment Requirements
sp.	species
t	tonne
TDS	total dissolved solids
UCS	Uniaxial Compressive Strength
V	volt
W	watt
WM Act	Water Management Act 2000
WoNS	Weeds of national significance
µg/L	microgram per litre
µm	micrometre
µS/cm	microsiemens per centimeter
°C	degree Celcius

1. Introduction

1.1. Purpose of this report

This aquatic ecology assessment supports the Environmental Impact Statement (EIS) for the Proposal. It documents aquatic ecology assessment methods and results ('aquatic ecology assessment'), the initiatives built into the Proposal 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 Proposal 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:

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

Austral Research and Consulting (Austral) has ensured that the objectives of the aquatic ecology assessment have been addressed to a standard suitable for assessment by relevant regulators. Austral followed best practice and undertook the assessment in accordance with relevant legislation, policy and guidance material, summarised in sections 1.1.1, 1.1.2 and 2.

1.1.1. Assessment guidelines and requirements

This aquatic ecology assessment report has been prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs) for the Proposal, issued on 31 May 2024, 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, Housing and Infrastructure (DPHI) invited relevant government agencies to advise on matters to be

addressed in the EIS. These matters were taken into account by the Secretary for the DPHI when preparing the SEARs. The SEARs must be addressed by the EIS.

Table 1 lists the matters relevant to this assessment and where they are addressed in this report.

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

Key issue	Requirement	Chapter/section
Biodiversity	9. The proponent must undertake a test of significance as required by Part 7A of the <i>Fisheries Management Act 1994</i> for relevant threatened fish species, including the Southern Purple Spotted Gudgeon (<i>Mogurnda adspersa</i>), with known or expected distributions within areas impacted by the proposal;	Section 15: Appendix P – FM Act Significant Impact Assessments
	10. The proponent must undertake an assessment of suitable opportunities within the Tweed catchment to offset the impact of the proposed dam upgrade on fish passage and the potential impacts on fish associated with water releases and overtopping of the dam;	Section 10: Indicative offsets approach
Hydrology, Flooding and Water Quality	2. The Proponent must assess and model the impact of the operation of the Proposal and any ancillary facilities (both built elements and discharges) on hydrology in accordance with the current guidelines, including: (a) natural processes within rivers, wetlands and floodplains that affect ecological health, aquatic connectivity and access to habitat for spawning and refuge	This document and EMM Consulting Pty Limited (2024b; 2023)
Protected and Sensitive Lands	1. The Proponent must assess the impacts of the proposal on environmentally sensitive land including, but not limited to:	

Key issue	Requirement	Chapter/section
	(b) key fish habitat as mapped and defined in accordance with the <i>Fisheries Management Act 1994</i> (FM Act)	Sections 5.1.8: Key fish habitat; section 7: Ecological values; section 8: Impact assessment; section 10: Indicative offsets approach
	(c) land or waters identified as Critical Habitat under the FM Act	Section 5.1.6: Aquatic habitats; section 6.1: Habitat characterisation; section 15: Appendix P – FM Act Significant Impact Assessments; section 16: Appendix Q – EPBC Act Significant Impact Assessments
	e) matters protected under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) or other Commonwealth legislation	Sections 5, 6, 7, 8 and 9

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 Proposals. Factsheet: Aquatic biodiversity* (Department of Primary Industries, 2014)
- *NSW Aquifer Interference Policy* (Department of Primary Industries, 2012a)
- *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, 2012b), as well as associated guidelines in this series (where applicable)

- *Guidelines for controlled activities on waterfront land: Riparian corridors* (Department of Primary Industries, 2019)
- *Matters of National Environmental Significance (MNES) Significant impact guidelines 1.1* (Department of the Environment, 2013).

1.1.2. Other relevant reports

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

- *Clarrie Hall Dam Raising EIS: Surface Water Assessment* (EMM Consulting Pty Limited, 2024b);
- *Doon Doon Creek and Tweed River: Geomorphology modelling* (EMM Consulting Pty Limited, 2023);
- *Clarrie Hall Dam Raising: Flood Impact Assessment* (KBR, 2024b); and,
- *Groundwater Impact Assessment: Clarrie Hall Dam Raising* (EMM Consulting Pty Limited, 2024b).

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 *Fisheries Management Act 1994* (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 Sections 220ZZ and 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 Sections 3.2.1 and 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 (i.e. first and second order streams) (Strahler, 1952) or farm dams constructed on these (Department of Primary Industries, 2013). Generally, third 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 first or second 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 Proposal.

To inform aquatic offsets, the assessment of impacts on aquatic biodiversity must be undertaken in accordance with the NSW *Biodiversity Offsets Policy for Major Proposals 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'.

2.2. Water Management Act 2000

The *Water Management Act 2000* (WM Act), administered by the Department of Planning, Industry and Environment (DPE) 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 would occur to ‘waterfront land’.

Division 6 of the WM Act requires consideration of aquifer interference activities. The NSW Aquifer Interference Policy (Department of Primary Industries, 2012a) 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, 2012b).

2.3. Environmental Protection and Biodiversity Conservation Act 1999

The *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), administered by the Department of Climate Change, Energy, the Environment and Water (DCCEEW), is the primary piece of Commonwealth legislation that may be 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 that 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),
- 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 an 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 an 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 Proposal is assessed under the EPBC Act and a decision is made as to whether or not to grant approval.

Of the 9 MNES that are regulated by the EPBC Act, the following have the potential to be associated with the Proposal, and this report aims to evaluate whether these MNES are applicable:

- Nationally threatened species and ecological communities.

Assessment guidelines to determine whether a significant impact is expected are detailed in *Matters of National Environmental Significance: Significant impact guidelines 1.1* (Department of the Environment, 2013).

In addition, the DCCEEW (Department of Climate Change, Energy, the Environment and Water, 2020) released on 24 March 2020 a revised provisional list of animal species identified as requiring urgent management intervention following the 2019–2020 bushfire season in southern and eastern Australia. Most of the species have potentially had at least 30% of their range burnt. The list includes a number

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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 that influence their vulnerability to fire. While the list primarily comprises species already listed under the EPBC Act, it also includes species that 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. Proposal description

In 2018, a detailed concept design was prepared by NSW Public Works Advisory (PWA). The options assessment and concept design for the raised dam and its components were based on hydrological studies, geotechnical investigations, and seismic and structural assessments. The preferred option for the dam raising incorporates increasing the height of the existing concrete faced rockfill embankment and constructing a new concrete lined spillway higher up in the left (west) abutment. The existing intake tower and access bridge would also be raised.

The optimum size of the proposed raised Clarrie Hall Dam is 42,300 ML, based on raising the dam wall height by 8.5 m to a height of reduced level (RL) of 70 m Australian Height Datum (AHD). The raised dam would, as a result, provide adequate water supply to the Tweed Shire until at least 2065. Raising the wall height further was not considered feasible due to topographical constraints in the catchment.

The concept design includes:

- constructing access roads to construction areas and establishing the construction site,
- re-establishing the quarry used to construct the existing dam,
- removing and storing parapet walls for reuse,
- increasing the base width of the valley-side abutment and raising the crest of the concrete faced rockfill embankment to RL 70 m,
- constructing a new concrete lined spillway higher on the west abutment,
- extending the upstream concrete face to the new crest height,
- raising the intake tower and access bridge,
- constructing a new section of the Clarrie Hall Dam Road to provide access to the east abutment of the dam wall,
- establishing new recreation and operational facilities including an amenities block, public shelters, viewing areas, interpretation signage, paths, car parks, landscaping, security fences, lighting, monitoring equipment and a boat ramp.

The operational footprint of the upgraded dam would increase the area of inundation to below the RL 70 m contour, which would become the waterline boundary at full supply level (FSL).

Ancillary works would also be required to support the Proposal, including:

- upgrading the Kyogle Road and Clarrie Hall Dam Road intersection,

- replacing McCabes Bridge and realigning Commissioners Creek Road,
- removing or reconstructing impacted infrastructure and facilities at Crams Farm,
- relocating Telstra assets,
- realigning power line easements along Doon Doon Road and Commissioners Creek Road.

Further work has identified several options for locating staff accommodation, the concrete batching plant and site offices during construction. For further detail refer to the CHDR EIS (KBR (2024a).

A summary of the main elements of the Proposal is shown in **Error! Reference source not found..** An overview of the Proposal is provided in Figure 1. For further detail, refer to the CHDR EIS (KBR, (2024a).

Table 2: Proposal summary

Proposal element	Summary of the Proposal
Operation	
Description	
Operational footprint	Approximately 209 ha for the proposed FSL Approximately 248 ha for the area between the proposed FSL and the probable maximum flood (PMF)
Dam wall infrastructure	· Increasing the base width of the valley-side abutment and raising the crest of the concrete faced rockfill embankment to the RL 70 m · Constructing a new concrete lined spillway higher on the west abutment · Extending the upstream concrete face to the new crest height · Raising the intake tower and access bridge · Constructing a new section of the Clarrie Hall Dam Road to provide access to the east abutment of the dam wall · Establishing new recreation and operational facilities including an amenities block, public shelters, viewing areas, interpretation signage, paths, car parks, landscaping, security fences, lighting, monitoring equipment and boat ramp.
Ancillary facilities	· Upgrading the intersection of Clarrie Hall Dam Road and Kyogle Road · Replacing McCabes Bridge over Doon Doon Creek · Realigning and approximate 1,000 m section of Commissioners Creek Road · Removing or reconstructing impacted infrastructure and facilities at Crams Farm · Realigning overhead power lines and Telstra assets.
Construction footprint	Approximately 49.6 ha, consisting of 26.2 ha at the dam wall, 6.6 ha of construction compound and workforce accommodation areas and 16.8 ha of ancillary sites for road realignments and relocating overhead power

Proposal element	Summary of the Proposal
	lines. The removal of the existing overhead power line is not included in the impact area.
Workforce	Estimated peak of 180 persons at the main dam wall site.
Cut/fill	Approximately 100 000 m ³ deficit of fill material would be derived from the quarry located approximately 300 m from the existing dam.
Ancillary construction facilities	· Constructing access roads to construction areas and establishing the construction site · Re-establishing the quarry used to construct the existing dam · Establishing construction compounds including site offices and materials stockpiling areas · Establishing a concrete batching plant · Establishing workforce accommodation site compounds.
Temporary facilities	Establishment and use of temporary ancillary facilities, temporary construction sedimentation basins, access tracks and haul roads during construction.
Dewatering	Dam storage would be lowered by 300 mm below FSL during construction.
Property	Permanent and temporary property adjustments and property access refinements.



3.1. Proposal area

The location of the Proposal is the existing Clarrie Hall Dam. The disturbance areas include the main construction area, ancillary works areas, FSL and areas where potential changes in upstream and downstream hydrology may occur, including the PMF area. The types and extent of these disturbance areas are discussed below.

The area where direct impacts may occur during construction and/or operation of the Proposal is approximately 252.26 ha.

Approximately 49.6 ha would be impacted for construction and 209 ha for operation. During operation, approximately 248 ha would also be impacted in the area between the proposed FSL and the PMF.

The extent of the Proposal disturbance area includes all areas where direct impacts may occur due to construction and/or operation. These areas are the:

- construction activities disturbance area comprising:
 - o the raised dam wall, spillway, road realignments/upgrades, quarry, stockpile sites and construction compounds, intake tower and bridge and recreational areas
 - o upgrading the Kyogle Road and Clarrie Hall Dam Road intersection
 - o replacement of McCabes Bridge and realignment of Commissioners Creek Road
 - o removing or reconstructing impacted infrastructure and facilities at Crams Farm
 - o utilities relocations
- new recreation and operational facilities including an amenities block, public shelters, viewing areas, interpretation signage, paths, car parks, landscaping, security fences, lighting, monitoring equipment and boat ramp in addition to works at Crams farm and the dam wall area.
- operational disturbance areas including the:
 - o raised inundation area (to the RL 70 m contour), which is the waterline boundary at FSL
 - o area between FSL and PMF (to the 77 m contour)
 - o downstream areas, where there could be changes in flow.

The activities and disturbance area footprints of the Proposal provide the basis for assessing the extent of direct environmental impacts. Further details are provided in the CHDR EIS KBR (2024a).

4. Methods

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

- database searches and a literature review
- assessment of surface and groundwater modelling data and bore lithology logs, where available
- an aquatic ecology field survey, including:
 - o assessment of key fish habitat using a combination of habitat sensitivity (waterway type) and water classification (waterway class) to determine whether Clarrie Hall Dam and associated waterways and tributaries meets the definition of 'key fish habitat'
 - o cataloguing of photographs at each site assessed within Clarrie Hall Dam and associated waterways
 - o assessment of the suitability of identified habitats to support threatened aquatic species, communities or populations
 - o 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:
 - o summarise the above information and outline the environmental receptors
 - o present assessments of significance for aquatic species listed under the FM Act and the EPBC Act
 - o assess the potential for occurrence of direct, indirect and cumulative impacts on the aquatic ecology values of Clarrie Hall Dam and associated tributaries and waterways as a result of the construction and operation of the Proposal
 - o propose an aquatic offsets approach
 - o provide management and monitoring recommendations as appropriate.

4.1. Desktop assessment

4.1.1. Database searches

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

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

The database search results are provided in Appendix A – Database search summary.

4.1.2. Literature review

A review of publicly available literature relating to aquatic and subterranean environments in the region of the Proposal 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.

Information was also taken from the *Water Sharing Plan for the Tweed River Area Unregulated and Alluvial Water Sources 2023*, where applicable:

A summary of the results of the literature review is provided in Appendix B (excluding online databases, websites and reports listed in section 4.1.1).

4.1.3. GDE identification and assessment

Consideration was given to aquatic GDEs in the context of potential Proposal impacts, with reference to *Risk assessment guidelines for groundwater dependent ecosystems: Volume 1 – The conceptual framework* (Department of Primary Industries, 2012b). Where possible, the process that was followed was to:

- identify potential GDEs
- assess the degree of groundwater dependency of identified GDEs
- determine ecological values of GDEs, where possible.

The identification of potential aquatic GDEs (i.e. surface waterways and subterranean fauna) was undertaken via desktop assessment. A full assessment was undertaken by EMM Consulting Pty Limited (2024b).

4.1.4. Assessment of the likelihood of occurrence

The criteria for assessing the likelihood of occurrence of threatened species are summarised in Table 3 and the likelihood of occurrence assessment is presented in Appendix L – Likelihood of occurrence. While Commonwealth and State data sources indicate the 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 Tweed River catchment. The results of the likelihood of occurrence assessment are provided in Table 16 for all species identified during the desktop assessment.

Table 3: Criteria for the likelihood of occurrence

Likelihood	Description	Further assessment conducted?
Negligible	The potential for the species to occur is considered so unlikely as to not be worth considering.	No

Likelihood	Description	Further assessment conducted?
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 Proposal 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 had been recorded in the catchment/sub-catchment/waterway previously. There has not been any change in habitat values since then.	Yes

4.2. Field survey design

To aid in determining the ecological values of waterways with the potential to be impacted by the Proposal, a field survey was undertaken from 17 to 24 September 2023. A total of 15 sites were assessed within Clarrie Hall Dam, Doon Doon Creek, the Tweed River, Commissioners Creek and Big Creek (Figure 2 and Table 30) (Appendix C - Field survey design). The focus was particularly on the tributaries and creeks intersecting Clarrie Hall Dam, as DPI Fisheries agreed to provide results of the fish surveys it was undertaking in Clarrie Hall Dam during September 2023. Tributaries are sampled as they often provide a range of habitat types and many species of aquatic fauna will utilise a range of habitat types depending on seasonal requirements. Final sites were selected based on the presence of appropriate habitat for aquatic fauna. The survey comprised a range of abiotic and biotic components (Table 30). Field sampling was undertaken in accordance with DPI Fisheries Section 37 FM Act Scientific Collection Permit No P19/0050-1.0.

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
- 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 M – Site photographs). Each waterway assessed had previously been ranked by the DPI according to the Strahler (1952) method of waterway ordering, and only waterways ranked as third order and above have been included in the aquatic ecology assessment.

The content of the aquatic ecology assessment was limited to aquatic and riparian habitat and did not address terrestrial ecology or document plant species. Further information on riparian plant species that may be impacted by the Proposal are detailed in the *Clarrie Hall Dam Raising Biodiversity Development Assessment Report* (2024a). Riparian vegetation is defined by DPI Fisheries as '[t]he plants growing on the water's edge, the banks of rivers and creeks and along the edges of wetlands', and consists of trees, shrubs, grasses and/or vines across a number of structural components (i.e. groundcovers, understorey and canopy) (Department of Primary Industries, 2019).

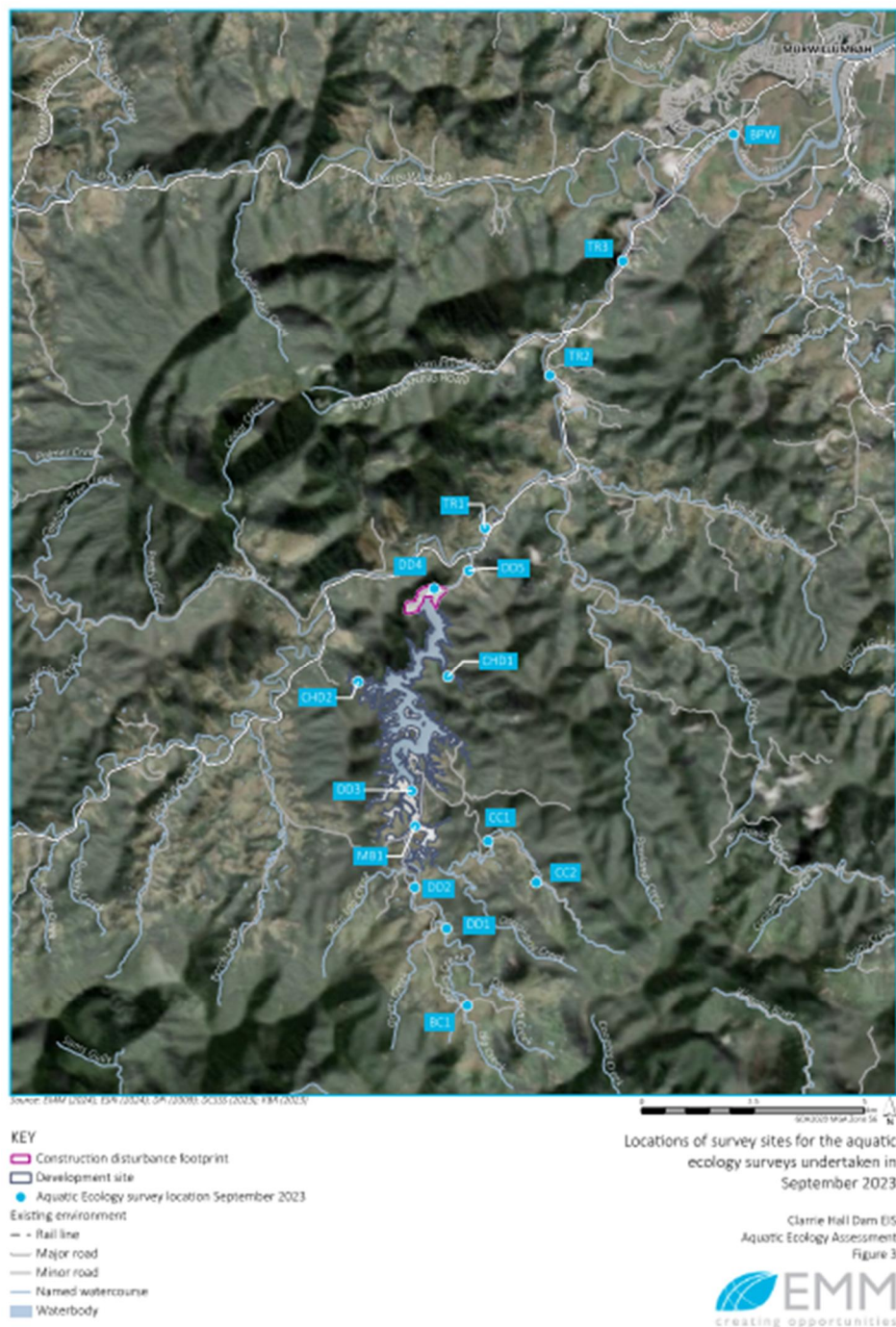


Figure 2: Locations of survey sites for the aquatic ecology surveys undertaken in September 2023
Source: EMM Consulting Pty Limited.

4.2.1. 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 15 sites (Figure 2; Table 30) (Appendix C - Field survey design) 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 4 and Table 5 respectively. DPI (Fisheries) (Department of Primary Industries, 2013) only recognises native aquatic plants with regard to waterway type classification. Where it was not known whether an aquatic plant was native or exotic, a conservative approach was taken, potentially overestimating the native vegetation component of waterway type classification.

Table 4: 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 5: 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.

Classification	Characteristics of waterway class
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 and 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).

4.2.2. Water quality

Surface water samples were collected at the 15 sites (Figure 2; Table 30) (Appendix C - Field survey design), using sterilised bottles provided by the NATA accredited Australian Laboratory Group (ALS), containing a 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 for a suite of parameters (Table 6). 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 and dissolved oxygen at all sites due to distance from Clarrie Hall Dam to the laboratory.

In-situ water quality parameters were measured at the time of the assessment and included dissolved oxygen (mg/L), temperature (°C), specific conductivity (µS/cm) and pH using a YSI ProPlus water quality meter. Turbidity was measured using a Hach 2100Q turbidity meter.

While the water quality analysis results have been compared to the Australian and New Zealand Guidelines for Fresh & Marine Water Quality (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000), trigger values for slightly disturbed ecosystems in south-eastern Australian (freshwater lakes and reservoirs or lowland rivers where applicable) and metals and metalloids were compared to the default guideline values (DGVs) for the protection of 80% of species representative of highly disturbed systems (Water Quality Australia, 2018). it should be noted that the results provided as part of this assessment are a 'snap shot' in time only and should be considered indicative only. Long-term water quality monitoring is required to truly assess water quality against the ANZECC and ARMCANZ (2000) trigger values or the DGVs for the protection of 80% of species representative of highly disturbed systems (Water Quality Australia, 2018).

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 (greater than 7.5) (Foged, 1978). Salinity was compared to Hammer (1986), classifying surface water into freshwater (less than 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 (greater than 50,000 mg/L) categories (Hammer, 1986). 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 or lowland rivers where applicable) in south-east Australia. Metal concentrations were compared to the Australian and New Zealand Guidelines for Fresh & Marine Water Quality (2000) (Water Quality Australia, 2018) DGVs for the protection of 80% of species in freshwater, representative of highly disturbed ecosystem (where available).

Table 6: Water quality parameters analysed from surface water during the September 2023 field survey

Basic	Major ions	Nutrients	Dissolved metals	
Biological oxygen demand	Alkalinity (total)	Ammonia	Aluminium	Iron
Dissolved oxygen	Calcium	Chlorophyll 'a'	Arsenic	Lead
Electrical conductivity	Chloride	Kjeldahl nitrogen (total)	Barium	Manganese
pH	Magnesium	Nitrogen (total)	Beryllium	Mercury
Total dissolved solids	Potassium	Nitrogen (oxidised)	Boron	Nickel
Turbidity	Sodium	Nitrate	Cadmium	Selenium
		Nitrite	Chromium	Vanadium
		Nitrite + nitrate	Cobalt	Zinc
		Phosphorus (total)	Copper	

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.

4.2.3. Sediment quality

Surface sediment samples were collected at the 15 sites (Figure 2; Table 30) (Appendix C - Field survey design), using sterilised glass jars provided by ALS. The top 2 to 3 centimetres of sediment was scraped into a sterilised glass container and couriered to ALS for analysis. Samples were collected for the analysis of total metals, metalloids and other trace elements ('metals') (Table 7).

Sediment pH was compared to Hazelton and Murphy (2007) that ranges from very strongly acidic (less than 5.0) to very strongly alkaline (greater than 9.0) (Hazelton & Murphy, 2007). Metal concentrations were compared to the DGV and GV High (Water Quality Australia 2018) (where available).

Table 7: Sediment quality parameters analysed during the September 2023 field survey

Basic	Major ions	Nutrients	Total metals	
Electrical conductivity	Calcium	Ammonium (N)	Aluminium	Lead
Moisture content	Chloride	Ammonium (NH ₄)	Arsenic	Manganese
pH	Magnesium	Kjeldahl nitrogen (total)	Cadmium	Mercury
	Potassium	Nitrite	Chromium	Nickel
	Sodium	Nitrate	Cobalt	Selenium
	Sulphate	Nitrogen (total)	Copper	Trivalent chromium
		Nitrite + nitrate	Hexavalent chromium	Vanadium
		Phosphorus (total)	Iron	Zinc

4.2.4. Algae and macrophytes

Samples of phytoplankton, periphyton and macrophytes were collected from surface water at 15 sites (Figure 2; Table 30) during the September 2023 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 Clarrie Hall Dam, the Tweed River, Doon Doon Creek, Commissioners Creek and Big Creek (**Error! Reference source not found.**; Table 30). Sample bottles were provided by the Australian Water Quality Centre (AWQC) and filled completely at each site. Samples were stored in a refrigeration unit until all samples were collected and then couriered to the laboratory for analysis. In the laboratory, 3 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. Holding times were breached for all samples due to the distance from the laboratory; however, the results are considered sufficient to provide accurate information on algal diversity and abundance.

II. Periphyton

Periphyton growing on submerged vegetation, sediment, rocks or woody debris in shallow surface water was collected for the analysis of diatoms (microalgae). Sample bottles were provided by the AWQC and filled completely at each site. Samples were stored in a refrigeration unit until all samples were collected and then couriered to the laboratory for analysis. 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. Holding times were breached

for all samples due to the distance from the laboratory and courier times; however, the results are considered sufficient to provide accurate information on algal diversity and abundance.

III. Macrophytes

During the September 2023 field survey, macrophytes (aquatic plants) were assessed and documented in the field by an experienced aquatic ecologist. All species were identified in the field, and taxonomic verification was undertaken to at least genus level (where possible), using appropriate taxonomic literature.

4.2.5. Aquatic invertebrates

During the September 2023 field survey, microinvertebrate and macroinvertebrate samples were collected from 13 of the 15 sites (Figure 2; Table 30) (Appendix C - Field survey design). Macroinvertebrates were collected at each site, except lake sites as standing waters cannot be analysed as part of the AUSRIVAS assessment, and photos and site assessment sheets were completed as per New South Wales (NSW) Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual (Turak, et al., 2004). Edge samples were collected using a 250 µm mesh dip net to sample 10 metres of representative habitat at each site, and a longer net was used in the riffle areas where present. Where riffle habitat was not present, 2 edge samples were collected. The contents of the net were placed into a white tray to be picked through for at least 40 minutes into 70% ethanol for later identification to family level, following the NSW Sampling and Processing Manual (Turak, et al., 2004). Macroinvertebrates were identified in the laboratory in accordance with the guidelines – to class for Oligochaeta, mites and Ostracoda; to sub-family for chironomids; and to family for all other taxa to family.

NSW Sampling and Processing Manual (Turak, et al., 2004) field sampling and habitat assessment sheets were filled out at each site and site photos taken. In-situ water quality parameters were measured at each site including dissolved oxygen (mg/L), temperature (°C), specific conductivity (µS/cm) and pH using a YSI ProPlus water quality meter. Turbidity (NTU) and alkalinity (mg/L) were measured using Hach meters and test kits respectively.

4.2.6. Aquatic vertebrates

During the September 2023 field survey, aquatic vertebrates were assessed at all 15 sites (Figure 2; **Error! Reference source not found.**), using a number of methods to sample aquatic vertebrate fauna (boat and backpack electrofishing, bait traps, fyke nets, and environmental deoxyribonucleic acid (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). The survey effort and equipment used at each site, outlined in **Error! Reference source not found.**, were

dependent on the site constraints and conditions (i.e. water depth). 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 the 15 sites (Figure 2; Table 30) 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. Where boat electrofishing was undertaken, it was conducted using a 4.3 m aluminium punt fitted with a Grassl Boat electrofisher for a standardised survey effort of 12 by 90 seconds of time (active electrofishing). Where backpack electrofishing was undertaken (i.e. wadable and non-boatable habitat), an EFish 500 W backpack electrofisher was used for a standardised survey effort of 8 by 150 seconds of time (active electrofishing). 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. Taxonomic verification was undertaken in situ at all sites, using appropriate taxonomic literature. Specimens were measured using a ruler, and once recovered, they were returned to the water. Total survey effort at each site is shown in Table 8.

II. Fyke nets

Small meshed (2 to 4 mm mesh) fyke nets were set at sites where habitat conditions permitted (Figure 2; Table 30). A 6-inch foam float was placed in the cod end of the net that was staked above water surface with a 30 cm air space maintained to protect air breathing animals such as turtles. Fyke nets were set overnight and retrieved the next morning.

III. Bait traps

A total of 10 bait traps, which consist of a 2 mm mesh and are approximately 250 mm by 250 mm by 450 mm, were set at each of the 15 sites (Figure 2; Table 30). Bait traps have a small aperture and are a passive trap. The traps were set overnight and retrieved the next morning. Captured fish were processed on a flat area immediately adjacent to the site. Taxonomic verification was undertaken in situ at all sites, using appropriate taxonomic literature. Each bait trap was cleaned and dried before leaving a site to prevent transfer of specimens and pathogens.

Table 8: Aquatic survey effort for Clarrie Hall Dam survey sites September 2023

Site	Code	Bait traps	Small mesh fyke nets	Electrofishing (boat/backpack and effort)
Clarrie Hall Dam	CHD2	10		12 x 90 - boat
Clarrie Hall Dam	CHD1	10		12 x 90 - boat
Clarrie Hall Dam	DD3	10		12 x 90 - boat
Doon Doon Creek	DD5	10	2	8 x 150 - BP
Doon Doon Creek	DD4	10	2	8 x 150 - BP
Doon Doon Creek	MB1	10	2	8 x 150 - BP
Doon Doon Creek	DD2	10		8 x 150 - BP
Doon Doon Creek	DD1	10		8 x 150 - BP
Tweed River	TR1	10	2	8 x 150 - BP
Tweed River	TR2	10	4	8 x 150 - BP
Tweed River	TR3	10	4	12 x 90 - boat
Tweed River	BPW	10		12 x 90 - boat
Big Creek	BC1	10		8 x 150 - BP
Commissioners Creek	CC1	10		8 x 150 - BP
Commissioners Creek	CC2	10		8 x 150 - BP

IV. Environmental DNA (eDNA) sampling

Analysis of eDNA is a non-invasive method for detecting single species or, more recently, entire taxonomic groups (Rees, et al., 2014; McColl-Gausden, et al., 2019; Thomsen & Willerslev, 2015). Genetic material that an organism leaves behind in its environment is known as eDNA. Quantitative comparisons with traditional sampling methods indicate that eDNA methods are effective at detecting scarce, elusive or cryptic species (Biggs, et al., 2015; Lugg, et al., 2018; Smart, et al., 2015; Thomsen, et al., 2012; Valentini, et al., 2016), or species at low densities.

During September 2023, water samples were collected from 15 sites (Figure 2; **Error! Reference source not found.**) by Austral staff following EnviroDNA sampling protocols. At each site, water samples were collected in triplicate by passing up to 500 mL of water (average 500 mL) through a 1.2 µm syringe filter. Filtering on site reduces deoxyribonucleic acid (DNA) degradation that may occur during transport of water (Yamanaka, et al., 2016). Clean sampling protocols were employed to minimise contamination including new sampling equipment at each site, not entering water, and taking care not to transfer soil, water or vegetation between sites. A preservative (approx. 0.5 ml 10x Tris-EDTA) was added to the filters after filtering to minimise DNA degradation. Filters were stored out of sunlight and kept at ambient temperature before being transported to the laboratory for processing. Samples were delivered to EnviroDNA for processing.

DNA was extracted from the filters using a commercially available DNA extraction kit (Qiagen Power Soil Pro) that minimizes compounds that can inhibit polymerase chain reaction (PCR) reactions. Real-

time quantitative polymerase chain reaction (qPCR) assays were used to amplify the target DNA, using species-specific markers targeting a small region of the platypus or fish mitochondrial DNA, previously developed and assessed for specificity and sensitivity by EnviroDNA (Lugg, et al., 2018). Positive and negative controls were included for all assays as well as an internal positive control (IPC) to detect inhibition. Assays were performed in triplicate on each sample. At least 3 positive qPCR assays (out of 9 assays undertaken for the site) were required to classify the site as positive for the presence of Platypus or fish species. To minimise false positives, sites were considered equivocal if only 1 or 2 assays returned a positive result, indicating very low levels of target DNA. While trace amounts of DNA may indicate the target species is actually present in low abundance, it may also arise from sample contamination through the sampling or laboratory screening process (minimised through strict protocols and negative controls), facilitated movement of DNA between waterbodies (i.e. water birds, recreational anglers, water transfers, predator scats), or dispersal from further upstream.

Using the existing DNA extracted samples, library construction involved 2 rounds of PCR, whereby the first round employed gene-specific fish primers to amplify the target region, and the second round incorporated sequencing adapters and unique barcodes for each sample-amplicon combination included in the library. Negative controls were included during library construction. Negative controls consisted of the extraction negative as well as PCR negatives, in which nuclease-free water was used in place of DNA during both rounds of PCR. Sequencing was carried out on an Illumina sequencing platform.

Following quality control filtering to remove primer sequences, truncated reads and low-frequency reads, DNA sequences were clustered into operational taxonomic units (OTUs) on the basis of sequence similarity. Taxonomic assignment was performed with VSEARCH software (Rognes, et al., 2016), whereby each OTU cluster was assigned a species identity using a threshold of 95% by comparing it against a reference sequence database. Where a species could not be assigned (i.e. the reference database was deficient and/or taxa were poorly-characterised), taxonomic assignments were manually vetted by first obtaining a list of possible species through BLASTN searches against the public repository Genbank (www.ncbi.nlm.nih.gov), then eliminating species on the basis of their geographic distribution using information from the Atlas of Living Australia (ALA). In cases where an OTU could not be adequately resolved to a single species (due to shared haplotypes for instance), either a list of multiple species was included, or it was assigned to the lowest taxonomic rank without further classification. Similar to the interpretation of qPCR results above, detection of species in multiple replicates from a site increases the confidence that the eDNA detection represents actual presence of the species. Detection of a species in a single replicate may indicate species presence at low abundance but can also arise from site level (in field) or sample level (sampling or laboratory protocols) contamination (Darling, et al., 2021).

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.

4.2.7. Targeted Oxleyan pygmy perch surveys

The eDNA analysis revealed a detection of unidentified “pygmy perch” downstream of the study area. Based on the historical distribution it was considered that the detection may have been Oxleyan pygmy perch. In discussions with DPI Fisheries it was determined that targeted Oxleyan pygmy perch surveys were required.

From 13 to 16 January 2024, targeted Oxleyan pygmy perch surveys were undertaken at 13 sites (separate from general survey sites) located downstream of Clarrie Hall Dam (Figure 3). Surveys were undertaken in accordance with both *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) and *A sampling protocol for the endangered freshwater fish, Oxleyan Pygmy Perch (Nannoperca oxleyana) Whitley* (Knight, et al., 2007). The survey effort and equipment used at each site, outlined in

, were dependent on the site constraints and conditions (i.e. water depth). Exotic species were not returned to the water.

I. Electrofisher

Electrofishing was undertaken at 9 sites (Figure 3; Table 9) to assess the presence of Oxleyan pygmy perch. A backpack electrofisher was used for all sites using an EFish 500 W backpack electrofisher for a standardised survey effort of 8 by 150 seconds of time (active electrofishing) where appropriate habitat and water quality was present. 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. Taxonomic verification was undertaken in situ at all sites using appropriate taxonomic literature. Fish of any species that were detected were measured using a ruler, and once recovered, returned to the water.

II. Bait traps

A total of 10 bait traps, which consist of a 2 mm mesh and are approximately 250 mm by 250 mm by 450 mm, were set at each of 9 sites with 15 bait traps set at one site only (Figure 3; Table 9). Bait traps have a small aperture and are a passive trap. The traps were set overnight and retrieved the next morning. Captured fish of any species were processed on a flat area immediately adjacent to the site. 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.

III. Dip netting

A total of 600 seconds of dip netting was undertaken in appropriate habitat at 2 sites only (Figure 3; Table 9).

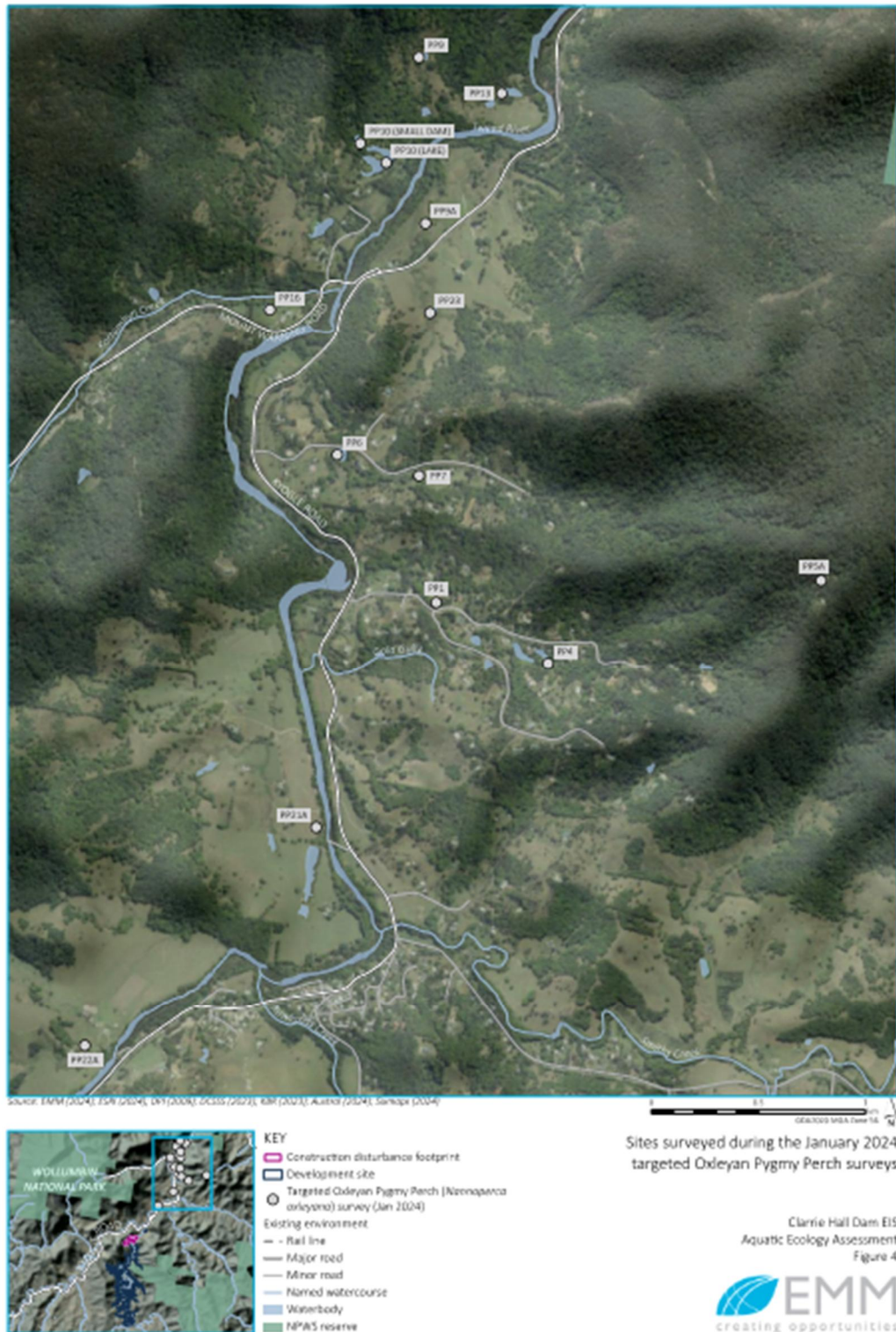


Figure 3: Sites surveyed during the January 2024 targeted Oxleyan pygmy perch surveys

Table 9: Survey effort undertaken at each site during the January 2024 targeted Oxleyan pygmy perch surveys

Site	Bait trap	Electrofishing	Dip netting
PP1	10	900	-
PP4	10	720	-
PP5a	10	-	-
PP6	10	-	-
PP7	10	1500	-
PP9	10	300	-
PP9a	-	1200	-
PP10 (Lake and small dam)	10	600	-
PP13	15	-	600
PP16	10	-	-
PP21a	10	900	-
PP22a	-	600	-
PP23	-	1200	600

4.3. 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 a species' habitat. The consequence criteria (Table 10), likelihood descriptors (Table 11) and risk matrix (Table 12) adopted for the risk assessment are provided below.

Table 10: Consequence criteria adopted for the risk assessment.

	Insignificant	Minor	Moderate	Major	Catastrophic
	Minimal, if any, impact that have an overall negligible net effect	Localised, reversible short-term reversible event with minor effects that 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 to 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 is up to 1 year	Changes to surface water quality due to activity, recovery is 1 to 2 years	Changes to surface water quality, where water becomes toxic, or permanent changes to quality, recovery is greater than 2 years

Table 11: 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 12: 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

4.4. Limitations

Austral has relied on information provided by third parties and publicly available information to undertake this assessment. Errors or omissions in the provided data could affect the validity of the assessment.

The eDNA results are presented as 'positive', 'negative' or 'equivocal', where equivocal indicates that only 1 or 2 of the 3 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 1 to 7 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 a species from a site at that point in time.

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 why not all of the predicted species would 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 25 sites were scheduled to be surveyed as part of the targeted Oxleyan pygmy perch surveys, 10 sites were abandoned due to either a negative response to the request for access or elevated water levels due to flooding.

While some species have been assessed as having a low likelihood of occurrence, it is acknowledged that this does not indicate the species would 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 or waterway on rare occasions and is therefore unlikely to be impacted by the Proposal.

This report investigates aquatic species listed under the FM Act only. Semi-aquatic species such as turtles are listed under the *Biodiversity Conservation Act 2016* (BC Act) and are addressed in the *Clarrie Hall Dam Raising Biodiversity Development Assessment Report* (BDAR) prepared by EMM Consulting Pty Limited (2024a).

5. Results

5.1. Desktop assessment

5.1.1. Biogeographical context

Clarrie Hall Dam lies within the South-East Queensland bioregion and the border of the Clarence-Moreton subregion (Figure 4) (Department of Climate Change, Energy, the Environment and Water, 2023a). In NSW the South-East Queensland bioregion is bounded by the NSW North Coast bioregion to the south and west (Department of Planning and Environment, 2021). The South-East Queensland bioregion extends from northern NSW into Queensland. Prior to the Interim Biogeographic Regionalisation for Australia (IBRA) version 6.1, the South-East Queensland bioregion did not extend beyond the Queensland border (Department of Planning and Environment, 2021). A large part of what was the NSW North Coast bioregion is now South-East Queensland, which now extends 200 km south to encompass Grafton.

The total area of the South-East Queensland bioregion is 7,804,921 ha, of which 1,655,317 ha occurs within NSW (Department of Climate Change, Energy, the Environment and Water, 2021; Department of Environment, Climate Change and Water NSW, 2010b). The South-East Queensland bioregion extends from the Conglomerate State Forest, West of Woolgoolga, NSW to north of Gladstone in Queensland (Department of Climate Change, Energy, the Environment and Water, 2021). The biogeographical context is taken from a description of the North Coast Bioregion, as the Department of Planning and Environment (2021) currently offers this in place of a description of the South-East Queensland bioregion. Some of this information may be historical in nature and updates may be required, should an updated description of the South-East Queensland bioregion be published in the future.

5.1.2. Land use

The North Coast bioregion (prior to partial reclassification as the South-East Queensland bioregion) had the second highest area of conservation of the NSW bioregions (NSW National Parks and Wildlife Service, 2003). The combined area of conservation within the North Coast bioregion occupied approximately 1,061,710 ha (18.65% of the bioregion). National parks and nature reserves made the greatest contribution to conservation areas, occupying an approximate area of 991,387 ha (17.42% of the bioregion). Of this area, approximately 347,426 ha was provided additional management under the *Wilderness Act 1987* and was composed of 11 declared wilderness areas occupying 6.1% of the bioregion. Further recognition was given to national parks in an area extending from Newcastle to Brisbane, known as the Central Eastern Rainforest Reserves. This area has been included on the internationally recognised World Heritage list as 1 of 3 world heritage areas in NSW (NSW National Parks and Wildlife Service, 2003). Reserves (protected under the *Crown Lands Act 1989*) contributed approximately 21,862 ha to the area managed for biodiversity conservation in the bioregion (NSW

National Parks and Wildlife Service, 2003; Department of Environment, Climate Change and Water NSW, 2010b). Other lands managed under the *National Parks and Wildlife Act 1974* included land managed as Aboriginal area (125.61 ha or 0.002% of the bioregion); land managed as historic sites (482.8 ha or 0.008% of the bioregion); and land managed as state recreation areas (222.1 ha or 0.004% of the bioregion) (NSW National Parks and Wildlife Service, 2003; Department of Environment, Climate Change and Water NSW, 2010b). The NSW National Parks and Wildlife Service (2003) reports that as of 2003, landholders on 25 properties had entered into voluntary conservation agreements, and that combined, the area managed permanently for conservation management occupied approximately 1,363 ha or 0.02% of the bioregion. Landholders on 71 properties also hold wildlife refuges, occupying 36,720.46 ha or 0.65% of the bioregion. Updated mapping is likely to increase this area. Clarrie Hall Dam lies within a valley and is partially bordered by the Mount Jerusalem National Park to the east, and the Wollumbin National Park lies less than 3 kilometres to the north-west (Department of Climate Change, Energy, the Environment and Water, 2023a; Department of Environment, Climate Change and Water NSW, 2010b).

Historical land use for the North Coast bioregion were predominantly agricultural in nature and included dairy, beef and various forms of cropping (NSW National Parks and Wildlife Service, 2003). Tourism accelerated in the 1960s and is still prolific today. Dairy farming has slowly decreased over time, while the beef industry has continued and now occupies much of the former dairy land. Various forms of mining also occur within the bioregion and includes, but is not limited to, gold, silver and copper (NSW National Parks and Wildlife Service, 2003). Agriculture, forestry and fishing business within the Northern Rivers region is reported to be 10% higher (more prevalent) than the average for NSW, with mining-related business marginally lower than the state average (Regional Development Australia, 2013).

As the North Coast 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 (NSW National Parks and Wildlife Service, 2003; Department of Environment, Climate Change and Water NSW, 2010b).

The Tweed Shire has developed a viable agricultural industry based on its highly productive alluvial flats, basalt derived uplands, subtropical climate and high rainfall (NSW Office of Water, 2010). Sugar, dairy farming and horticulture are the main types of agricultural produce, while beef and timber production are predominant in those areas of lower fertility soils of sandstone and shale. These industries have significantly impacted the landscapes natural attributes. However, a major portion of the upper Tweed Catchment still remains under forest cover, often protected either as national park or state forest (NSW Office of Water, 2010).

Both banana and dairy industries have declined since the 1950s, resulting in less intensive agricultural land management practices. In the 1960s and 1970s, sand mining occurred extensively along the

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coastal dune system. Dredging of the river and broadwaters has also occurred – earlier for navigation, and more recently, for commercial sand and gravel extraction. Tourism has also grown over a similar time period (NSW Office of Water, 2010).

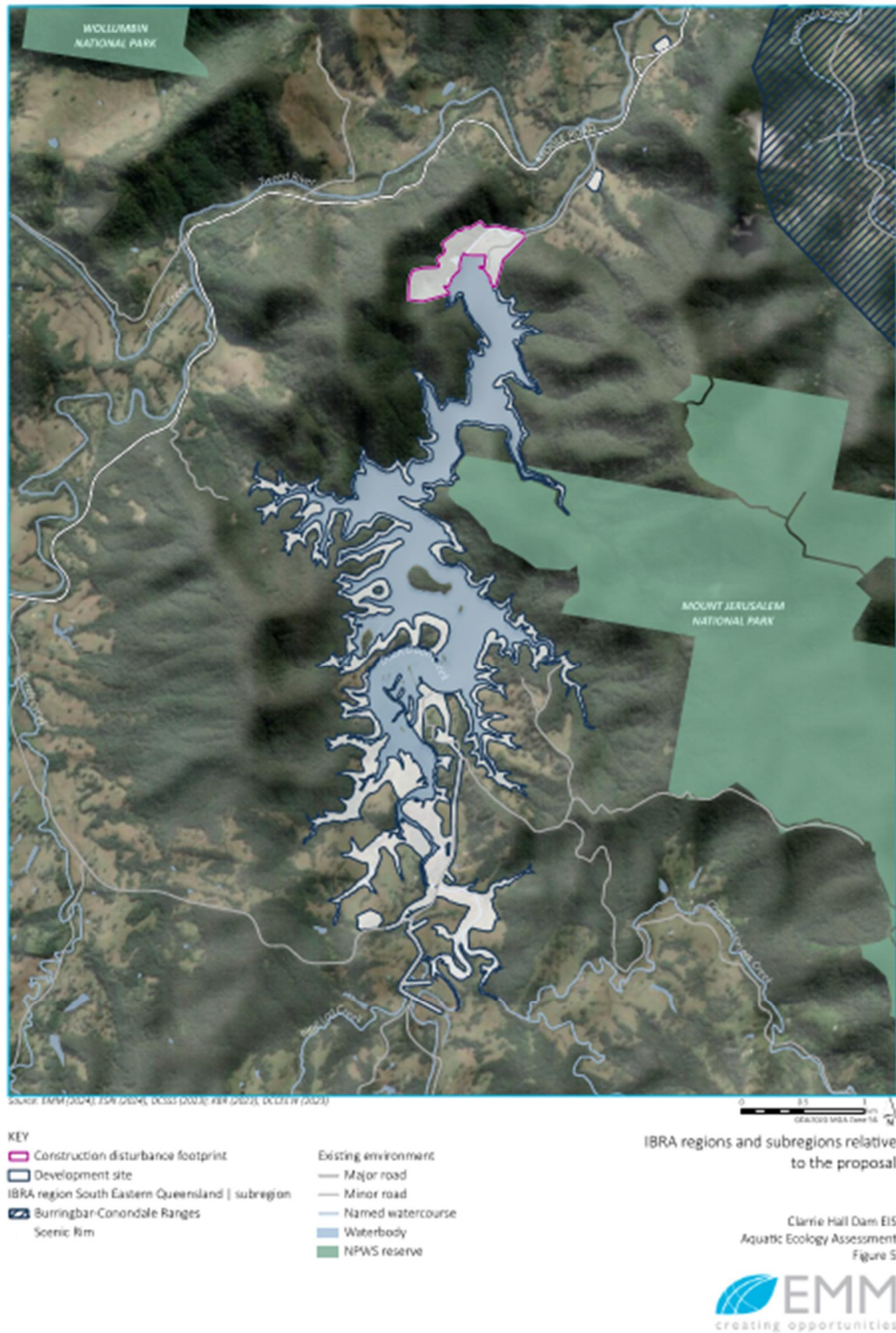


Figure 4: IBRA regions and subregions relative to the Proposal

Source: EMM Consulting Pty Limited

5.1.3. Climate

The general climatic trend within the North Coast bioregion (east to west) is a coastal, sub-tropical climate with hot summers, through sub-humid climate on the slopes to a temperate climate in the uplands in the west, characterised by warm summers and no dry season (NSW National Parks and Wildlife Service, 2003; Regional Development Australia, 2013). According to the NSW National Parks and Wildlife Service (2003), the mean annual temperature for the North Coast bioregion is 8 to 20°C and the minimum mean monthly temperature is -2.8 to 9.8°C. The mean maximum monthly temperature is 20.3 to 30.9°C. The minimum mean monthly rainfall is 30 to 99 mm and the maximum mean monthly rainfall is 76 to 499 mm (NSW National Parks and Wildlife Service, 2003; Department of Environment, Climate Change and Water NSW, 2010b).

The nearest BoM weather station to Clarrie Hall Dam is at Uki (Uki (Tweed River; 058167) for rainfall data (Bureau of Meteorology, 2023a) and Murwillumbah (Murwillumbah (Bray Park; 058158) for temperature data (Bureau of Meteorology, 2023b). Annual rainfall in the 12 months (September 2022 to August 2023) before the September 2023 field survey totalled 1,099.5 mm, 473.7 mm less than the long-term average of 1,573.2 mm (Figure 5) (Bureau of Meteorology, 2023a). This was attributed to below average rainfall recorded during November and December of 2022 and January through to August 2023, where monthly totals were on average 40.5 mm lower, than the corresponding monthly mean total (Figure 6) (Bureau of Meteorology, 2023a). Over the 10 years leading up to the 2023 field surveys, 4 years have recorded rainfall lower than the long-term annual average; however, 3 years had incomplete data resulting in no annual rainfall for that year (Figure 5) (Bureau of Meteorology, 2023a). Despite the high rainfalls in 2022, long-term lower-than-average rainfalls and low monthly rainfalls leading up to the September 2023 sampling event (Figure 6), there were low flows at the time of the September 2023 sampling event.

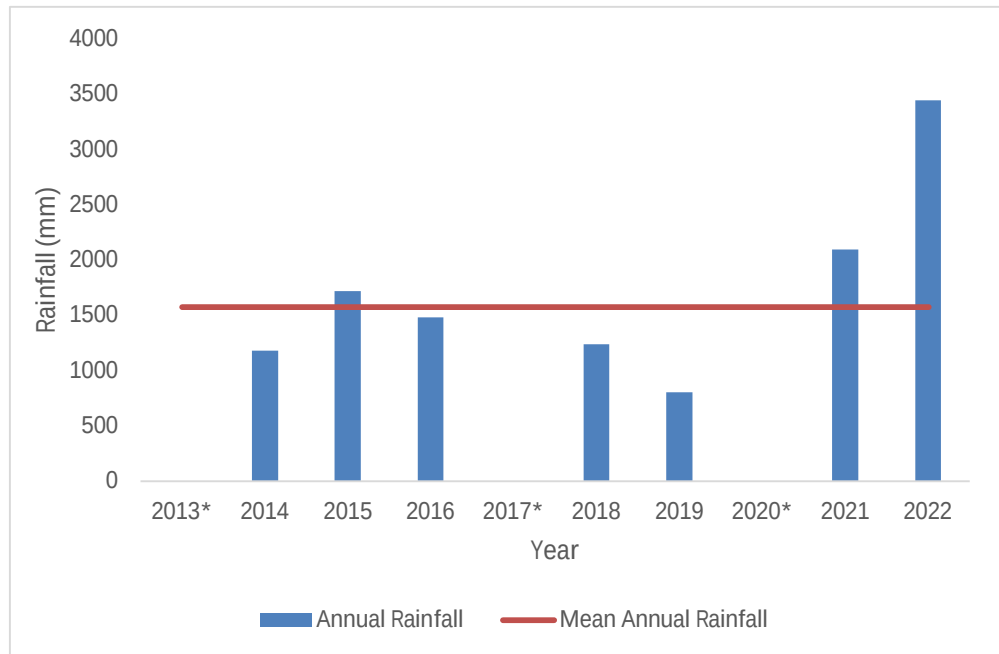


Figure 5: Annual rainfall compared to long-term mean annual rainfall (2013–2022) . * indicates incomplete data for that year.

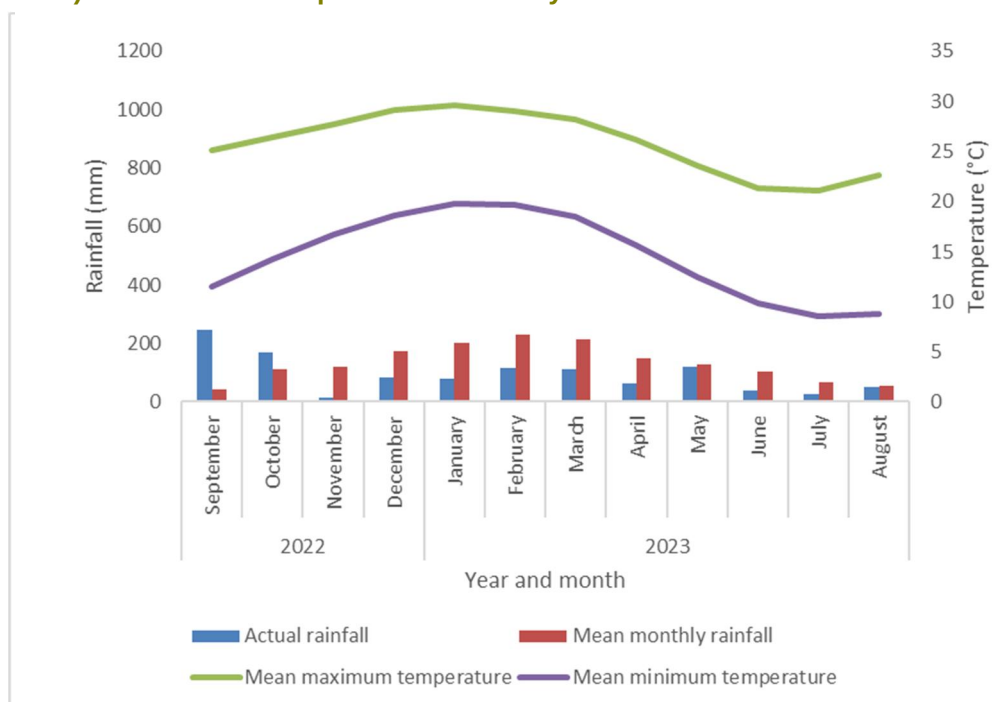


Figure 6: Mean monthly rainfall compared to actual monthly rainfall. Mean maximum temperature and mean minimum temperature (1972–2023)

5.1.4. Geology and topography

I. Topography

The North Coast bioregion covers northern NSW from the ocean to the Great Escarpment. The land transitions from a coastal sand barrier, through low foothills and ranges, to steep slopes and gorges of the Escarpment (NSW National Parks and Wildlife Service, 2003).

II. Geology and geomorphology

The North Coast bioregion is considered one of the most diverse in NSW with regard to geology and morphology (NSW National Parks and Wildlife Service, 2003). The bioregion has Devonian and Permian bedrocks that are part of the New England Fold Belt. The bedrocks have been closely faulted as they were driven over the northern margin of the Sydney Basin. Small bodies of granite and granodiorite have intruded the sedimentary rocks, and there are 3 centres of Tertiary basalt eruption (NSW National Parks and Wildlife Service, 2003). Plate movements 80 to 100 million years ago caused the opening of the Tasman Sea, and at that time the Australian coastline was uplifted and warped. As the ocean widened, the uplifted block subsided at the coast, and river systems developed that eroded back toward the inland flexure along the warp. Rapid headward erosion of these streams formed the Great Escarpment and cut deep gorges back into the plateau areas of the adjacent New England Tablelands bioregion.

The largest volcanic centre, resulting from Tertiary basalt eruption, is the Tweed volcano and associated Mt Warning caldera near the state border. This complex is dated between 20 and 24 million years old and at the time of the eruption was a shield volcano with low slopes that covered an area 80 km by 100 km. Mt Warning itself is the remains of a large central feeding chamber, filled with rock much coarser than the basalts, rhyolites and tuff on the caldera rim (NSW National Parks and Wildlife Service, 2003; NSW Office of Water, 2010).

III. Geodiversity

The North Coast bioregion supports significant diversity with regard to geology, geomorphology and biota. In addition to this diversity, there are a number of special features, as follows:

- The Tweed volcano complex and Mt Warning are one of the best exposed volcanos in Australia.
- Ebor Plateau and Comboyne Plateau are central volcanoes about 18 million years old.
- A large number of economic mineral deposits are present, including extended deposits of heavy minerals in beach and dune sands, most of which have associated heritage items.

- The Great Escarpment is well developed in the North Coast bioregion, with deep gorges on every major river.
- Areas of serpentine are evidence of deep-sea sediment accretion on the Australian mainland through time. These rocks weather to soils with toxic levels of some metals, which is known to impact the vegetation they support.

IV. Soils

Soils and vegetation patterns across and along the North Coast bioregion are considered complex because of the different substrates, the topographic variation and the climatic difference across the bioregion (NSW National Parks and Wildlife Service, 2003; NSW Office of Water, 2010). Typically, rainforests are only supported by the most fertile soils (typically basalt), but exceptions to this are found in numerous protected areas where plant nutrients have accumulated over time.

On the basalt the soils are typically red, friable loams or clay loams with relatively high fertility, good structure and excellent water-holding capacity. On granites and most of the quartz-rich sedimentary rocks, shallow yellow earths are found on hillcrests, yellow and brown texture contrast profiles are found on the slopes, and organic loams or sandy loams are found on the alluvial plains. In the coastal dunes, deep siliceous sands and very well developed podosols can be found (NSW National Parks and Wildlife Service, 2003; NSW Office of Water, 2010).

V. Groundwater

A review of the available literature revealed that the groundwater aquifer systems in the Northern Rivers catchment are generally in 'good' to 'very good' condition (Department of Environment, Climate Change and Water, 2010). Specifically, the Tweed River Coastal Sands regional groundwater levels are considered 'very good'. Local groundwater levels are also considered 'very good', and the aquifer integrity is considered 'very good'. For the Tweed River alluvium, the regional groundwater levels are considered 'very good', local groundwater levels are considered 'very good', and the aquifer integrity is considered 'very good' (Department of Environment, Climate Change and Water, 2010).

A number of potential pressures on local aquifers were identified within the literature. At a local level, it has been highlighted that previous mineral sand mining and current sand mining have the potential to release naturally occurring heavy metals at the Tweed Rivers Coastal Sands; however, the level of confidence in this information is reportedly low due to the number of groundwater level monitoring sites in the region and the limited data available on groundwater use, quality and GDEs (Department of Environment, Climate Change and Water, 2010).

5.1.5. Catchment and hydrology

Clarrie Hall Dam is located within the Tweed River Catchment within the broader Northern Rivers catchment (Figure 7). The Tweed River catchment covers an area of 1,303 km² (Department of Planning and Environment, 2023). Upstream of Murwillumbah, the Tweed and Oxley rivers are the main drainage lines for the caldera that encircles Mt Warning, which was previously the main volcanic vent (NSW Office of Water, 2010). Below Murwillumbah, the Tweed River flows across an extensive floodplain and is joined by the Rous River, which drains the dissected mid-northern areas of the catchment. Shallow tidal waterways join the Tweed River near the mouth via the Terranora Inlet before the river discharges to the ocean at Point Danger, immediately south of the Queensland–NSW border (NSW Office of Water, 2010).

Tidal influence penetrates up the Tweed River to the Bray Park Weir, which is located approximately 5 km upstream of Murwillumbah and regulates the river levels except during flood events. The two major infrastructures that impact flows in the Tweed River are the Bray Park Weir and Clarrie Hall Dam. Town water supply extraction occurs from the Bray Park Weir pool that is supplied by both the Tweed and Oxley Rivers. Releases from Clarrie Hall Dam top up the Bray Park Weir pool.

Clarrie Hall Dam is located on Doon Doon Creek, a tributary of the Tweed River. The Clarrie Hall Dam has a catchment area of 60 km² and a storage capacity of 16 000 ML. The primary function of the dam is to provide water storage for Tweed Shire's water supply (Department of Planning and Environment, 2023; NSW Government, 2023). Doon Doon Creek is fed by Commissioners Creek and Big Creek before flowing into the southern end of Clarrie Hall Dam. Unnamed tributaries contribute to the water balance of Clarrie Hall Dam. When Clarrie Hall Dam is full, water spills out of the dam into Doon Doon Creek from the northern end of the dam before joining the Tweed River. Water is released from the dam into Doon Doon Ck to maintain environmental flows during dry times as required in the Water Sharing Plan (Figure 8).

Clarrie Hall Dam is classified a 5th order Strahler stream, Doon Doon Creek ranges from a 3rd order stream to a 5th order stream, Commissioners Creek ranges from a 3rd order stream to a 4th order stream, Big Creek is classified a 3rd order stream, and the Tweed River ranges from a 5th order stream to a 7th order stream (Figure 9) (Strahler, 1952).

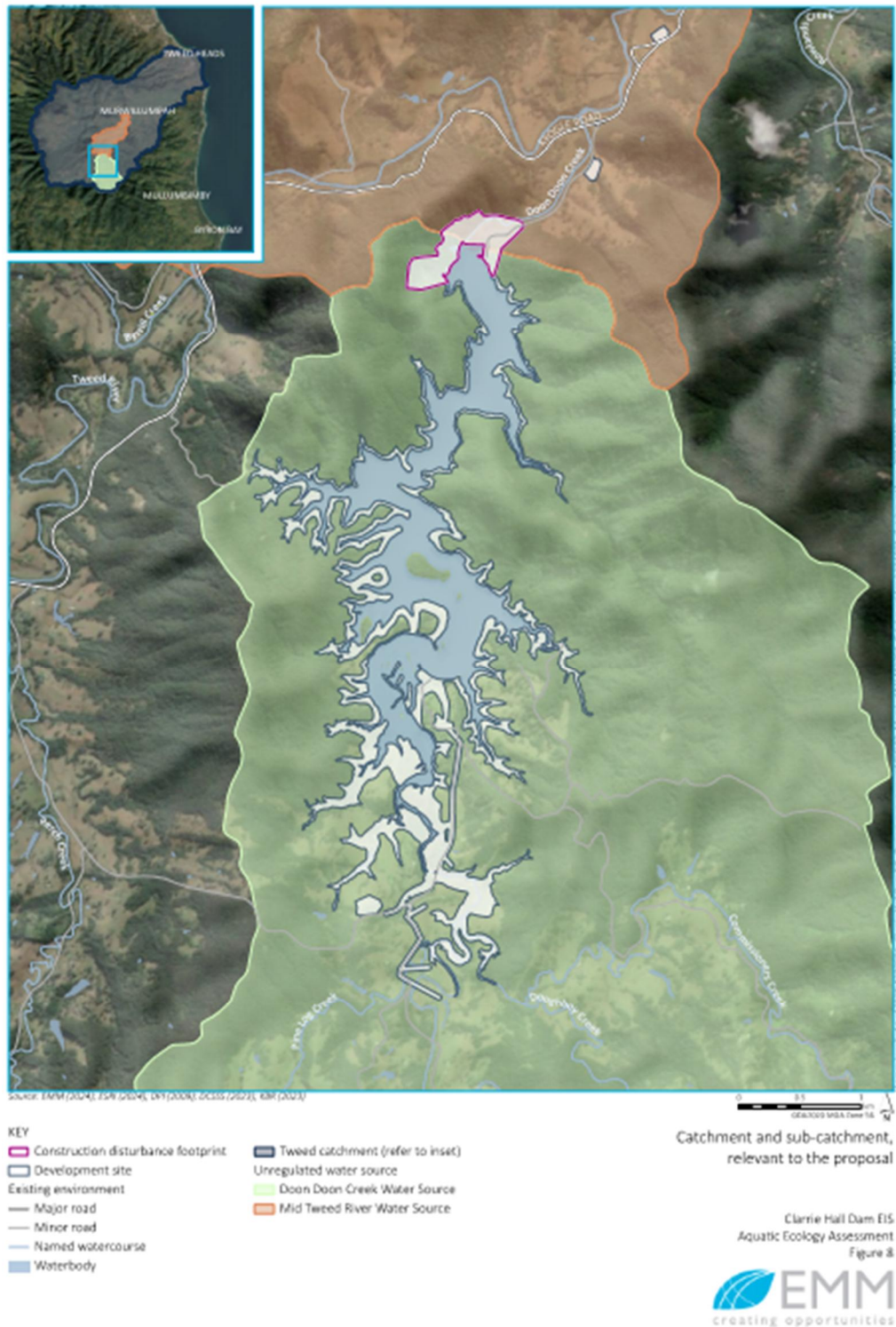


Figure 7: Catchment and sub catchment, relevant to the Proposal

Source: EMM Consulting Pty Limited.

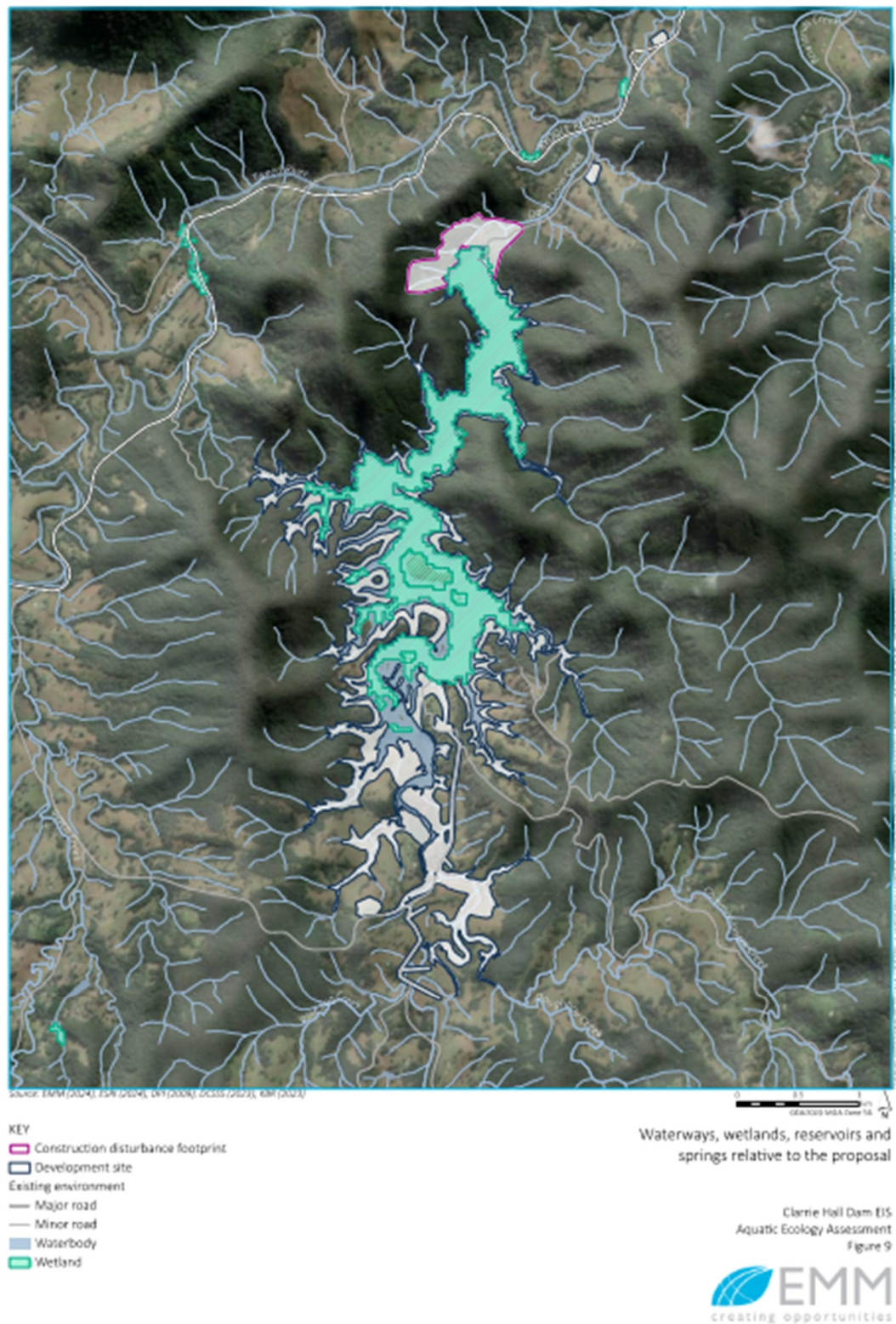


Figure 8: Waterways, wetlands, reservoirs and springs relative to the Proposal

Source: EMM Consulting Pty Limited.

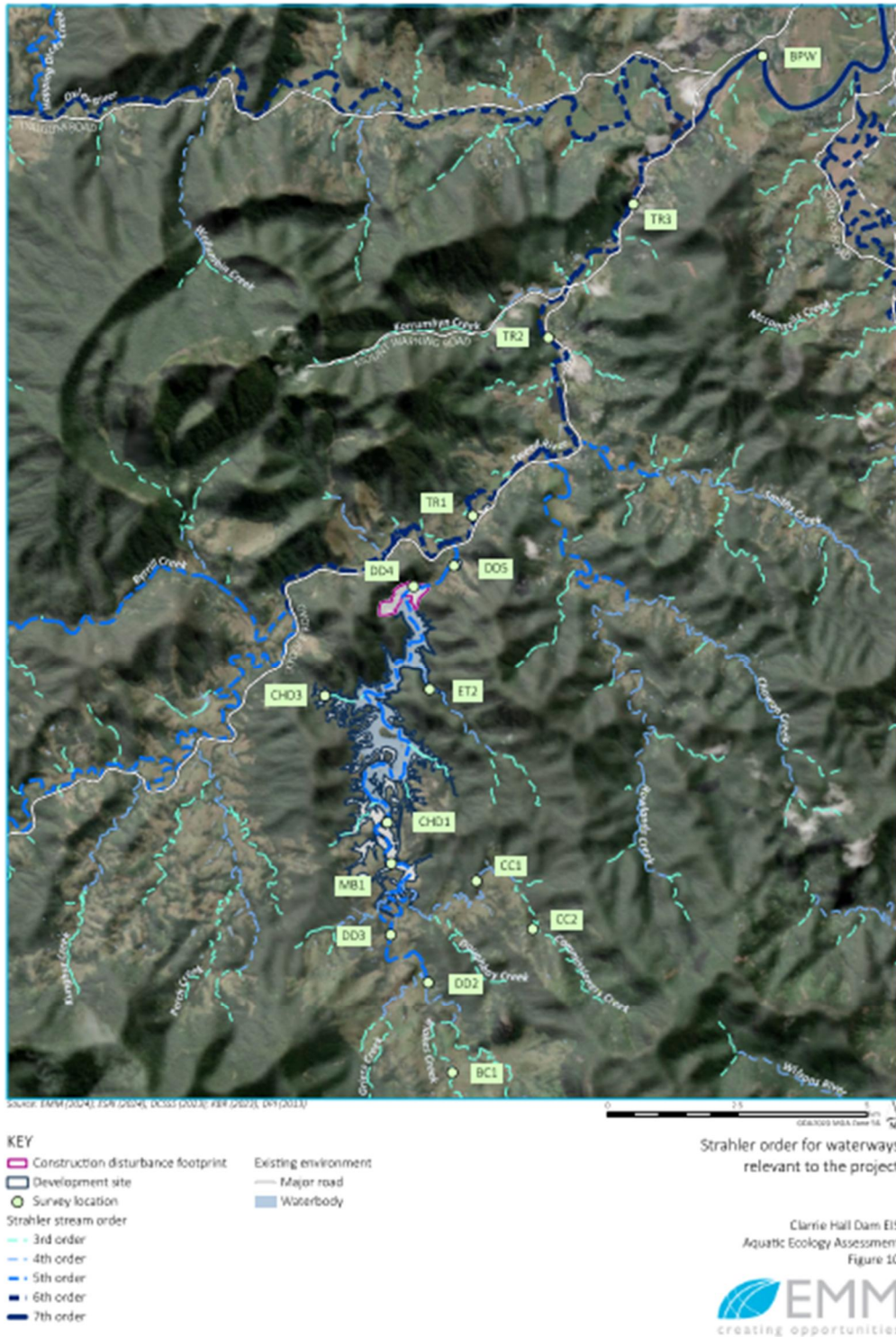


Figure 9: Strahler orders for streams relevant to the Proposal

Source: EMM Consulting Pty Limited.

5.1.6. Aquatic habitats

Eight significant wetlands have been identified in the North Coast bioregion:

- Clarrie Hall Dam is reported to support several significant species of bird.
- The Brunswick River Floodplain is listed and reported to support several significant species of bird; there are also reports that several species of threatened flora occurs on the floodplain, including Bakers wattle (*Acacia bakeri*) and Spiny gardinia (*Randia moorei*).
- Cumbebin Swamp is listed as a significant wetland within the bioregion and is reported to provide habitat for a range of threatened species of bird and bat.
- Cokora Lagoon is listed and reported to support a high diversity of wetland birds.
- Blue Lake is protected within Yuraygir National Park. The lake is reported to provide habitat for a range of protected birds, amphibians and arboreal mammals.
- An unnamed swamp next to the Kalang River in the Nambucca catchment has been identified as one of the most significant wetlands within the bioregion. This wetland is reported to support a range of threatened birds and arboreal mammals.
- Lake Innes is listed and supports a wide range of birds, amphibians, bats and arboreal mammals.
- Grahamstown Lake is listed and is reported to provide habitat for a range of threatened birds, arboreal mammals and the tiger quoll (*Dasyurus maculatus*).

Threats to the wetlands in the North Coast bioregion are reported to be numerous and include changed drainage patterns from the construction of roads, drains and channels, particularly in expanding urban areas. Water quality is reported to be continually affected by urban and agricultural runoff such as the discharge of treated sewerage to waterways. Minor impacts are reported in the form of recreational activities such as camping and bushwalking. Other impacts include the introduction and continued presence of feral animals and exotic weed species, acid sulphate soils, sedimentation, erosion and grazing pressure (NSW National Parks and Wildlife Service, 2003).

The *State of the catchments 2010* report for the Northern Rivers region (2010a) assessed wetlands within the Northern Rivers region and determined that in general, wetlands in the region are in 'very poor condition'. A total of 14 wetlands within the Northern Rivers region were assessed, and all of them were considered to be either in 'very poor condition' or 'data deficient' (Department of Environment, Climate Change and Water, 2010a; Department of Environment, Climate Change and Water NSW,

2010b). The presence of pest species was highlighted at all assessed wetlands as a major contributing factor to the low condition scores. The following pressures were reported to be 'high' at most wetlands:

- catchment disturbance: modifications or changes to the catchment structure or processes that affect the wetland such as urbanisation, vegetation clearing, infrastructure and fire
- hydrological disturbance: the levels of nutrients entering a wetland, water and soil chemistry, vegetation patterns, the biota present and the wetland's productivity. Also drainage, damming, extraction and river regulation
- habitat disturbance: both the direct removal of wetland habitat and activities that modify, damage or disturb wetland habitat areas.

The *State of the catchments 2010* report for the region (2010c) assessed the riverine ecosystem condition using macroinvertebrate, fish and hydrology indicators. The macroinvertebrate condition for the Clarrie Hall Dam region ranged from 'moderate to good'. However, macroinvertebrate communities are poorly understood in the Northern Rivers catchment. A study by Turak et al. (2000) reported that waterways in the coastal plains are in 'poor health', with those in the eastern fringe being the poorest. Waterways in the midland hills are in better condition, and those in the escarpment ranges are near to optimal condition, with waterways in the tablelands less healthy (Department of Environment, Climate Change and Water, 2010c; Turak, et al., 2000). Insufficient data was available to assess the fish community condition for the Clarrie Hall Dam region; however, the hydrology condition for the area was rated 'good' (Department of Environment, Climate Change and Water, 2010c). The report stated that 'no data' was available on the condition of alien fish species assemblages in the area (Department of Environment, Climate Change and Water, 2010c). Estuaries and coastal lake ecosystems are reported to be in 'good' condition, and pressures on these ecosystems are considered 'low' (Department of Environment, Climate Change and Water, 2010d). Regional pressures with the potential to impact on riverine ecosystem condition are reported as polluted runoff from agricultural, industrial and domestic sources; livestock grazing; clearing of riparian vegetation; clearing of the catchment for grazing; de-snagging of instream channels; a decline in natural replenishment of instream wood; introduction of aquatic and riparian weeds; and alteration to natural flow patterns and climate change (Department of Environment, Climate Change and Water, 2010c).

The Northern Rivers catchment supports a number of endangered wetland communities, including montane peatlands and swamps in the New England Tableland, NSW North Coast and other regions (Bell, et al., 2008). A large number of coastal lakes occur within the Northern Rivers catchment. Minnie Water and Lake Hiawatha are considered to be in 'pristine condition', and a number of other coastal lakes including Lake Arragan and Saltwater Lake are considered 'near pristine' (Department of Environment, Climate Change and Water NSW, 2010b). Other small coastal lakes are considered to be ecologically important, including Wommin Lake south of Tweed Heads; Taylors Lake south of Byron

Bay; and Salty Lagoon north of Evans Head. Many, if not all, of these coastal lakes are considered likely to be high-conservation-value aquatic ecosystems.

The Tweed Shire in which Clarrie Hall Dam is situated is reported to support the highest plant diversity within a 2,000 km section of the Australian east coast (Tweed Shire Council, 2008). Threatening processes such as weed invasion and clearing for agricultural, commercial and residential land uses are reported as contributing to an extensive list of rare, vulnerable and endangered species. The Tweed Shire is reported to support the highest vertebrate biodiversity of any region in Australia and is thought to support more species of bird, fish, amphibian and mammals than Kakadu, and a similar number of reptiles (Tweed Shire Council, 2008). Threats and pressures to the natural environment within the Tweed Shire include stormwater entering the Tweed River and changing land use; increasing volumes and pollutant loadings from stormwater outfalls; water extraction and water supply demands; acid sulphate soil discharges; erosion and sediment associated with agricultural and construction activities; invasive environmental weeds affecting coastal vegetation communities; draining of swamps and wetlands; and clearing and fragmentation of coastal habitat (Tweed Shire Council, 2008).

5.1.7. Threatened communities and habitats

It has been reported that 130,000 ha of wetlands occur in the Northern Rivers catchment (Department of Environment, Climate Change and Water NSW, 2010b). Little Llangothlin Lagoon near Armidale is the only wetland in the Northern Rivers catchment listed as a Ramsar Wetland (Department of Environment, Climate Change and Water NSW, 2010b; Department of Climate Change, Energy, the Environment and Water, 2023a). The site is a nature reserve and is considered a high-conservation-value aquatic ecosystem and is one of the few lagoons that remain in a near-natural condition. A total of 22 wetland sites in the Northern Rivers Catchment are listed on the *Directory of Important Wetlands in Australia* (Department of Climate Change, Energy, the Environment and Water, 2021). As of 2010, only 20% of the nationally important wetlands in the region were reserved (Department of Environment, Climate Change and Water NSW, 2010b). This varies between catchments – with over 80% of the nationally important wetlands in the Tweed River catchment reserved, compared to 10% in the Clarence and Macleay catchments (Department of Environment, Climate Change and Water NSW, 2010b).

A review of online databases revealed that the nearest Ramsar listed wetland to Clarrie Hall Dam is Moreton Bay (Australian Ramsar site number 41), which is located approximately 125 km to the north in the Brisbane region (Department of Climate Change, Energy, the Environment and Water, 2019). No purely aquatic EPBC Act listed threatened ecological communities (TECs) occur in the vicinity of Clarrie Hall Dam; however, the Subtropical and Temperate Coastal Saltmarsh TEC listed as ‘vulnerable’ under the EPBC Act is considered ‘likely’ to occur within 50 km of Clarrie Hall Dam (Department of Climate Change, Energy, the Environment and Water, 2023a). Clarrie Hall Dam does not occur within the bounds of any aquatic endangered ecological communities (EECs) listed under the FM Act.

5.1.8. Key fish habitat

The key fish habitat map for the Proposal area (Figure 10) (Department of Primary Industries, 2023a) indicates that, of the waterways within the Proposal area, the majority are considered to contain key fish habitat, including Clarrie Hall Dam, Doon Doon Creek, Big Creek, Commissioners Creek and the Tweed River (Figure 10).

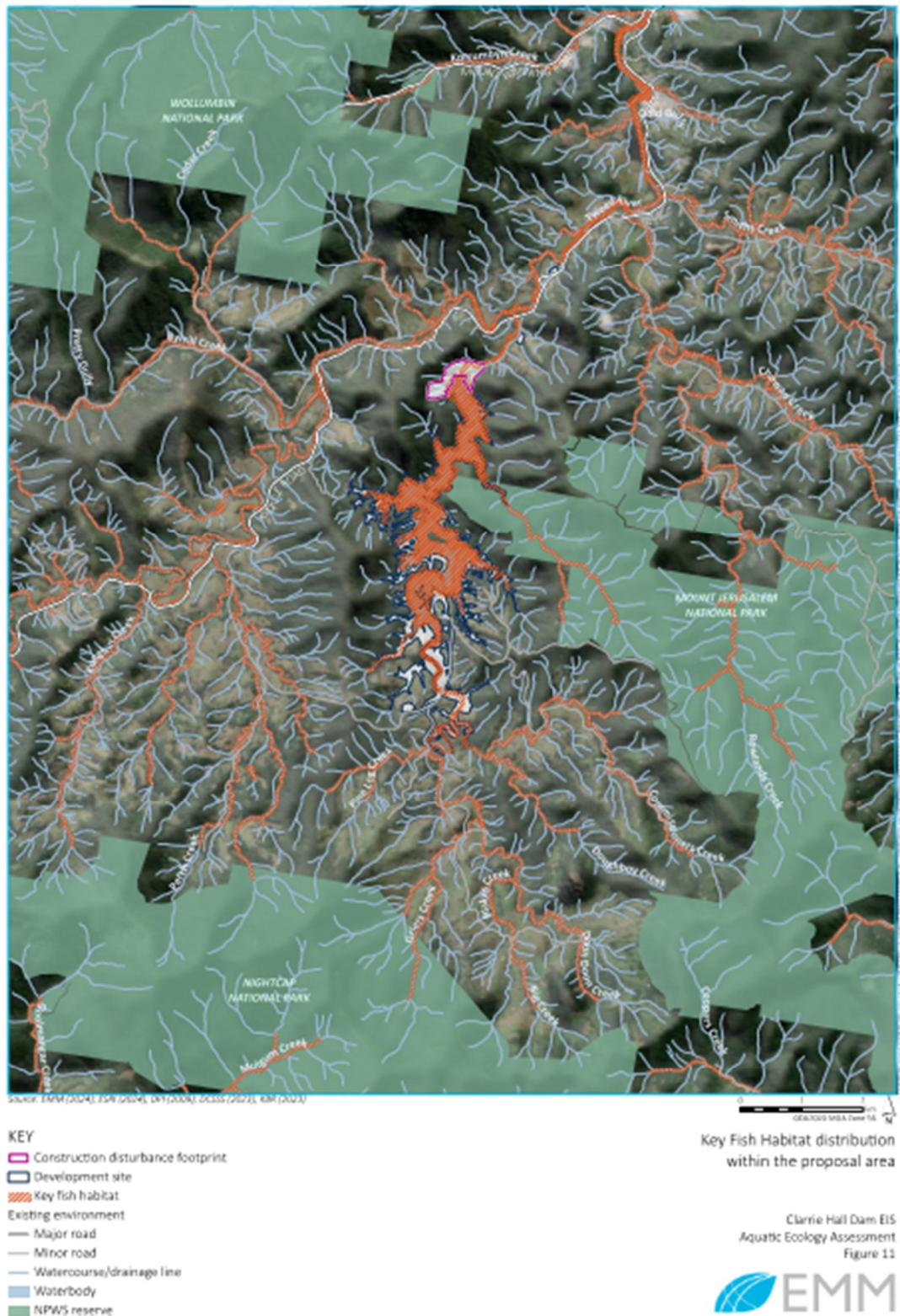


Figure 10: Key fish habitat distribution within the Proposal area

Source: (Department of Primary Industries, 2023b)

5.1.9. Water quality

Long-term water quality monitoring has been undertaken by the Tweed Shire Council as part of the ongoing management of Clarrie Hall Dam. The Council supplied water quality data for Clarrie Hall Dam which is summarised below. Monitoring points and results for water quality are shown in Figure 11 and Table 33 and are provided in Appendix E – Water quality data (desktop analysis).

Where applicable, water quality parameters were compared to the ANZECC and ARMCANZ (2000) trigger values for slightly disturbed ecosystems in south-eastern Australian (freshwater lakes and reservoirs or lowland rivers where applicable), and metals and metalloids were compared to the DGVs for the protection of 80% of species representative of highly disturbed systems (Water Quality Australia, 2018).

- The concentrations of metals and nutrients recorded at site X and site Z (Figure 11) by council between 2001 and 2023; although date ranges vary between constituents. Both upper and lower concentrations for each depth are reported in Table 33 as well as the median concentration for each depth across each date range.
- The median concentration for soluble iron at site X ranged from 0.19 mg/L (surface water) to 14.40 mg/L at 30 m depth. The median concentration for soluble iron at site Z ranged from 0.17 mg/L to 6.44 mg/L at 24 m depth (Table 33).
- The median concentration for soluble manganese at site X ranged from 0.01 mg/L (surface water) to 0.76 mg/L (30 m depth); The median concentration for soluble manganese at site Z ranged from 0.01 mg/L (surface water) to 0.87 mg/L (24 m depth).
- The median concentration for total Kjeldahl nitrogen at site X ranged from 0.6 mg/L (4, 8 and 12 m depth) to 4.8 mg/L (28 m depth). The median concentration for total Kjeldahl nitrogen at site Z ranged from 0.6 mg/L (4 m to 16 m depth) to 3.2 mg/L at 24 m depth (Table 33).
- The median concentration for total phosphorous at site X ranged from 0.03 mg/L (surface water) to 0.67 mg/L (28 m depth). The median concentration for total phosphorous at site Z ranged from 0.03 mg/L (surface water) to 0.06 mg/L (24 m depth). All records for total phosphorous exceeded the ANZECC & ARMCANZ (2000) triggers (Table 33).
- The median concentration for total nitrogen at site X ranged from 0.33 mg/L (surface water) to 4.8 mg/L (28 m depth). The median concentration for total nitrogen at site Z ranged from 0.32 mg/L (surface water) to 3.4 mg/L (24 m depth). All median concentrations for total nitrogen except surface water readings exceeded the ANZECC & ARMCANZ (2000) triggers (Table 33).

- The median concentration for nitrogen oxidised at site X ranged from 0.01 mg/L (surface water) to 0.05 mg/L (8 m to 12 m depth). The median concentration for nitrogen oxidised at site Z was 0.05 mg/L for all depths. All records for nitrogen oxidised exceeded the ANZECC & ARMCANZ (2000) triggers (Table 33).
- The median concentration for total manganese at site X ranged from 0.04 mg/L (surface water) to 0.39 mg/L (24 m depth). The median concentration for total manganese at site Z ranged from 0.03 mg/L (surface water) to 0.45 mg/L (20 m depth). The upper range of total manganese exceeded the ANZG 'DGVs for 80% species protection' at 12 m depth and 20 m depth for site Z (Table 33).
- The median concentration for nitrate at site X ranged from 0.45 mg/L (surface water) to 0.57 mg/L (20 m depth). The median concentration for nitrate at site Z ranged from 0.47 mg/L (8 m depth) to 0.62 mg/L (20 m depth) (Table 33).
- The median concentration for total iron at site X ranged from 0.41 mg/L (surface water) to 2.65 mg/L (20 m depth). The median concentration for total iron at site Z ranged from 0.39 mg/L (surface water) to 3.45 mg/L (20 m depth) (Table 33).
- The median concentration for total organic carbon at site X ranged from 3.69 mg/L (surface water) to 3.9 mg/L (8 m and 20 m depth). The median concentration for total organic carbon at site Z ranged from 3.6 mg/L (surface water) to 4 mg/L (16 m and 20 m depth) (Table 33).
- The median concentration for total aluminium at site X ranged from 3.24 mg/L (surface water) to 35.60 mg/L (20 m depth). The median concentration for total aluminium at site Z ranged from 3.42 mg/L (surface water) to 14.9 mg/L (20 m depth). It is likely that concentrations of total aluminium exceeded the DGV for the protection of 80% of species representative of highly disturbed systems (Water Quality Australia, 2018); however, it was not possible to accurately determine the appropriate DGV, as pH was not recorded across that time period for that location. The median concentration for soluble aluminium at site X ranged from 0.84 mg/L (surface water) to 0.97 mg/L (12 m depth). The median concentration for soluble aluminium at site Z ranged from 0.78 mg/L (surface water) to 0.9 mg/L (12 m depth) (Table 33).

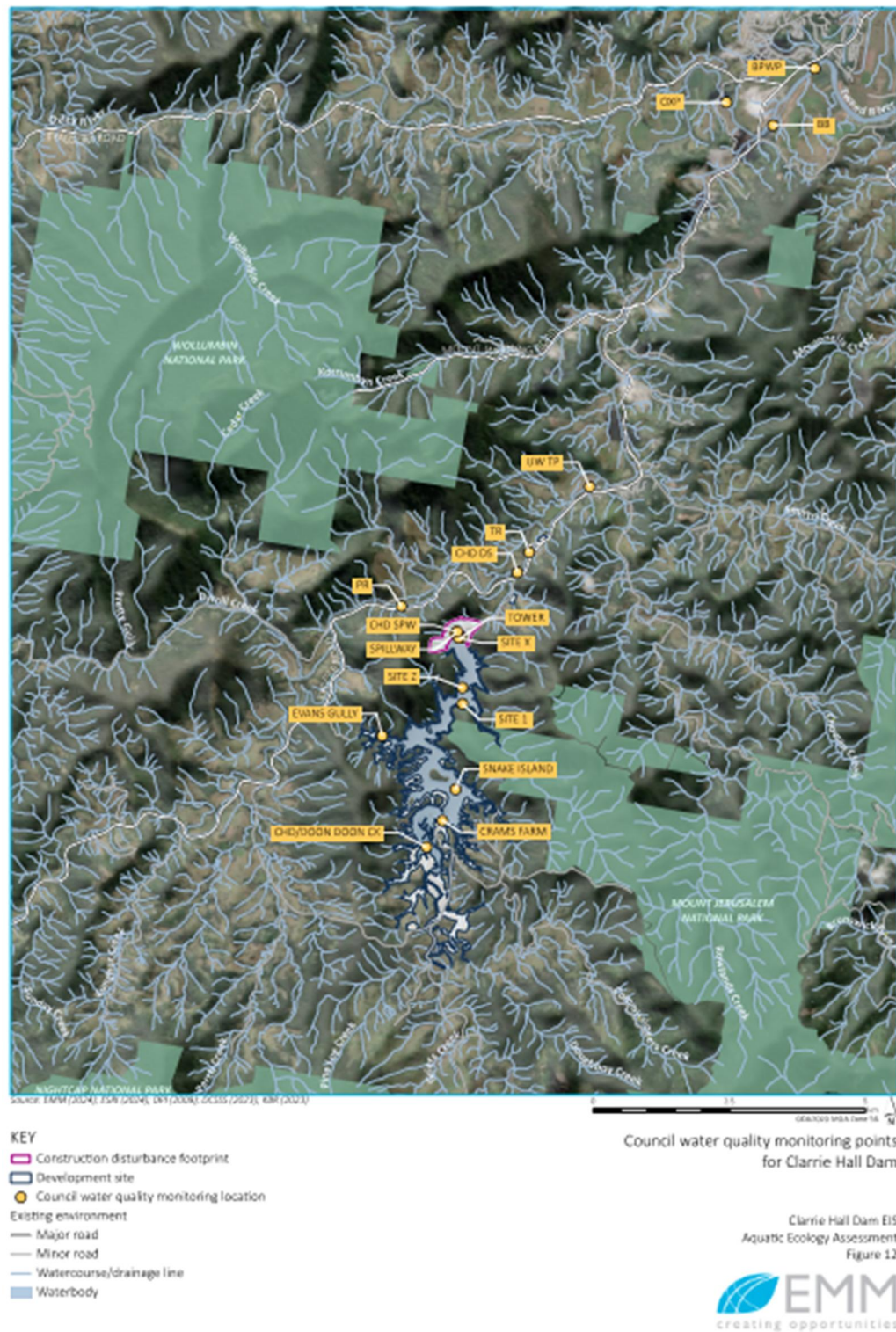


Figure 11: Council water quality monitoring points for Clarrie Hall Dam

Source: EMM Consulting Pty Limited.

Table 34 shows the minimum, median and maximum concentrations of a large range of parameters recorded from a range of sites by the Tweed Shire Council. Water quality recording sites include the intake tower, McCabes Bridge, Palmers Road Crossing, Tweed River upstream of Byangum Bridge and the Tweed River downstream of Smiths Creek (Table 34, shown in Appendix E – Water quality data (desktop analysis)). Given the large amount of data provided in Table 34, this section only reports on those parameters that exceed the ANZECC & ARMCANZ (2000) trigger values and/or the ANZG 'DGVs for 80% species protection (ANZECC and ARMCANZ, 2000; Water Quality Australia, 2018).

- The maximum recorded concentration of total aluminium exceeded the DGVs at the intake tower (37.7 mg/L). Both the median and maximum concentrations of total aluminium (0.3 mg/L and 5.66 mg/L) exceeded the DGVs at Tweed River downstream of Smiths Creek (Table 34).
- The maximum ammonia concentration exceeded the DGVs at the intake tower only (11 mg/L) (Table 34).
- The median and maximum chlorophyll 'a' concentrations at the intake tower exceeded the default trigger values for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs) (ANZECC and ARMCANZ, 2000). The maximum chlorophyll 'a' concentrations exceeded the default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers) at all other sites (Table 34).
- All conductivity concentrations for the intake tower exceeded the default trigger values for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs) (ANZECC and ARMCANZ, 2000). All conductivity concentrations at all other sites except the maximum reading at both McCabes Bridge and Palmers Crossing, fell outside the default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers) (ANZECC and ARMCANZ, 2000) (Table 34).
- The percentage of saturation of oxygen fell outside the recommended concentrations for slightly disturbed ecosystems in south-east Australia (lowland rivers) for the minimum and maximum concentrations at McCabes Bridge; however, the median concentration fell within acceptable levels. The minimum concentration for dissolved oxygen fell outside acceptable levels at the Palmers Road Crossing, and both the minimum and maximum concentrations fell outside acceptable levels at both Tweed River upstream of Byangum Bridge and Tweed River downstream of Smiths Creek (Table 34).

- All oxidised nitrogen concentrations exceeded the default trigger values for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs) at the intake tower. Both the median and maximum concentrations of oxidised nitrogen exceeded the default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers) at all river sites (ANZECC and ARMCANZ, 2000) (Table 34).
- Total nitrogen concentrations exceeded the default trigger values for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs) for median and maximum concentrations at the intake tower. Maximum concentrations exceeded the default trigger values for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs) at all other sites (ANZECC and ARMCANZ, 2000) (Table 34).
- The minimum pH reading lay outside acceptable limits for the default trigger values for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs) for the intake tower. The minimum and maximum, but not the median, readings exceeded the default trigger values for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs) at McCabes Bridge. Both the minimum and maximum readings, but not the median, exceeded the default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers) at both Tweed River upstream of Byangum Bridge and Tweed River downstream of Smiths Creek (Table 34).
- Total phosphorous concentrations exceed the relevant default trigger values for slightly disturbed ecosystems in south-east Australia for all readings except the minimum reading at McCabes Bridge, Palmers Road Crossing, the Tweed River upstream of Byangum Bridge and Tweed River downstream of Smiths Creek (Table 34).
- Turbidity fell outside the default trigger values for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs) for the minimum and maximum concentrations at the intake tower. Turbidity fell outside the default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers) for the maximum reading at McCabes Bridge, the minimum and maximum readings for the Palmers Road Crossing, and all other readings at all other river sites (Table 34).

Table 35 (Appendix E – Water quality data (desktop analysis)) shows the minimum, median and maximum concentrations of a range of physico-chemical parameters at the Bray Park Weir on the Tweed River (various date ranges) and Site X (various date ranges) and Site Z (various date ranges) within Clarrie Hall Dam (Figure 11). Temperature ranges and median temperature readings varied within, and across sites as is to be expected when data is recorded across a number of years (Table 35).

- The minimum dissolved oxygen (percent saturation) concentrations fell outside the acceptable limits for the default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers) from 2 m to 20 m depth (Table 35) at the Bray Park Weir and the median dissolved oxygen (percent saturation) concentrations fell outside the acceptable limits for the default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers) from 9 m to 20 m depth.
- The maximum dissolved oxygen (percent saturation) concentrations fell outside the acceptable limits for the default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers) from 1 m to 8 m depth, and 11 m to 20 m depth (ANZECC and ARMCANZ, 2000). At the Bray Park Weir Hole (Table 35) the minimum dissolved oxygen (percent saturation) concentrations fell outside the acceptable limits for the default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers) from 2 m depth to 15 m depth.
- The median dissolved oxygen (percent saturation) concentrations fell outside the acceptable limits for the default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers) from 9 m to 15 m depth and the maximum dissolved oxygen (percent saturation) concentrations fell outside the acceptable limits for the default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers) 2 m to 8 m and 11 m to 15 m depth (Table 35).
- All dissolved oxygen (percent saturation) concentrations fell outside the acceptable limits for the default trigger values for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs) for all depths except (median) 0 m and 1 m depth and (maximum) 12 m at site X; and maximum concentrations from 11 m to 20 m depth (Table 35).
- Conductivity fell outside the default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers and lakes and reservoirs) for all depths at all sites except 14 m to 17 m and 19 m to 24 m for the minimum readings at site X (Table 35).
- pH concentrations varied within and between sites. pH fell within the acceptable limits for the default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers)

except for minimum readings at 5 m, 7 m and 8 m, and maximum reading (0 m) at the Bray Park Weir (2021-2022). This pattern was repeated at the Bray Park Weir Hole (2021-2022) (Table 35). pH fell outside the acceptable limits for the default trigger values for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs) except at median 1 m, 2 m and 24 m depth at site X, and median 0 m, 1 m, 2 m, 20 m and 24 m and maximum 24 m at site Z (Table 35).

- Turbidity frequently fell outside the acceptable limits for the default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers) including 0 m to 10 m (minimum, Bray Park Weir (2022-2023)), median 8 m depth and maximum 4 m and 5 m depth (Bray Park Weir (2022-2023)) (Table 35). Turbidity fell outside the acceptable limits for the default trigger values for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs) for all minimum readings for sites X and Z, for median depths 0 m to 3 m at site X and median 0 m at site Z and all depths for maximum readings for sites X and Z (ANZECC and ARMCANZ, 2000) (Table 35).

5.1.10. Algae

A study on phytoplankton that included Clarrie Hall Dam reported that the dam supported a large range of phytoplankton species, with chlorophytes dominating. Low concentrations of cyanoprokaryotes were recorded at the time of the study and included: *Dolicospermum circinale*, *Microcystis aeruginosa*, *Chrysosporum ovalisporum* and *Geitlerinema amphibium*. These species are considered potentially toxic (Everson, 2013).

Algal data was collected by the Tweed Shire Council from sites X and Z within Clarrie Hall Dam between 2001 and 2023 (Figure 11 - Appendix H – Phytoplankton (field assessment); Table 13).

A total of 59 taxa were identified from the phytoplankton (free-floating algae) assemblage at site X between 2001 and 2023 (Table 13, below). This included representatives from 7 phyla: Bacillariophyta (diatoms), Chlorophyta (green algae), Cyanophyta (blue green algae), Cryptophyta (cryptomonads), Dinophyta (dinoflagellates), Chrysophyta (golden algae) and Euglenophyta (euglenida) (Table 13). The diversity and abundance of algal taxa was variable between depths, ranging from 23 to 51 taxa and from 178362 cells to 10861091 cells (Table 13). The lowest diversity was recorded at 4 m and the highest diversity was recorded at 12 m, whereas the lowest abundance was recorded at 8 m and the highest abundance was recorded at 0 m (Table 13). Surface water receive the highest amount of sunlight, which likely explains the higher abundance of algae species in surface waters.

The majority of taxa recorded at site X belong to the Cyanophyta (33 taxa), while the Chlorophyta accounted for 10 taxa. The Bacillariophyta accounted for 7 taxa, the Dinophyta 3 taxa, Chrysophyta and Cryptophyta both accounted for 2 taxa and the Euglenophyta accounted for 1 taxon (Table 13). Cyanophyta, Chlorophyta, Bacillariophyta and Dinophyta were recorded at all depths. Chryptophyta

were recorded at all depths except 4 m and 8 m. Euglenophyta were also recorded at all depths except 4 m and 8 m (Table 13).

Of the Bacillariophyta, *Aulacoseira* sp. was the most abundant and recorded at all depths (Table 13). *Aulacoseira* sp. typically occur in freshwater, grow in linear colonies joined together by linking spines and appear to have best adapted to lakes, ponds and larger rivers (Stoermer & Julius, 2003). Some species of *Aulacoseira* are known to survive sediment burial for extended periods of time (Stoermer & Julius, 2003).

Of the Chlorophyta, *Closterium* was the most abundant species and was recorded at every depth (Table 13). *Closterium* is common in lakes, ponds and slow-flowing streams and is frequently found to be abundant in sewage ponds any time of year (Gerrath, 2003). *Closterium* is often found free-floating in the water column.

A total of 30 taxa, or approximately 50%, of the taxa recorded at site X, have the potential to be toxic and/or bloom-forming (Table 13).

The *Anabaena* genus is considered widespread across Australia and forms unbranched filaments, which are planktonic in standing to slow-flowing water (Entwistle, et al., 1997). The genus has the potential to be toxic and/or bloom-forming (Entwistle & Skinner, 2002) and is seasonally abundant throughout late spring to autumn in Australia. Some species can produce an anatoxin, which can result in livestock death after drinking and may cause skin irritation (Entwistle, 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). Given the high number of potentially toxic and/or bloom-forming algae taxa within Clarrie Hall Dam it is considered that there is a high likelihood for potentially toxic algal blooms to occur within Clarrie Hall Dam and in downstream waters during warmer months when algal blooms are likely to form.

Overall, none of the taxa recorded are considered to be threatened or of restricted distribution, although *Snowella* is considered rare.

Table 13: Algal species recorded at site X (2001–2023)

Phylum	Taxonomic name	0m	4m	8m	12m	16m	20m
Bacillariophyta	<i>Acanthoceras</i>	-	50	40	78	51	
Cyanophyta	<i>Anabaena</i>	125305	15907	3715	6270	1215	1210
Cyanophyta	<i>Anagnostidinema</i>	-	-	-	1980	1910	1050
Chlorophyta	<i>Ankistrodesmus</i>	-	240	72	-	-	-
Cyanophyta	<i>Aphanizomenon</i>	18450	14102	4687	4312	2243	4103
Cyanophyta	<i>Aphanocapsa</i>	1669820	89643	130571	560785	280155	201953
Cyanophyta	<i>Aphanothece</i>	3680	-	-	1400	-	-

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Phylum	Taxonomic name	0m	4m	8m	12m	16m	20m
Cyanophyta	<i>Arthrospira</i>	720	-	20	12540	5063	3570
Bacillariophyta	<i>Asterionella</i>	-	-	-	1550	-	-
Bacillariophyta	<i>Aulacoseira</i> sp.	565	6942	8445	8296	8906	21843
Chlorophyta	<i>Botryococcus</i>	2800	-	-	-	-	-
Dinophyta	<i>Ceratium</i>	1170	113	493	889	270	215
Chlorophyta	<i>Chlorophyta</i>	878550	-	265	424055	393160	216385
Cyanophyta	<i>Chroococcus</i>	36620	-	-	424055	13320	6700
Chrysophyta	<i>Chrysophyta</i>	11325	-	-	845	2905	1155
Cyanophyta	<i>Chrysosporum</i>	5275	-	-	1640	1181	300
Cyanophyta	<i>Chrysosporum ovalisporum</i> [Aphaniz. ovalisporum]	5633	-	50	1065	1510	740
Chlorophyta	<i>Closterium</i>	245	2221	1261	1361	1173	269
Cyanophyta	<i>Coelosphaerium</i>	-	2695	20	3000	1225	1750
Cryptophyta	<i>Cryptomonas</i>	-	-	-	-	3600	2300
Cryptophyta	<i>Cryptophyta</i> sp.	17120	-	-	4765	1730	1135
Cyanophyta	<i>Cuspidothrix</i>	3625	-	-	350	275	350
Cyanophyta	<i>Cyanocatena</i>	18900	-	-	8200	1600	1200
Cyanophyta	<i>Cyanodictyon</i>	22500	19200	-	5000	4200	2200
Cyanophyta	<i>Cyanogranis</i>	575500	-	-	225700	135350	72480
Cyanophyta	<i>Cyanogranis libera</i>	294560	-	-	42500	17700	43800
Bacillariophyta	<i>Cyclotella</i>	-	730	480	170	250	1600
Bacillariophyta	Diatoms	51935	1606	908	32169	22665	49183
Chlorophyta	<i>Dictyosphaerium</i>	300	420	1047	526	95	-
Chrysophyta	<i>Dinobryon</i>	482	305	795	93	-	-
Dinophyta	<i>Dinophyta</i>	1590	-	-	1905	625	455
Cyanophyta	<i>Dolichospermum</i>	12288	-	-	1055	2045	7180
Cyanophyta	<i>Dolichospermum circinale</i> [Anabaena circinalis]	948424	-	4350	88283	51348	42255
Chlorophyta	<i>Elakotothrix</i>	-	-	115	70	-	55
Euglenophyta	<i>Euglenophyta</i>	820	-	-	840	880	280
Cyanophyta	<i>Geitlerinema</i>	-	60	800	3175	1805	280
Cyanophyta	<i>Glaucospira</i>	-	-	-	290	380	-
Cyanophyta	<i>Gloeothoece</i>	2200	-	-	1000	-	-
Chlorophyta	<i>Gonium</i>	-	310	124	-	-	-
Chlorophyta	<i>Kirchneriella</i>	-	-	-	-	160	-
Cyanophyta	<i>Limnothrix</i>	-	-	-	150	-	-
Cyanophyta	<i>Merismopedia</i>	23280	-	-	6160	4040	3740
Cyanophyta	<i>Microc. aeruginosa</i>	23625	-	-	8526	7075	1670
Cyanophyta	<i>Microcystis</i>	5709690	9205	5975	8638	6575	4625
Cyanophyta	<i>Oscillatoria</i>	820	1	775	1070	3400	9650

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Phylum	Taxonomic name	0m	4m	8m	12m	16m	20m
Bacillariophyta	Pennate Diatoms	185	-	65	555	55	250
Dinophyta	<i>Peridinium</i>	40	-	-	-	-	-
Cyanophyta	<i>Phormidium</i>	1600	-	1	27650	24730	18560
Cyanophyta	<i>Planktolyngbya</i> sp.	338867	-	50	179167	157417	92545
Chlorophyta	<i>Planktonema</i>	-	900	2900	1200	-	-
Cyanophyta	<i>Planktothrix</i>	15520	-	-	142850	104615	106687
Cyanophyta	<i>Pseudanabaena</i>	290	270	1140	3105	6035	2390
Cyanophyta	<i>Romeria</i>	-	-	-	240	640	-
Cyanophyta	<i>Snowella</i>	2960	-	-	-	-	-
Cyanophyta	<i>Sphaerospermopsis</i>	3410	-	-	920	1575	-
Cyanophyta	<i>Spirulina</i>	-	45	680	5057	8109	4408
Chlorophyta	<i>Staurostrum</i>	152	708	38	10	-	-
Bacillariophyta	<i>Urosolenia</i>	-	-	2000	3740	2230	625
Cyanophyta	<i>Woronichinia</i>	30250	15080	6480	-	-	-
Diversity		42	23	31	51	45	40
Abundance		10861091	180753	178362	2259250	1285491	931146

Note: Brown shading indicates taxa is potentially bloom-forming and/or toxic.

A total of 57 taxa were identified from the phytoplankton (free-floating algae) assemblage at site Z between 2002 and 2023 (Table 14, below). This included representatives from 7 phyla: Bacillariophyta (diatoms), Chlorophyta (green algae), Cyanophyta (blue-green algae), Cryptophyta, Dinophyta (dinoflagellates), chrysophyta and Euglenophyta (Table 14). The diversity and abundance of algal taxa was variable between depths, ranging from 38 to 51 taxa and from 661,045 cells to 3,488,053 cells (Table 14). The lowest diversity was recorded at 20 m and the highest diversity was recorded at 4 m, whereas the lowest abundance was recorded at 20 m and the highest abundance was recorded at 0 m (Table 14). Surface waters receive the highest amount of sunlight, which likely explains the higher abundance of algae species in surface waters.

Like at site X, the majority of taxa recorded at site Z belong to the Cyanophyta (36 taxa,) while the Bacillariophyta accounts for 6 taxa and the Chlorophyta accounted for 5 taxa. The Dinophyta account for 4 taxa, Chrysophyta accounted for 3, Cryptophyta accounted for 2 taxa, and the Euglenophyta accounted for 1 taxon (Table 14). Cyanophyta, Bacillariophyta, Dinophyta, Chrysophyta and Cryptophyta were recorded at all depths. Euglenophyta was recorded from 0 m to 16 m depth but not 20 m depth, and Chlorophyta was recorded at all depths except 0 m (Table 14).

Of the Cyanophyta, *Aphanocapsa* was the most abundant and was recorded at all depths.

Aulacoseira sp. was the most abundant and recorded at all depths for Bacillariophyta – the same as site X (Table 14).

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Of the Chlorophyta, *Closterium* was the most abundant species and was recorded from 4 m to 20 m depth (Table 14).

A total of 31 taxa or approximately 54% of the taxa recorded at site Z have the potential to be toxic and/or bloom-forming (Table 14).

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

Table 14: Algal species recorded at site Z (2002–2023)

Phylum	Taxonomic name	0m	4m	8m	12m	16m	20m
Bacillariophyta	<i>Acanthoceras</i>	-	97	94	97	70	97
Cyanophyta	<i>Anabaena</i>	7585	14371	6688	3302	2055	1685
Cyanophyta	<i>Anabaenopsis</i>	225	-	-	-	-	-
Cyanophyta	<i>Anagnostidinema</i>	-	-	1700	1700	750	250
Cyanophyta	<i>Aphanizomenon</i>	19958	19860	8148	1700	3560	1880
Cyanophyta	<i>Aphanizomenon minderi</i>	175	-	60	-	-	-
Cyanophyta	<i>Aphanocapsa</i>	2075640	1857420	926033	423105	234750	209975
Cyanophyta	<i>Aphanocapsa delicatissima</i>	-	-	1500	-	-	-
Cyanophyta	<i>Aphanothece</i>	1700	910	4000	-	-	-
Cyanophyta	<i>Arthrospira</i>	1340	1875	10920	26545	4405	1290
Bacillariophyta	<i>Aulacoseira</i>	3565	9031	7925	6275	7169	12017
Dinophyta	<i>Ceratium</i>	1920	3703	3053	1722	819	593
Cyanophyta	<i>Chroococcus</i>	52500	52585	45580	30780	13480	1600
Chrysophyta	<i>Chrysophyta</i>	5420	4235	2345	5070	890	1148
Cyanophyta	<i>Chrysosporum</i>	4491	3793	3485	3448	1338	150
Cyanophyta	<i>Chrysosporum ovalisporum</i> [Aphaniz. ovalisporum]	9235	8030	3540	690	2410	400
Chlorophyta	<i>Closterium</i>	-	4069	1533	1291	991	728
Cyanophyta	<i>Coelosphaerium</i>		11420	1240	1400	5400	11200
Cryptophyta	<i>Cryptomonas</i>	1140	130	-	3500	4600	1400
Cryptophyta	<i>Cryptophyta</i>	13850	12760	9250	6565	3660	1350
Cyanophyta	<i>Cuspidothrix</i>	1900	2000	200	475	400	125
Cyanophyta	<i>Cyanocatena</i>	5000	8200	6800	3200	1600	-
Cyanophyta	<i>Cyanodictyon</i>	29700	12200	21900	7400	1800	-
Cyanophyta	<i>Cyanogranis</i>	261800	213080	222720	115540	120700	181200
Cyanophyta	<i>Cyanogranis libera</i>	237840	160370	149650	55750	39870	35800
Bacillariophyta	<i>Cyclotella</i>	-	1180	520	260	160	67
Bacillariophyta	<i>Diatoms</i>	49490	277283	44971	28755	22263	33438
Chlorophyta	<i>Dictyosphaerium</i>	-	186	278	246	150	136
Chrysophyta	<i>Dinobryon</i>	-	-	240	90	-	-

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Phylum	Taxonomic name	0m	4m	8m	12m	16m	20m
Dinophyta	<i>Dinophyta</i>	2028	-	3399	1680	775	895
Cyanophyta	<i>Dolichospermum</i>	10805	8015	5255	2040	1465	1750
Cyanophyta	<i>Dolichospermum circinale</i> [<i>Anabaena circinalis</i>]	288051	156226	74156	58418	18183	18813
Chrysophyta	<i>Dinobryon</i>	-	435	-	-	-	-
Dinophyta	<i>Dinophyta</i>	-	1702	-	-	-	-
Chlorophyta	<i>Elakotothrix</i>	-	190	-	-	30	-
Euglenophyta	<i>Euglenophyta</i>	480	600	120	380	120	-
Cyanophyta	<i>Geitlerinema</i>	-	1085	5140	3313	775	1700
Cyanophyta	<i>Glaucospira</i>	-	1000	2300	855	275	-
Cyanophyta	<i>Gloeotheca</i>	2700	400	240	200	-	-
Cyanophyta	<i>Merismopedia</i>	5920	8130	28540	8340	1040	-
Cyanophyta	<i>Microc. aeruginosa</i>	25875	30955	13905	7440	6525	13080
Cyanophyta	<i>Microcystis</i>	5775	7975	6875	5975	8368	2530
Cyanophyta	<i>Oscillatoria</i>	380	1175	880	1720	1785	4160
Bacillariophyta	<i>Pennate Diatoms</i>	405	590	520	420	35	235
Dinophyta	<i>Peridinium</i>	40	210	175	195	75	60
Cyanophyta	<i>Phormidium</i>	1405	1220	6870	13010	5815	-
Cyanophyta	<i>Planktolyngbya</i> sp.	294430	215993	186892	131100	90033	32250
Chlorophyta	<i>Planktonema</i>	-	90	-	243	-	75
Cyanophyta	<i>Planktothrix</i>	3540	46495	167830	195020	102600	83395
Cyanophyta	<i>Pseudanabaena</i>	435	2000	3645	2185	2795	2345
Cyanophyta	<i>Romeria</i>	-	30	-	-	-	-
Cyanophyta	<i>Snowella</i>	3460	1840	1200	2160	1480	-
Cyanophyta	<i>Sphaerospermopsis</i>	3210	1900	2345	680	1060	-
Cyanophyta	<i>Spirulina</i>	-	2581	8879	7470	8341	1133
Chlorophyta	<i>Staurostrum</i>	-	173	116	20	-	-
Bacillariophyta	<i>Urosolenia</i>	1560	2810	2285	1920	120	185
Cyanophyta	<i>Woronichinia</i>	53080	28530	19430	10500	7580	1910
Diversity		40	51	50	49	46	38
Abundance		3488053	3201138	2025370	1184190	732565	661045

Note: Brown shading indicates taxa is potentially bloom-forming and/or toxic.

5.1.11. Aquatic flora

A wide range of aquatic flora is reported to occur within the Northern Rivers region. Wetland vegetation in the coastal floodplains is frequently dominated by *Eleocharis* spp.; swales in coastal dune systems are typically dominated by *Baumea* spp. In the tablelands, bogs are dominated by *Sphagnum* spp. and other *Cyperaceae* spp. A highly diverse mangrove community located in the Tweed River supports 5 species of mangrove including grey mangrove (*Avicennia marina*), stilt-rooted mangrove (*Rhizophora stylosa*), black mangrove (*Bruguiera gymnorhiza*), river mangrove (*Aegiceras corniculatum*) and milky

mangrove (*Excoecaria agallocha*) (Department of Environment, Climate Change and Water NSW, 2010b).

Invasive species such as willow (*Salix* spp.), alligator weed (*Alternanthera philoxeroides*), salvinia (*Salvinia* spp.) and water hyacinth (*Eichhornia crassipes*) are all reported to occur with the Northern Rivers catchment (Department of Environment, Climate Change and Water NSW, 2010b).

Reports provided by the Tweed Shire Council provided important information on both native and exotic aquatic flora within the study area. A review of *Clarrie Hall Dam Management Plan: Doon Doon* (Tweed Shire Council, 2021a) and *Aquatic Weed Management Works Plan Clarrie Hall Dam, Doon Doon* (Tweed Shire Council, 2021b) revealed that exotic aquatic weed species such as salvinia (*Salvinia molesta*) and cabomba (*Cabomba caroliniana*) occur within fringing habitat within Clarrie Hall Dam (Tweed Shire Council, 2021a). The Australian Government has classified both species as Weeds of National Significance (WoNS) based on their invasiveness, potential for spread and environmental, social and economic impacts (National Weeds Strategy Executive Committee, 1999). Salvinia is a floating water weed that forms dense mats that can take over waterways and reduces water quality (Department of Primary Industries, 2023c). Salvinia is considered common within the Tweed River catchment (Department of Primary Industries, 2023c). Cabomba is a submerged weed and is known to choke water bodies and degrade water quality (Department of Primary Industries, 2023d). Known infestations are present within the Tweed River catchment near Murwillumbah (Department of Primary Industries, 2023d).

Additional exotic species recorded within Clarrie Hall Dam include yellow waterlily (*Nymphaea Mexicana*), parrot's feather (*Myriophyllum aquaticum*), cape waterlily (*Nymphaea capensis*) and exotic Trad (*Tradescantia fluminensis*). Yellow waterlily is known to form dense infestations in waterways that reduce water quality and out compete native aquatic plants (Department of Primary Industries, 2023f). Parrot's feather is a common weed in coastal waterways of NSW and can form dense stands that impede water flows and alter natural habitat (Department of Primary Industries, 2023g). Cape waterlily has a similar appearance to yellow waterlily and can have a similar impact on a waterway (Department of Primary Industries, 2023f). Trad forms dense mats that smother and outcompete other plants. Invasion and establishment of exotic vines and scramblers has been identified as a key threatening process for many vulnerable and endangered species in NSW (Department of Primary Industries , 2024). Table 15 is taken from Tweed Shire Council (2021a) and has been modified for this report. It summarises the weed species present within Clarrie Hall Dam and surrounding waterways.

It should be noted that Tweed Shire Council have prepared management plans to address the impact of the above exotic species and regularly undertake on-ground works to assist in controlling weed infestations.

Table 15: Aquatic weed species recorded in Clarrie Hall Dam by Tweed Shire Council (Tweed Shire Council, 2021a)

Weed species	Conservation status	Biosecurity Duty	Habit	Depth range (m)	Infestation areas	Relative abundance
Cabomba (<i>Cabomba caroliniana</i>)	WoNS; State priority species	General Biosecurity Duty This plant must not be sold anywhere in NSW	Floating – rooted to bed & survives free floating for up to ~6 weeks	1 – 6	Upstream: Crams Farm, Upper Doon Doon Creek, periphery in vicinity of Snake Island. Downstream: Spillway west, Spillway east (near boat ramp).	D
Parrot's feather (<i>Myriophyllum aquaticum</i>)	North Coast region priority species	General Biosecurity Duty	Submerged and emergent – rooted to bed	0 – 2	Upstream: Cram's Farm, Upper Doon Doon Creek. Mid-section: sporadic outbreaks along periphery of reservoir. Downstream: Spillway.	D
Salvinia (<i>Salvinia molesta</i>)	WoNS; State priority species	General Biosecurity Duty This plant must not be sold anywhere in NSW	Free-floating	Any depth	Upstream: Crams Farm, Upper Doon Doon Creek. Mid-section: sporadic outbreaks along periphery of reservoir. Downstream: Spillway.	C
Yellow waterlily (<i>Nymphaea mexicana</i>)	Regional watch species	General Biosecurity Duty	Floating - rooted to bed	0 – 3m	Upstream: Cram's Farm, Upper Doon Doon Creek, periphery in vicinity of Snake Island. Mid-sections: along the periphery of the reservoir. Downstream: Spillway west.	C

Note: Relative abundance: D – dominant, C – common, O – occasional, R – rare.

5.1.12. Aquatic fauna

The NSW Department of Primary Industries (DPI) Fisheries Fisheries Spatial Data Portal revealed that the freshwater fish community status in Commissioners Creek is considered 'poor'. The freshwater fish community status in Doon Doon Creek ranges from 'poor' to 'fair', is considered 'poor' in Clarrie Hall Dam and is 'fair' to 'good' in the Tweed River (Department of Primary Industries, 2023b).

A search of the NSW Department of Planning and Environment (DPE) BioNet Atlas revealed 1,042 animal records have been recorded from the Northern Rivers catchment (Department of Environment and Heritage, 2023). Non-aquatic species are beyond the scope of this report and were subsequently excluded. Further review of publicly available desktop databases and a comprehensive literature review revealed that Clarrie Hall Dam provides habitat for a range of common fish species, both native and exotic. A report prepared by NSW DPI Fisheries (2014) revealed that Clarrie Hall Dam supported populations of fish species such as the longfin eel (*Anguilla reinhardtii*), eel-tailed catfish (*Tandanus tandanus*), Agassiz's glassfish (eastern population) (*Ambassis agassizii*), fly-specked hardyhead (*Craterocephalus stercusmuscarum*), firetail gudgeon (*Hypseleotris galii*), western carp gudgeon (*Hypseleotris klunzingeri*), flathead gudgeon (*Phylipnodon grandiceps*), dwarf flathead gudgeon (*Phylipnodon macrostomus*), Australian smelt (*Retropinna semoni*), bony herring (*Nematolosa erebi*), mountain galaxias (*Galaxius olidus*) and the fork-tailed catfish (*Arius graeffei*) (Butler, et al., 2014; Department of Primary Industries, 2006; Department of Climate Change, Energy, the Environment and Water, 2023a; Department of Environment and Heritage, 2023; Department of Environment, Climate Change and Water NSW, 2010b) (Appendix A – Database search summary; Appendix B – Literature review summary).

Additional common species recorded in Clarrie Hall Dam, Doon Doon Creek and the Tweed River include freshwater mullet (*Trachystoma petardi*), sea mullet (*Mugil cephalus*), ox-eye herring (*Megalops cyprinoides*), freshwater herring (*Alosa pseudoharengus*), short-finned eel (*Anguilla australis*), Duboulayi rainbowfish (*Melanotaenia duboulayi*), Pacific blue-eye (*Pseudomugil signifer*), empire gudgeon (*Hypseleotris compressa*), striped gudgeon (*Gobiomorphus australis*), Cox's gudgeon (*Gobiomorphus coxii*) and estuary perchlet (*Ambassis marianus*) (Eco Logical Australia, 2019).

Exotic fish species recorded within the Northern Rivers catchment include eastern gambusia (*Gambusia holbrooki*), common carp (*Cyprinus carpio*), redfin perch (*Perca fluviatilis*) and goldfish (*Carassius auratus*) (Regional Development Australia, 2013; Eco Logical Australia, 2019; Butler, et al., 2014; Department of Environment and Heritage, 2023).

Limited information was available on the Department of Primary Industries' fish stocking database (Department of Primary Industries, 2023h). Two species are reported as being stocked within Clarrie Hall Dam. Australian bass (*Perca latipes*) is reported as being stocked in 2010, 2013, 2014, 2015, 2021 and 2023, and Mangrove jack (*Lutjanus argentimaculatus*) is reported as being stocked in 2015 and 2016 (Department of Primary Industries, 2023h). No fish stocking is reported in any of the waterways surrounding Clarrie Hall Dam.

5.1.13. Threatened aquatic fauna

The results of the desktop assessment and literature review indicate that 4 threatened aquatic species listed under the FM Act and/or the EPBC Act, and the platypus have the potential to occur in waterways within 50 km of Clarrie Hall Dam (Table 16) (Butler, et al., 2014; Department of Primary Industries, 2023a; Department of Climate Change, Energy, the Environment and Water, 2023a; Eco Logical Australia, 2019; Department of Environment and Heritage, 2023) (Appendix A – Database search summary; Appendix B – Literature review summary). These species include:

- Eastern freshwater cod (*Maccullochella ikei*)
- Mary River cod (*Maccullochella mariensis*)
- Southern purple-spotted gudgeon (*Mogurnda adspersa*)
- Oxleyan pygmy perch (*Nannoperca oxleyana*)
- Platypus (*Ornithorhynchus anatinus*).

Of these species, the platypus, Oxleyan pygmy perch and eastern freshwater cod are included on the DCCEEW (2020) provisional list of animal species identified as requiring urgent management intervention following the 2019–2020 bushfire season.

The eastern freshwater cod is listed as 'endangered' under both the EPBC Act and FM Act, while the Mary River cod is listed as 'endangered' under the EPBC Act only. The southern purple-spotted gudgeon is listed as 'endangered' under the FM Act, while the Oxleyan pygmy perch is listed as an *Endangered* population under both the EPBC Act and FM Act.

While the platypus is not currently listed under the FM Act or the EPBC Act, there is a lack of knowledge regarding species abundance at a local catchment level, and the species is subject to similar impacts as threatened fish, including waterway bank erosion, channel sedimentation, regulated waterways,

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barriers to water flow (e.g. dams and weirs), riparian zone degradation and loss of riparian vegetation (Grant & Temple-Smith, 2003; Hawke, et al., 2021).

6. An assessment was undertaken to evaluate the likelihood of each of these threatened aquatic species occurring within waterways intersecting the Proposal, or downstream of the Proposal, based on the aquatic habitats likely to be present, as well as existing literature and DPI Fisheries datasets (Department of Environment and Heritage, 2023; Department of Primary Industries, 2023b; Eco Logical Australia, 2019) (Appendix H – Phytoplankton (field assessment))

Table 38: Phytoplankton taxa recorded during the September 2023 field survey

		Clarrie Hall Dam		McCabes Bridge	Tweed River					Doon Doon Creek					Big Creek	Commissioners Creek	
Phylum	Taxonomic name	CHD2	CHD1	MB1	TR1	TR2	TR3	BPW	DD5	DD4	DD3	DD2	DD1	BC1	CC1	CC2	
Cyanophyta	<i>Anabaena</i>	1820					200				66	64					
Cyanophyta	<i>Aphanocapsa</i>	900	614														
Cyanophyta	<i>Cylindrospermum</i>															1720	
Cyanophyta	<i>Dolichospermum</i> (coiled small)	176															
Cyanophyta	<i>Dolichospermum circinale</i>	300	50														
Cyanophyta	<i>Dolichospermum planctonicum</i>	1110	20					206			66						
Cyanophyta	<i>Dolichospermum</i> (straight)							152									
Cyanophyta	<i>Dolichospermum</i> (straight small)					166	388				60	220	244		84	224	
Cyanophyta	<i>Heteroleibleinia</i> *						132	784									
Cyanophyta	<i>Geitlerinema</i>						106			70		252	94				
Cyanophyta	<i>Komvophoron</i>		40														
Cyanophyta	<i>Lyngbya</i>							378									
Cyanophyta	<i>Merismopedia</i>							1380									
Cyanophyta	<i>Oscillatoria</i>						54			480							
Cyanophyta	<i>Phormidium</i> *			68		44	50	288	80					24	242		
Cyanophyta	<i>Pseudanabaena</i>			50		24											
Cyanophyta	<i>Tapinothrix</i> *				100		124	2590		110				36			
Cyanophyta	<i>Trichodesmium</i>	3320	166				26				668						
Chrysophyta	<i>Dinobryon</i>		8					10			20						
Chrysophyta	<i>Synura</i>					100									10		
Bacillariophyta	<i>Achnantheidium</i>																
Bacillariophyta	<i>Aulacoseira</i>	30	40								748					20	
Bacillariophyta	<i>Bacillaria</i>		16	310	180	1580	150	676	480	32		174	46			40	
Bacillariophyta	<i>Cocconeis</i>													10			
Bacillariophyta	<i>Cyclotella</i>													400			
Bacillariophyta	<i>Cyclotella</i> small_spp										30						
Bacillariophyta	<i>Cymbella</i>				2			4	2	4							
Bacillariophyta	<i>Euglena</i>								2								
Bacillariophyta	<i>Gomphonema</i>								4				10		10		
Bacillariophyta	<i>Gyrosigma</i>	10		12	20	50		2	105	20	26	26	8			8	
Bacillariophyta	<i>Melosira</i>			6				90		8		72	14	50		72	
Bacillariophyta	<i>Navicula</i>				70	50	200	20				24	20	100	14	20	
Bacillariophyta	<i>Naviculoids</i>				2										6	30	
Bacillariophyta	<i>Nitzschia</i>	2		90	24	350	250	60			42	102	62	400	62	210	
Bacillariophyta	Pennate diatoms			8	6	100	60		20			30		200	2	20	
Bacillariophyta	<i>Rhoicosphenia</i>															40	
Bacillariophyta	<i>Rhopalodia</i>				10	50	30	40		4	2	2	4		4	4	

Phylum	Taxonomic name	Clarrie Hall Dam		McCabes Bridge MB1	TR1	Tweed River		BPW	DD5	Doon Doon Creek				Big Creek BC1	Commissioners Creek	
		CHD2	CHD1			TR2	TR3			DD4	DD3	DD2	DD1		CC1	CC2
Bacillariophyta	<i>Staurosira</i>								56							
Bacillariophyta	<i>Surirella</i>									2		2				
Bacillariophyta	<i>Synedra</i>	4	18	12	2		60			140	58	2	16	40	48	
Bacillariophyta	<i>Urosolenia</i>	1520	275								80					
Euglenophyta	<i>Lepocinclis</i>				2						8					
Euglenophyta	<i>Trachelomonas</i>	350	10					10			20					
Chlorophyta	<i>Cladophora</i>				56					12		40				
Chlorophyta	<i>Closterium</i>	10	10						12				8	10	4	
Chlorophyta	<i>Coenochloris</i>	15300	22300								1120					
Chlorophyta	Colonial green algae small_spp			114												
Chlorophyta	<i>Cosmarium</i>	10	6		2					12	2					
Chlorophyta	<i>Crucigenia</i>							40			40					
Chlorophyta	<i>Cylindrocapsa</i>									1230						
Chlorophyta	<i>Desmidium</i>	218	1980							640	52					
Chlorophyta	<i>Elakatothrix</i>	375														
Chlorophyta	<i>Eudorina</i>							74								
Chlorophyta	<i>Geminella</i>	790	1150													
Chlorophyta	<i>Gonatozygon</i>	76	72		6	125	30			100		92			18	
Chlorophyta	<i>Hyalotheca</i>	480														
Chlorophyta	<i>Kirchneriella</i>		120													
Chlorophyta	<i>Klebsormidium*</i>														138	
Chlorophyta	<i>Mougeotia</i>			8					6	10						
Chlorophyta	<i>Oedogonium</i>				26				18	106						64
Chlorophyta	<i>Oocystis</i>			8												
Chlorophyta	<i>Pediastrum</i>										275					
Chlorophyta	Phytoflagellates	575				700	2050			300	625	60	60	400	80	
Chlorophyta	Phytoflagellates small_spp			400	180			1750	250							
Chlorophyta	<i>Pleurotaenium</i>	4									4					
Chlorophyta	<i>Pteromonas</i>														10	
Chlorophyta	<i>Scenedesmus</i>			8							40					
Chlorophyta	<i>Spirogyra</i>			238	16					58		338	2			
Chlorophyta	<i>Staurastrum</i>	1170	166	2					12	16	20					
Chlorophyta	<i>Staurodesmus</i>	22	10							12						
Chlorophyta	<i>Stigeoclonium</i>				20											
Chlorophyta	<i>Ulothrix</i>									132						
Chlorophyta	<i>Zygnema</i>							84		762						
Cryptophyta	<i>Cryptomonas</i>												20		20	
Pyrrhophyta	<i>Peridinales^*</i>												10			
Xanthophyta	<i>Centrtractus</i>	40	8								10					
Unidentified	Unidentified						100									

		Clarrie Hall Dam		McCabes Bridge	Tweed River				Doon Doon Creek					Big Creek	Commissioners Creek	
Phylum	Taxonomic name	CHD2	CHD1	MB1	TR1	TR2	TR3	BPW	DD5	DD4	DD3	DD2	DD1	BC1	CC1	CC2
	Diversity	25	21	15	18	12	17	20	13	23	23	16	15	11	16	13
	Total	28612	27079	1334	724	3339	4010	8638	1047	4260	4082	1500	618	1670	752	2472

Notes: Units are cells/ml. * indicates that the identification for this organism is tentative only. ^ organism is tentatively identified as *Ensiculifera* sp. Brown shading indicates taxa are potentially bloom-forming and/or toxic.

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7. Appendix I – Macrophytes (field assessment)

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Table 39: Macrophyte taxa recorded during the September 2023 field survey

Macrophyte taxa	Clarrie Dam CHD2	Hall CHD1	Doon Doon Creek						Big Creek		Commissioners Creek CC2	Tweed River			
			DD5	DD4	DD3	MB1	DD2	DD1	BC1	CC1		TR1	TR2	TR3	BPW
Alismatales															
Potamogetonaceae															
<i>Potamogeton</i> sp.													ü	ü	ü
Alismatales															
Potamogetonaceae															
<i>Potamogeton crispus</i>						ü									
Alismatales															
Hydrocharitaceae															
<i>Vallisneria</i> sp.						ü	ü								
Asterales															
Menyanthaceae															
<i>Nymphoides</i> sp.	ü	ü		ü	ü							ü	ü	ü	
Brassicales															
Brassicaceae															
<i>Nastrurtium</i> sp.								ü	ü						
Caryophyllales															
Polygonaceae															
<i>Persicaria</i> sp.				ü		ü	ü	ü	ü	ü	ü		ü	ü	
Cyperales															
Cyperaceae															
<i>Cyperus</i> sp.*	ü	ü	ü	ü		ü	ü	ü				ü		ü	
Cyperales															

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Macrophyte taxa	Clarrie Dam	Hall	Doon Doon Creek						Big Creek		Commissioners Creek	Tweed River			
	CHD2	CHD1	DD5	DD4	DD3	MB1	DD2	DD1	BC1	CC1	CC2	TR1	TR2	TR3	BPW
Cyperaceae															
<i>Cyperus eragrostis*</i>													ü	ü	
Cyperales															
Cyperaceae															
<i>Schoenoplectus</i>				ü		ü									
<i>tabernaemontani</i>															
Cyperales															
Cyperaceae															
<i>Carex</i> sp.						ü				ü	ü				
Cyperales															
Cyperaceae															
<i>Carex tereticaulis</i>				ü											
Myrtales															
Onagraceae															
<i>Ludwigia</i> sp.	ü	ü		ü	ü	ü		ü							
Myrtales															
Onagraceae															
<i>Ludwigia peploides</i>			ü												
Nymphaeales															
Cabombaceae															
<i>Cabomba</i>	ü	ü			ü										
<i>caroliniana*</i>															
Nymphaeales															
Nymphaeaceae															

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Macrophyte taxa	Clarrie Dam CHD2	Hall CHD1	Doon Doon Creek DD5 DD4 DD3 MB1 DD2 DD1						Big Creek BC1 CC1		Commissioners Creek CC2	Tweed River TR1 TR2 TR3 BPW			
<i>Nymphaea Mexicana*</i>	ü														
Poales															
Typhaceae															
<i>Typha</i> sp.		ü													
Poales															
Cyperaceae															
<i>Eleocharis</i> sp.	ü	ü													
Poales															
Juncaceae															
<i>Juncus</i> sp.					ü	ü			ü				ü		
Salviniales															
Salviniaceae															
<i>Azolla</i> sp.	ü														
Salviniales															
Salviniaceae															
<i>Salvinia molesta*</i>	ü	ü		ü											
Saxifragales															
Haloragaceae															
<i>Myriophyllum</i> sp.				ü	ü										
Saxifragales															
Haloragaceae															
<i>Myriophyllum aquaticum</i>	ü					ü									

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Macrophyte taxa	Clarrie Dam	Hall	Doon Doon Creek						Big Creek		Commissioners Creek	Tweed River			
	CHD2	CHD1	DD5	DD4	DD3	MB1	DD2	DD1	BC1	CC1	CC2	TR1	TR2	TR3	BPW
Diversity	10	7	2	8	5	9	3	4	3	2	2	2	5	5	1

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8. Appendix J – Macroinvertebrates (edge habitat)

Table 40: Aquatic invertebrate taxa recorded in edge habitat during the September 2023 field survey

Taxonomic name	BC1	BPW1	BPW2	CC1A	CC1B	CC2	DD2	DD2A	DD4	DD5	MB1	TR1	TR2	TR3	TR3A	Total
Acarina																
Mites		1	11	2	1	8	1			17	3	4		6	4	58
Amphipoda																
Corophiidae															1	1
Basommatophora																
Ancylidae							3	1				1				5
Coleoptera																
Dytiscidae	7				2	2			1		3	2	1			18
Elmidae	1											2				3
Gyrinidae				1	2						1					4
Hydrophilidae	2			4	4		6	1	2	3	4	4	4			34
Psephenidae						1										1
Decapoda																
Atyidae	1	6	3		2	6	1	3	6	7	3	6	5	5	6	60
Palaemonidae		1	3	1	1		1			2	2		1	2	2	16
Diptera																
Ceratopogonidae					1	1				2	2					6
Chironominae	14		14	5	7	13	6	2		7	28	5	2	10	7	120
Culicidae					1											1
Dixidae	11					4	2	3		1		1				22
Orthocladiinae	9		1	1		10					1					22
Tanypodinae	8	1		6	8	12	12	12	7	1	16		1	1	1	86
Ephemeroptera																
Ameletopsidae						1										1

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Taxonomic name	BC1	BPW1	BPW2	CC1A	CC1B	CC2	DD2	DD2A	DD4	DD5	MB1	TR1	TR2	TR3	TR3A	Total
<i>Baetidae</i>	4					2	4	1			1	1				13
<i>Caenidae</i>	7					14	30	11		2	3	2				69
<i>Leptophlebiidae</i>	30		1	14	17	9	19	26		1	4	4	3			128
Gordioidea																
<i>Gordiidae</i>						1										1
Hemiptera																
<i>Corixidae</i>	19	1		19	13	1	25	3	17	5	19	13				135
<i>Gerridae</i>				5	5	1		8	5	1		4	1			30
<i>Naucoridae</i>									1							1
<i>Veliidae</i>	8	3						14		1		2			2	30
Isopoda																
<i>Cirolanidae</i>			1													1
<i>Sphaeromatidae</i>		17	15							3			10	16	29	90
Littorinimorpha																
<i>Hydrobiidae</i>												2				2
Lymnophila																
<i>Lymnaeidae</i>	3			2	1			1	5			1			1	14
<i>Physidae</i>				4	5		1					1	1			12
<i>Planorbidae</i>		1	1													2
Odonata																
<i>Aeshnidae</i>			1													1
<i>Coenagrionidae</i>	4	30	10		1		3		1	1		4	4	3	1	62
<i>Corduliidae</i>							2					5	9			16
<i>Diphlebiidae</i>						1										1
<i>Gomphidae</i>	1			2	2	3	10	10	4	7	1		1	1	3	45
<i>Isostictidae</i>		1	5							7		6	10	8	1	38

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Taxonomic name	BC1	BPW1	BPW2	CC1A	CC1B	CC2	DD2	DD2A	DD4	DD5	MB1	TR1	TR2	TR3	TR3A	Total
<i>Libellulidae</i>	2															2
<i>Megapodagrionidae</i>								1								1
<i>Protoneuridae</i>													1			1
<i>Synthemistidae</i>		1			1											2
Trichoptera																
<i>Calamoceratidae</i>								1		1						2
<i>Calocidae</i>										1						1
<i>Ecnomidae</i>	1					3		5								9
<i>Hydropsychidae</i>								1		2						3
<i>Hydroptilidae</i>						3	2				1				1	7
<i>Leptoceridae</i>	30	4	10	1	3	3	8	4		23	6	16	6	2	9	125
<i>Notonectidae</i>	6			1	4	3	2	6				1				23
Tricladida																
<i>DugesIIDae</i>				2	1			1								4
Venerida																
<i>Corbiculidae</i>												3				3
Unknown order																
<i>Oligochaeta</i>	1	2											1		1	5
<i>Ostracoda</i>						1										1
Diversity	21	13	13	16	21	23	16	21	10	21	17	23	17	10	15	
Grand total	169	69	76	70	82	103	138	115	49	95	98	90	61	54	69	1338

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9. Appendix K – Aquatic vertebrates (field assessment)

Table 41: Aquatic vertebrate (and large invertebrate) species presence/absence and abundance recorded during the September 2023 field survey

		Clarrie Hall Dam			Doon Doon Creek					Big Creek	Commissioners Creek		Tweed River				
Common name	Taxonomic name	CHD2	CHD1	DD5	DD4	DD3	MB1	DD2	DD1	BC1	CC1	CC2	TR1	TR2	TR3	BPW	Total
Fish																	
Agassiz's glassfish	<i>Ambassis agassizii</i>	1	-	3	23	-	63	-	-	-	-	-	-	-	-	1	91
Australian bass^	<i>Percalates novemaculeata</i>	1	1	-	1	-	-	-	-	-	-	-	2	-	31	32	68
Australian smelt	<i>Retropinna semoni</i>	26	37	1	3	6	68	-	2	-	-	2	-	-	-	-	145
Black bream	<i>Acanthopagrus butcheri</i>	-	-	-	1	-	-	-	-	-	-	-	-	-	-	40	41
Bullrout	<i>Notesthes robusta</i>	-	-	-	-	-	-	-	-	-	-	-	1	3	-	1	5
Common carp*	<i>Cyprinus carpio</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	9
Cox's gudgeon	<i>Gobiomorphus coxii</i>	-	-	-	-	-	1	-	-	15	-	-	4	7	2		29
Duboulayi rainbowfish	<i>Melanotaenia duboulayi</i>	-	-	-	2	-		-	-	-	-	-	-	-	1	1	4
Eastern gambusia*	<i>Gambusia holbrooki</i>	-	-	-	-	-	23	-	-	49	25	-	1	-	1	1	100
Flathead gudgeon	<i>Philypnodon grandiceps</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2
Freshwater catfish	<i>Tandanus tandanus</i>	-	9	4	10	7	10	23	26	-	20	5	7	10	10	18	159
Freshwater herring	<i>Alosa pseudoharengus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	19	7	26
Genus of carp gudgeons	<i>Hypseleotris</i> spp.	127	141	213	103	97	747	246	127	-	107	4	202	71	172	137	2 494
Longfin eel	<i>Anguilla reinhardtii</i>	4	-	19	34	4	5	3	4	5	2	1	5	13	10	12	121
Pearl cichlid*	<i>Geophagus brasiliensis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Sea mullet	<i>Mugil cephalus</i>	-	-	50	-	-	-	-	-	-	-	-	-	-	115	237	402
Striped gudgeon	<i>Gobiomorphus australis</i>	-	-	27	44	-	-	-	-	1	-	7	46	27	17	17	186
Invertebrates																	
Inland river prawn	<i>Macrobrachium</i> sp.	7	-	1	2	-	29	8	7	1	16	2	4	4	7	19	107
Powerful crayfish	<i>Euastacus valentulus</i>	2	-	-	-	-	-	1	2	2	-	2	-	-	-	-	9
Total		168	188	318	223	114	946	281	168	73	170	23	272	135	386	534	3999

Note: * indicates exotic species. ^indicates a stocked species.

Table 42: Results of the eDNA analysis from the September 2023 fish surveys

		Clarrie Hall Dam			Doon Doon Creek				Big Creek	Commissioners Creek			Tweed River			
Common name	Taxonomic name	CHD2	CHD2	DD5	DD4	DD3	MB1	DD2	DD1	BC1	CC1	CC2	TR1	TR2	TR3	BPV
Fish																
Agassiz's glassfish	<i>Ambassis agassizii</i>	ü	ü			ü	ü									
Australian bass	<i>Percalates novemaculeata</i>			ü	ü			ü					ü	ü	ü	ü
Australian smelt	<i>Retropinna semoni</i>		ü	ü	ü	ü	ü	ü	ü			ü	ü	ü	ü	ü
Bony bream	<i>Nematalosa erebi</i>															ü
Common carp*	<i>Cyprinus carpio</i>	ü	ü	ü	ü	ü	ü	ü		ü	ü	ü	ü	ü	ü	ü
Dwarf flathead gudgeon	<i>Philypnodon macrostomus</i>														ü	ü
Eastern gambusia*	<i>Gambusia holbrooki</i>	ü	ü		ü	ü	ü	ü		ü	ü					
Flathead gudgeon	<i>Philypnodon grandiceps</i>													ü		ü
Flyspecked hardyhead	<i>Craterocephalus stercusmuscarum</i>	ü	ü													
Freshwater catfish	<i>Tandanus tandanus</i>							ü								

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		Clarrie Hall Dam			Doon Doon Creek				Big Creek	Commissioners Creek			Tweed River			
Common name	Taxonomic name	CHD2	CHD2	DD5	DD4	DD3	MB1	DD2	DD1	BC1	CC1	CC2	TR1	TR2	TR3	BPW
Genus of carp gudgeons	<i>Hypseleotris</i> spp.	ü	ü	ü	ü	ü	ü	ü	ü		ü	ü	ü	ü		ü
Genus of pygmy perch	<i>Nannoperca</i> sp.														ü	
Genus of rainbowfish	<i>M. duboulayi</i> or <i>M. splendida</i>							ü					ü			
Genus of sleeper gobies	<i>Gobiomorphus</i> spp.		ü						ü	ü						
Longfin eel	<i>Anguilla reinhardtii</i>		ü	ü	ü	ü	ü	ü	ü	ü	ü		ü	ü		
Freshwater mullet	<i>Trachystoma petardi</i>			ü	ü								ü	ü	ü	ü
Sea mullet	<i>Mugil cephalus</i>			ü	ü								ü	ü	ü	ü
Shortfin eel	<i>Anguilla australis</i>				ü											ü
Mammals																
Platypus	<i>Ornithorhynchus anatinus</i>			ü		ü		ü	ü	ü	ü				ü	

Note: Bold/green indicates a listed species. * indicates exotic species.

Table 43: Survey results from fish surveys undertaken by DPI Fisheries, funded by the Recreational Fishing Trust

Common name	Taxonomic name	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Total
Agassiz's glassfish	<i>Ambassis agassizii</i>	2	-	1	-	1	-	-	-	4
Australian bass	<i>Percalates novemaculeata</i>	8	4	14	7	16	10	13	-	72
Australian smelt	<i>Retropinna semoni</i>	-	101	50	44	-	2	2	-	199
Carp gudgeon species complex	<i>Hypseleotris</i> spp.	785	-	802	1371	759	1138	-	-	4855
Eastern gambusia*	<i>Gambusia holbrooki</i>	1	33	-	-	9	-	6	6	55
Firetail gudgeon	<i>Hypseleotris galii</i>	-	567	-	-	-	-	2787	62	3416
Freshwater catfish	<i>Tandanus tandanus</i>	2	3	12	-	29	3	-	-	49
Longfin eel	<i>Anguilla reinhardtii</i>	-	-	-	-	-	2	-	-	2
Unspecked hardyhead	<i>Craterocephalus stercusmuscarum fulvus</i>	-	-	2	2	3	-	1	6	14
Western carp gudgeon	<i>Hypseleotris klunzingeri</i>	-	1	-	-	-	-	-	9	10
	Total	798	709	881	1424	817	1155	2809	83	8676

Note: * indicates exotic species.

Table 44: Results of the Targeted Oxleyan pygmy perch surveys undertaken in January 2024

Common name	Taxonomic name	Sites													Total
		PP1	PP4	PP5a	PP6	PP7	PP9	PP9a	PP10	PP13	PP16	PP21a	PP22a	PP23	
Fish															
Agassiz's glassfish	<i>Ambassis agassizii</i>	-	-	-	-	-	-	1	-	-	-	1	-	-	2

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Common name	Taxonomic name	Sites													Total
		PP1	PP4	PP5a	PP6	PP7	PP9	PP9a	PP10	PP13	PP16	PP21a	PP22a	PP23	
Carp gudgeon species complex	<i>Hypseleotris</i> sp.	40	59	40	59	1	-	66	78	136	200	65	-	37	781
Duboulayi rainbowfish	<i>Melanotaenia duboulayi</i>	-	-	-	3	-	-	-	-	-	-	1	-	-	4
Eastern gambusia*	<i>Gambusia holbrooki</i>	49	84	69	-	-	-	2	1 285	91	10	140	-	12	1 742
Longfin eel	<i>Anguilla reinhardtii</i>	-	4	-	-	23	-	1	2	4	-	-	7	2	43
Striped gudgeon	<i>Gobiomorphus australis</i>	25	-	-	-	-	-	46	-	10	-	-	12	102	195
Invertebrates															
Freshwater crayfish	<i>Euastacus valentulus</i>	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Total		114	148	109	62	24	0	116	1 365	241	210	207	19	153	2 768

Note: * indicates exotic species.

). Of the 5 species, only the platypus has been recorded in Clarrie Hall Dam, Doon Doon Creek, Commissioners Creek or the Tweed River in the last 20 years (Department of Environment and Heritage, 2023).

DPI Fisheries data indicates that the southern purple-spotted gudgeon has the potential to occur within, immediately upstream, or downstream of Clarrie Hall Dam, and therefore has the potential to be impacted by the Proposal. The likelihood of occurrence assessment is provided in Appendix L – Likelihood of occurrence, and summaries of the ecology of the two species with the potential to occur are provided in subsequent sections.

The potential distribution of the southern purple-spotted gudgeon and location of platypus records relative to the Proposal is shown in Figure 12 and the ecology of each species is provided in the following sections. The tests of significance for relevant species are provided in Appendix P – FM Act Significant Impact Assessments and Appendix Q – EPBC Act Significant Impact Assessments.

Table 16: Results of the desktop analysis and literature review including species, conservation listing and likelihood of occurrence (LoO).

Family	Common name	Scientific name	Data source				Conservation status		LoO
			DPI	BioNet	PMST	Lit.	FM Act	EPBC Act	
Fish									
Percichthyidae	Eastern freshwater cod	<i>Maccullochella ikei</i>	ü	ü	ü	ü	E	E	Negligible
Percichthyidae	Mary River cod	<i>Maccullochella mariensis</i>	-	-	ü	-	-	E	Negligible
Eleotridae	Southern purple-spotted gudgeon	<i>Mogurnda adspersa</i>	ü	-	ü	ü	E	-	Moderate
Percichthyidae	Oxleyan pygmy perch	<i>Nannoperca oxleyana</i>	-	ü	ü	-	E	E	Low
Mammals									
	Platypus	<i>Ornithorhynchus anatinus</i>	-	ü	-	ü	-	PL	Recorded

Note: LoO = likelihood of occurrence; E = endangered; PL = species is listed on the DCCEEW revised provisional list of animals requiring urgent management intervention.

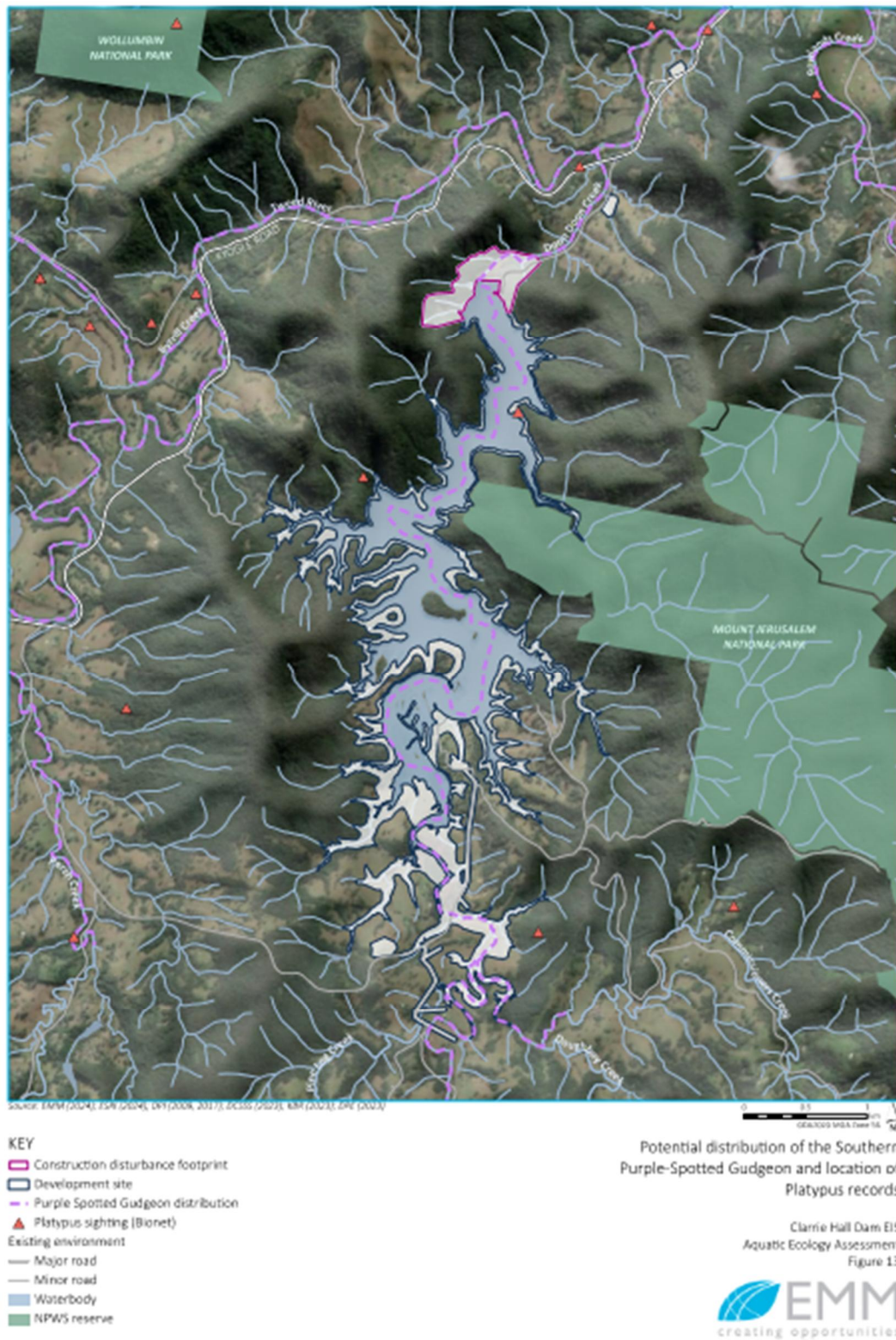


Figure 12: Potential distribution of the southern purple-spotted gudgeon and location of Platypus records

I. 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 of 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 to 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. Moderate quality habitat for the southern purple-spotted gudgeon is present within the study area. Based on the lack of habitat, the presence of exotic species known to degrade habitat for the southern purple-spotted gudgeon or compete for resources, and the lack of records, it is considered of moderate likelihood that the species is present in the vicinity of the study area (Table 16).

II. Eastern freshwater cod

The only known breeding population of the eastern freshwater cod is located in the Mann–Nymboida sub-catchment of the Clarence River (Department of Climate Change, Energy, the Environment and Water, 2023b). Previously, the species was also recorded in the Richmond and Brisbane rivers, where it is now considered extinct (Department of Climate Change, Energy, the Environment and Water, 2023b). It is now thought that there are fewer than 100 mature individuals in the wild. The eastern freshwater cod is known to prefer clear, rocky streams and rivers with low flow velocity and an abundant instream cover of hard structure such as rocks, timber or tussocks (Department of Climate Change, Energy, the Environment and Water, 2023b). The eastern freshwater cod is associated with the deeper parts of appropriate waterways, often near cover such as rocky islands, large boulders and pools in fast-flowing water. Large woody debris and overhangs are thought to provide shelter and important spawning sites (Department of Climate Change, Energy, the Environment and Water, 2023b). Females deposit eggs onto hard substrate such as rocks and hollow logs, the female leaves after the eggs are deposited, and the care of the nest is left exclusively to the male. Threats to the species include habitat degradation and the associated impacts such as sedimentation, large woody debris removal, changes to natural river flows, barriers to fish migration, removal of riparian vegetation and clearing (Department of Climate Change, Energy, the Environment and Water, 2023b). Despite the presence of appropriate habitat in the Tweed River and waterways associated with Clarrie Hall Dam, the restricted distribution of the species makes it unlikely the species occurs within the study area. As such, the likelihood of

occurrence is considered to be negligible (Table 16) and the species is not considered further in this report.

III. Mary River cod

The Mary River cod is found in south-east Queensland in the Mary River system. Typical habitat consists of deep, shaded, slow-flowing pools with an abundance of instream woody debris and log piles (Department of Climate Change, Energy, the Environment and Water, 2023c). The Mary River cod is a yellowish to pale green fish with a concave head profile and a protruding jaw (Simpson & Jackson, 1996). Mary River cod have been measured to 23.5 kg (Department of Climate Change, Energy, the Environment and Water, 2023c). The species form pairs and spawn annually around spring. The eggs are laid in logs, and the male guards the brood until they disperse to search for food (Department of Climate Change, Energy, the Environment and Water, 2023c). Despite the presence of appropriate habitat in the Tweed River and waterways associated with Clarrie Hall Dam, the restricted distribution of the species makes it unlikely the species occurs within the study area. As such, the likelihood of occurrence is considered to be negligible (Table 16) and the species is not considered further in this report.

IV. Oxleyan pygmy perch

The Oxleyan pygmy perch has a patchy distribution and is confined to dystrophic, freshwater systems draining through sandy coastal lowlands, swamps, streams, lakes of coastal 'wallam' heaths, also known as Banksia-dominated heathlands between north-eastern NSW and south-eastern Queensland (Department of Climate Change, Energy, the Environment and Water, 2023d; Department of Primary Industries, 2005). In NSW the species has never been recorded north of the Richmond River (Department of Primary Industries, 2005). Specific habitat requirements include slow-moving, fresh, acidic waters with abundant vegetation (Department of Climate Change, Energy, the Environment and Water, 2023d; Department of Primary Industries, 2005). The Oxleyan pygmy perch is a small, brown to olive-coloured fish with a distinctive orange-rimmed, black spot at the base of the tail (Department of Primary Industries, 2005). There is potential for appropriate habitat to occur within the study area, and the study area is within the historical range for the species (Department of Primary Industries, 2005). However, given there is a lack of records in the area, the likelihood of occurrence is considered to be low (Table 16).

V. Platypus

Platypuses inhabit a variety of freshwater streams throughout eastern Australia (Grant, 1992). The platypus was recently listed as 'near threatened' by the International Union for the Conservation of Nature (IUCN) (Woinarski, et al., 2014; Woinarski & Burbidge, 2016) and 'vulnerable' in Victoria. As an apex predator in Australian aquatic ecosystems, platypuses are vulnerable to a number of threatening processes that may degrade their habitats or reduce the availability of macroinvertebrate food

resources. Threats include a reduction of available surface water through drought, water extraction or diversion, changes to flow regimes, clearing riparian and broader catchment vegetation, poor water quality, barriers to dispersal, entanglement in litter or fishing equipment, and predation (Grant & Temple-Smith, 2003). Platypuses are highly mobile, with individual home ranges and daily movements encompassing several kilometres (Gust & Handasyde, 1995; Griffiths, et al., 2014; Kelly, et al., 2012; Serena, et al., 1998; Otley, et al., 2000). Densities are roughly estimated at 1 to 2 per kilometre in a small creek around Melbourne (Serena, et al., 1998). Platypuses require adequate surface water, flow regimes and habitat to support sufficient food resources of macroinvertebrate prey. Platypuses are adapted to feed exclusively in water where they forage for a range of benthic macroinvertebrates. Adults consume approximately 15–30% of their bodyweight daily (Krueger, et al., 1992; Holland & Jackson, 2002). Other habitat variables known to be important for platypuses include large riparian trees, undercut vegetation, pools 1 to 3 m deep, and near vertical or undercut banks at least 0.5 m above the water (Serena, et al., 1998; Ellam, et al., 1998; Bethge, et al., 2003; Grant, 2004; Serena, et al., 2001; Worley & Serena, 2000). Reproduction in the platypus has been linked with rainfall (and presumably reliable flows) in the months preceding breeding (August to December) (Serena, et al., 2014; Grant & Temple-Smith, 1998). Whilst various individual councils across Australia have prepared recovery plans for the platypus, no formal, overarching recovery plan for it has been prepared at the state or federal level. Given the previous records for the species within the study area, the likelihood of occurrence is considered 'known' for the platypus (Table 16).

9.1.1. Groundwater-dependent ecosystems

A detailed groundwater assessment has been prepared by EMM Consulting Pty Limited as part of the EIS process – the *Groundwater Impact Assessment: Clarrie Hall Dam Raising* (EMM Consulting Pty Limited, 2024b).

The report states that 'with the exception of a stand of River Oak in the construction footprint, impacts to potential GDEs are not anticipated due to the Proposal. The risk ranking for all potential groundwater impacts is low.' (EMM Consulting Pty Limited, 2024b).

The report also states that 'a Water Management Plan (WMP) will be developed for the Proposal.' (EMM Consulting Pty Limited, 2024b).

The *Groundwater Impact Assessment: Clarrie Hall Dam Raising* (EMM Consulting Pty Limited, 2024b) provides further details.

10. Field survey results

10.1. Habitat characterisation

10.1.1. Key fish habitat

The results of the key fish habitat assessments undertaken at 15 sites (Figure 2; Table 30) (Appendix C - Field survey design) during the September 2023 field survey are discussed below. General habitat characteristics of each site are summarised in Table 31 (Appendix D – Habitat characteristics).

All 15 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 (e.g. southern purple-spotted gudgeon). It should be noted that classifications based on these features are considered conservative, as many sites were generally defined by a cleared riparian zone; and structures providing in-stream habitat comprised relatively sparse large snags and aquatic plants.

Fish habitat was present at all sites and included instream woody debris (snags), macrophytes, trailing bank vegetation, hard substrate (boulders) and undercut banks (Table 31).

Many sites were subject to pressures from surrounding land use, with the dominant pressures being agricultural in nature. Examples of pressures observed during the September 2023 surveys include clearing of the riparian zone, grazing, uncontrolled stock access and forestry activities (Table 31).

10.1.2. Oxleyan pygmy perch habitat characterisation

Habitat characteristics were recorded for all sites surveyed during the January 2024 targeted Oxleyan pygmy perch surveys. Descriptions are shown in Table 32 and site photos are shown in Appendix M – Site photographs.

10.2. In situ water quality

In situ water quality parameters were measured at each survey site (Figure 2; Table 30) (Appendix C - Field survey design). Measured water quality parameters are shown in (Table 17). In situ water quality provides a 'snapshot' of water quality at a specific moment in time. In situ water quality parameters have not been compared to the ANZECC and ARMCANZ (2000) trigger values or to the DGVs (Water Quality Australia, 2018).

Temperature ranged from 16.8 °C (DD5) to 26.4 °C (BC1) and is likely a reflection of season, climate, flow, depth and elevation (Table 17). Dissolved oxygen (mg/L; per cent) ranged from 5.5 mg/L, 60.9% (TR3) to 10.08 mg/L, 117.7% (MB1), and is likely to be a reflection of temperature, flow, presence/absence of instream vegetation and algae (Table 31). Conductivity ranged from 96.4 µS/cm (DD5) to 177.4 µS/cm, and all sites should be considered fresh (Hammer, 1986). pH ranged from 6.31 (CC1) to 7.87 (MB1), ranging from acidic to alkaline depending on the site (Foged, 1978). The pH is often a reflection of surrounding land use and soil type. Turbidity ranged from 1.24 NTU (CHD2 and CC2) to 13.3 NTU (TR2). All sites are considered to be of 'low turbidity'. Alkalinity ranged from 35 mg/L (DD1) to 70 mg/L (CHD1) (Table 17). Alkalinity is a measure of a waterway's ability to buffer against acidic conditions.

In situ water quality parameters were measured at each survey site during the January 2024 targeted Oxleyan pygmy perch surveys (

; Table 18). Measured water quality parameters are shown in (Table 18). In situ water quality parameters have not been compared to the ANZECC and ARM CANZ (2000) trigger values or to the DGVs (Water Quality Australia, 2018).

Temperature ranged from 22.8 °C (PP7) to 31.5 °C (PP21a) and is likely a reflection of season, climate, flow, depth and elevation (Table 18). Dissolved oxygen (mg/L; per cent) was low to moderate across all sites, ranging from 0.8 mg/L; 10.1% (PP13) to 6.13 mg/L; 74.3% (PP22a) and is likely to be a reflection of temperature, recent flood conditions, lack of flow, presence/absence of instream vegetation and algae (Table 18). Conductivity ranged from 84.9 µS/cm (PP9) to 199.8 µS/cm (PP23), and all sites should be considered fresh (Hammer, 1986). The pH ranged from 6.26 (PP13) to 7.28 (PP22a), ranging from acidic to alkaline depending on the site (Foged, 1978). Turbidity ranged from low to high turbidity depending on the site. Turbidity ranged from 2.96 NTU (PP7) to 33.9 NTU (PP16).

Table 17: In situ water quality parameters measured during the September 2023 surveys

Site	Temp (°C)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (%)	Specific conductivity @ 25°C (µS/cm)	Conductivity (µS/cm)	pH	Turbidity (NTU)	Alkalinity (mg/l)
DD3	22.9	8.78	99.7	182.3	174.9	7.25	4.73	70
CHD2	22.1	7.70	87.7	109.7	103.1	6.93	1.24	50
DD1	24.5	7.92	94.8	137.8	136.3	7.56	9.47	35
DD2	24.8	8.25	98.5	170.7	169	7.59	11.7	38
DD4	18.2	8.61	89.7	113.6	98.9	7.36	6.01	40
DD5	16.8	7.77	78.8	114.2	96.4	7.2	4.12	40
MB1	23.9	10.08	117.7	181.1	177.4	7.87	4.35	50
BPW	19.0	6.22	67.8	194.9	172.5	7.47	5.14	55
TR1	21.2	9.73	100.0	169.2	157	7.61	7.25	60
TR2	22.9	6.68	82.8	168.8	161.9	7.48	13.3	60
TR3	20.3	5.5	60.9	176.9	161	7.7	6.17	60
CHD1	21.1	8.40	94.3	110.2	102.1	7.09	1.43	50
CC1	18.2	6.52	70.4	117.6	102.4	6.31	3.81	60
CC2	18.9	7.43	79.0	129.3	114.4	7.42	1.24	60
BC1	26.4	7.04	87.9	117.5	120.8	7.25	8.77	40

Table 18: In situ water quality parameters measured during the January 2024 targeted Oxleyan pygmy perch surveys

Site	Temp (°C)	Dissolved oxygen saturation (%)	Dissolved oxygen (mg/L)	Conductivity (µS/cm)	Specific conductivity @ 25°C (µS/cm)	pH	Turbidity (NTU)
PP1	24	20.6	1.71	118.5	119.1	6.51	8.73
PP4	24.7	53.6	4.51	123.3	124.1	6.94	8.73
PP5a	23.6	59.5	4.96	92.9	95.8	6.44	12.2
PP6	23.4	34.1	3.54	124.6	128.4	6.37	8.2
PP7	22.8	67.6	5.86	120.7	126	6.37	2.96

Site	Temp (°C)	Dissolved oxygen saturation (%)	Dissolved oxygen (mg/L)	Conductivity (µS/cm)	Specific conductivity @ 25°C (µS/cm)	pH	Turbidity (NTU)
PP9	29.4	65.2	4.73	84.9	78.4	6.5	16.6
PP9a	24.6	26.6	2.18	165.2	166.7	6.41	8.59
PP10	27.3	21.4	1.62	118.5	113.6	6.62	18.3
PP13	27.8	10.1	0.8	122.4	116.2	6.26	23.8
PP16	27.2	49.2	3.91	90.4	86.7	6.54	33.9
PP21a	31.5	64.5	4.75	110.8	98.6	6.72	9.08
PP22a	25.1	74.3	6.13	150	149.8	7.28	3.78
PP23	25.5	11.2	0.87	199.8	197.7	6.49	5.32

10.3. Water quality

Surface water quality samples were collected at each of 15 sites (Figure 2; Table 30) and analysed in the laboratory. All water quality results are presented in Table 36 (Appendix F – Water quality (field assessment)). Water quality parameters were compared to the ANZECC and ARMCANZ (2000) trigger values for slightly disturbed ecosystems in south-eastern Australian (freshwater lakes and reservoirs or lowland rivers where applicable). Metals and metalloids were compared to the DGVs for the protection of 80% of species representative of highly disturbed systems (Water Quality Australia, 2018). It should be noted that water quality was collected as a 'one-off' event and that water quality should be monitored for a period of time before it can be accurately compared to the ANZECC and ARMCANZ (2000) trigger values. Comparisons to the ANZECC and ARMCANZ (2000) trigger values should be taken as indicative only.

During the September 2023 field survey, the pH of surface water ranged from circumneutral (pH 6.89 at DD5 – Doon Doon Creek) to alkaline (pH 8.08 at TR1 – Tweed River) (Table 36). No sites were outside the trigger values for the ANZECC and ARMCANZ (2000) guideline trigger values. The pH is often driven by surrounding land uses and soil type.

Total dissolved solids (TDS) ranged from 65 mg/L (DD5) to 123 mg/L (BPW) (Table 36). Typically, water can be considered potentially corrosive if it has a TDS concentration of less than 50 mg/L, or 'hard' if it has a TDS concentration of over 250 mg/L (Water Research Center, 2023).

Conductivity (salinity) ranged from 108 µS/cm (CHD1) to 184 µS/cm (BPW). Conductivity fell outside the ANZECC and ARMCANZ (2000) guideline trigger values at all sites (Table 36). Overall, salinity measured higher in the Tweed River than all other waterbodies, followed by Clarrie Hall Dam and then Doon Doon Creek. Sites within the Tweed River averaged 176.5 µS/cm, compared to 144.5 µS/cm at Clarrie Hall Dam and 134 µS/cm at Doon Doon Creek. Big Creek recorded 114 µS/cm and Commissioners Creek averaged 121 µS/cm per site (Table 36).

Contributing to salinity, the major ions recorded in surface water included sodium, calcium, potassium, magnesium, chloride and sulphate, with sodium and chloride the dominant ions. 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, et al., 2014).

Dissolved oxygen concentrations were within the allowable values for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs) but exceeded the ANZECC and ARMCANZ (2000) guideline trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers) at McCabes Bridge, the Tweed River, DD4 on Doon Doon Creek and Commissioners Creek (Table 36). Concentration of dissolved oxygen is known to vary with water temperature, salinity, photosynthetic activity and microbial activity, and over short time periods of as little as 24 hours, particularly in systems where there is significant nutrient enrichment. Temperatures were generally moderate to high across all waterways (Table 36). Seasonal variation and the time of the day that sites were sampled during the field survey likely contributed to the range of temperatures and dissolved oxygen observed between sites.

Surface water turbidity was consistently low across sites and waterways (Table 36). Turbidity concentrations fell below the acceptable limits for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs) in Clarrie Hall Dam (CHD2). Turbidity was also below the acceptable limits for slightly disturbed ecosystems in south-east Australia (lowland rivers) at all river or stream sites (Table 36). Most Australian inland waters can experience naturally high turbidity due to extremely old land masses and highly clayey soils; extensive clearing for widespread agricultural land uses in the locality is likely to contribute to higher turbidity concentrations likely observed in wetter years.

Concentrations of total nitrogen ranged from 0.1 mg/L (TR1 and DD5) to 4.6 mg/L (CC2) and can be considered low (Table 36). All sites fell below the ANZECC and ARMCANZ (2000) guideline trigger values for the relevant site (Table 36). Nitrogen concentrations are typically driven by surrounding land uses, levels of runoff and microbial action within waterways.

Concentrations of total phosphorus across all sites were within ANZECC and ARMCANZ (2000) guideline trigger values ranging from below the detectable limit at CHD2 and CHD1, to 0.83 mg/L at Big Creek (Table 36). Like nitrogen, phosphorous concentration is driven by surrounding land uses and levels of runoff. High phosphorus concentrations are strongly associated with algal blooms.

Concentrations of dissolved metals and trace elements were generally either below the analytical limit of reporting or within ANZECC and ARMCANZ (2000) DGVs, except chromium at TR3 (0.008 mg/L), copper concentration 0.032 at DD3 and nickel (0.671 mg/L at DD3) (Water Quality Australia, 2018) (Table 36).

10.4. Sediment quality

During the September 2023 field survey, sediment pH ranged from 5.1 (CHD2) to 7.0 (DD2) (Table 37) (Appendix G – Sediment quality (field assessment)) and can be classified as ranging from mildly acidic to neutral (Hazelton & Murphy, 2007). 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 (Zhang, et al., 2014).

- Salinity (measured as conductivity standardised at 25°C) ranged from 5.0 µS/cm (CHD2, DD4, CC1 and CHD1) to 46.0 µS/cm (CC2) (Table 37). The low salinity concentrations are likely attributed to water volume and flow, and runoff from surrounding agricultural areas. Low salinity concentrations as shown on both the water quality results (Table 37) and sediment quality results (Table 37) can be considered 'fresh' (Hammer, 1986).
- Sodium was the dominant ion recorded in sediment; however, all ions showed low concentrations across all sites, with many ion concentrations below the detectable limit (Table 37). The moisture content of sediment ranged from 6.1% (DD3) to 75.7% (CC2) across sites (Table 37). Sediment was typically composed of sand with coarse gravel and silt.
- Sediment concentrations of total nitrogen ranged from 40 mg/kg (DD3) to 1,980 mg/kg (CC2) (Table 37). Total phosphorus concentrations ranged from 96 mg/kg (CHD1) to 1,130 mg/kg (BPW) (Table 37). These concentrations are attributed to the dominant land use of the surrounding area being widespread agriculture, as well as the absence of a riparian zone at a number of survey sites (Figure 2; Table 31). 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 (Schachtschneider, et al., 2017). Land use around CC2 is agricultural, with the riparian zone predominantly absent (Figure 2; Table 31). During the surveys it was noted that there was a strong sewage smell between sites CC2 and CC1 on Commissioners Creek, and algal abundance was extremely high. An orchard on large, manicured lawns was present in the vicinity of CC2 – runoff containing fertiliser may be responsible for the elevated nitrogen levels. 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 (Shaughnessy, et al., 2019).

- Phosphorous concentrations were elevated at the Bray Park Weir, which is attributed to surrounding land use; however, it is possible that nutrients and metals are also transported from upstream settle-out and deposited into the sediment at the weir.
- The concentration of metals was variable across sites during the September 2023 field survey; however, 8 parameters were detected in concentrations higher than the DGVs for the protection of 80% of species representative of highly disturbed systems at one or more sites (aluminium, total chromium, trivalent chromium, cobalt, copper, lead, vanadium and zinc) (Table 37). 3 parameters were below the limit of analytical reporting at all sites (nitrite, cadmium and hexavalent chromium) (Table 37). Concentrations of metals within sediments were frequently substantially higher than the DGVs for the protection of 80% of species representative of highly disturbed systems at those sites where the DGVs were exceeded (Water Quality Australia, 2018) (Table 37). The origin of the elevated metals concentrations is not currently known.

10.5. Algae and macrophytes

10.5.1. Phytoplankton

A total of 77 taxa were identified from the phytoplankton (free-floating algae) assemblage in the surface water at 15 sites during the September 2023 survey (Table 38) (Appendix H – Phytoplankton (field assessment)). This included representatives from 8 phyla; Bacillariophyta (diatoms), Chlorophyta (green algae), Cyanophyta (blue-green algae), Chrysophyta (golden algae), Cryptophyta (cryptomonads), Pyrrophyta (dinoflagellates), Xanthophyta (yellow-green algae) and Euglenophyta (euglenida). One taxa was unidentified. The diversity and abundance of algal taxa was variable between sites, ranging from 11 taxa to 25 taxa and from 618 cells/ml to 28,612 cells/ml (Table 38). The lowest diversity was recorded at Big Creek (BC1) and the Tweed River (TR2) (11 and 12 taxa, respectively) and the highest at Clarrie Hall Dam (CHD2) (25 taxa). Doon Doon Creek (DD4 and DD3) recorded the second-highest diversity, supporting 23 taxa at each site (Table 38). The 2 sites at Clarrie Hall Dam (CHD2 and CHD1) supported the highest abundance of algal cells with 28,612 cells/ml at CHD2 and 27,079 cells/ml at CHD1). Site DD1 on Doon Doon Creek supported the lowest abundance of algae, with 618 cells/ml. Algal abundance was also low at TR1 (724 cells/ml) and CC1 (752 cells/ml) (Table 38).

The majority of taxa recorded during the surveys belonged to the Chlorophyta (30 taxa), while the Bacillariophyta accounted for 21 taxa, Cyanophyta for 20 taxa, Chrysophyta and Euglenophyta for 2 taxa each and Cryptophyta, Pyrrophyta and Xanthophyta for 1 taxon each. The unidentified taxa also accounted for 1 taxa (Table 38). Of the Euglenophyta, *Trachelomonas* was the most abundant and was recorded at 4 sites (Table 38). *Trachelomonas* is considered common and is known to be limited by increased salinity (Wolowski & Grabowska, 2007).

Of the Cyanophyta, *Trichodesmium* spp. was the most abundant and was recorded at 4 sites; however, the most widespread genera of the Cyanophyta were the *Phormidium* and the *Dolichospermum* (straight small), both of which were recorded at 7 sites each (Table 38). The *Phormidium* and *Dolichospermum* genera are both known to contain species that produce anatoxin and can be bloom-forming (Humbert, 2009). Of the Bacillariophyta, *Urosolenia* was the most abundant and were recorded at 3 sites only. The most widespread of the Bacillariophyta was the *Nitzschia* genus, which occurs in fresh, estuarine, marine and hypersaline conditions and is considered to be widespread genus across Australia (McCarthy, 2013). However, the highest diversity is usually associated with fresh waters (John, 2000). Of the Chrysophyta, the *Synura* was most abundant, with 110 cells recorded across 2 sites (Table 38). The Synurophyceae are characterised by chloroplasts that have 4 surrounding membranes. Three genera of Synurophyceae are known internationally, while an additional genus is found in Australia only. Synurophytes such as *Synura* are exclusively found in freshwater, specifically in lakes, ponds and slow-flowing waterways (Sheath & Wehr, 2003). Of the Euglenophyta, *Trachelomonas* was the most abundant and was recorded at 4 sites (Table 38). *Trachelomonas* is a relatively common genus of the Euglenophyta, which has been recorded around the world in freshwater habitats (Wolowski & Grabowska, 2007). Of the Chlorophyta, *Coenochloris* was the most abundant genus, found in higher abundances than any other taxa recorded during the surveys, but recorded in 2 waterways only including all sites on Clarrie Hall Dam and one site on Doon Doon Creek (DD3) (Table 38). Although recorded in lower numbers, Phytoflagellates were the most widespread of the Chlorophyta and were recorded at 9 out of 15 sites (Table 38). *Coenochloris* is a freshwater species (Guiry & Guiry, 2018). This species is common throughout the world as plankton in environments such as ponds, eutrophic lakes, occasionally oligotrophic lakes, slow-flowing rivers, and swamps (Kim, 2013). Phytoflagellates tend to be associated with slower waters where they can utilise their flagella. Phytoflagellates are often found in areas of dense macrophyte beds (Pelechata, et al., 2020). Only one taxon was recorded for the *Cryptophyta*, *Pyrrophyta* and *Xanthophyta* and all in low abundances (Table 38).

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

10.5.2. Macrophytes

A total of 22 macrophytes from 13 families were recorded across 15 sites during the September 2023 survey (Table 39) (Appendix I – Macrophytes (field assessment)). A total of 17 native species of macrophyte and 5 exotic species of macrophyte were recorded across all sites. All sites supported macrophytes (Table 39). Diversity and abundance vary between sites, with CHD2 supporting 10 species of macrophyte, MB1 supported 9 species, DD4 supported 7, down to 1 species at BPW (Table 39). Exotic species were more common in Clarrie Hall Dam; however, all waterways except Commissioners Creek and Big Creek supported exotic species. It is highly likely that both Commissioners Creek and Big Creek support exotic species; however, the lower number of survey sites

on those waterways increase the likelihood that exotic species were not detected despite their presence in the waterway.

- Knotweed (*Persicaria* sp.) and nutsedges (*Cyperus* sp.) were the most widespread species – both were recorded at 9 sites (Table 39). Knotweed species were absent from all sites at Clarrie Hall Dam but present at all other waterways. Knotweed is a common aquatic herb that prefers damp to wet habitats (Sainty & Jacobs, 2003). *Cyperus* sp., a potential exotic, was detected at all waterways except Big Creek and Commissioners Creek (Table 39). Plants in the genus *Cyperus* may prefer wet or dry soils depending on the species (Sainty & Jacobs, 2003).
- *Nymphoides* sp. was detected at all waterways except Big Creek and Commissioners Creek (Table 39). *Nymphoides* is a wetland specialist (Sainty & Jacobs, 2003).
- *Nastrurtium* sp. was recorded in Doon Doon Creek and Big Creek only (Table 39). *Nastrurtium* is known to prefer slow-flowing waters in creeks, drains and lakes, and particularly those waters with a high nutrient loading (Sainty & Jacobs, 2003).
- Softstem bulrush (*Schoenoplectus tabernaemontani*) was recorded in Doon Doon Creek only (Table 39). Softstem bulrush prefers the margins of slow-moving waters and swamps and has been recorded in all states except the Northern Territory (Sainty & Jacobs, 2003).
- *Carex* sp. was recorded at McCabes Bridge and on Commissioners Creek only (Table 39). Australia supports approximately 85 species of *Carex* and has been recorded in all states except the Northern Territory (Sainty & Jacobs, 2003).
- *Ludwigia* sp. was detected at Clarrie Hall Dam and Doon Doon Creek only (Table 39). *Ludwigia* sp. prefers slow or stationary waters, creek banks or swamps (Sainty & Jacobs, 2003).
- Cabomba (*Cabomba caroliniana*) was recorded in Clarrie Hall Dam and Doon Doon Creek only (Table 39). Cabomba is considered a weed of national significance (WoNS). Severe infestations of this species are known from the Tweed River near Murwillumbah (Department of Primary Industries, 2023d).
- Yellow waterlily (*Nymphaea Mexicana*) was detected at one site on Clarrie Hall Dam only (Table 39). Yellow waterlily is considered an exotic in Australia and can form dense infestations on waterways that reduce water quality and outcompete native plants (Department of Primary Industries, 2023f).
- Cumbungi (*Typha* sp.) was recorded at one site in Clarrie Hall Dam only (Table 39). Cumbungi is a common species in Australia and can form dense stands of vegetation (Sainty & Jacobs, 2003).

- *Eleocharis* sp. was recorded at both sites on Clarrie Hall Dam (Table 39). *Eleocharis* sp. is a common wetland species in Australia and is often found in or alongside perennial wetlands (Sainty & Jacobs, 2003).
- *Juncus* sp. was recorded on Doon Doon Creek, Big Creek and the Tweed River during the September 2023 surveys (Table 39). Approximately 68 species of *Juncus* occur in Australia across all states (PlantNET, 2022).
- *Azolla* sp. was recorded at on site on Clarrie Hall Dam only (Table 39). *Azolla* sp. is a species of free-floating fern that prefers slow or still waters. At least one species of *Azolla* has been recorded in each state (Sainty & Jacobs, 2003).
- *Salvinia* (*Salvinia molesta*) is a WoNS and can form dense mats that can smother the surface of the water (Department of Primary Industries, 2023c). *Salvinia* was recorded in Clarrie Hall Dam and Doon Doon Creek only (Table 39).
- Milfoils (*Myriophyllum*) occurs in freshwater and can provide shelter for eggs and juvenile fish (PlantNET, 2023). Milfoil was recorded in Clarrie Hall Dam and Doon Doon Creek only (Table 39).

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

10.6. Aquatic invertebrates

10.6.1. Edge habitat results

A total of 52 taxa were identified from the aquatic invertebrate assemblage within edge habitat within the Tweed River, Big Creek, Doon Doon Creek and Commissioners Creek during the September 2023 field survey (Table 40) (Appendix J – Macroinvertebrates (edge habitat)). Where site names show an 'A' or a 'B', the site has been sampled twice (Table 40). The most diverse taxa were those belonging to the order Odonata (dragonflies and damselflies), recording taxa from 10 different families (Table 40). Although the most diverse order, the Odonata were the fifth most abundant order recorded across all sites surveyed within edge habitat (Table 40). The most dominant order recorded in edge habitat was the Diptera (flies and mosquitos), with 257 individuals recorded from 6 taxa (Table 40). The Ephemeroptera (mayflies) and the Hemiptera (true bugs) were the next most abundant orders, with 211 individuals from 4 taxa, and 196 individuals from 4 taxa respectively (Table 40).

Diversity varied between sites, with CC2 (Commissioners Creek) and TR1 (Tweed River) supporting the highest diversity: 23 taxa were recorded at each site (Table 40). BC1 (Big Creek), CC1B (Commissioners Creek), DD2A (Doon Doon Creek) and DD5 (Doon Doon Creek) were the next most abundant sites, supporting 21 taxa each (Table 40). All other edge habitat sites supported less than 20

taxa. No taxa was recorded at all sites; however, the Atyidae and the Leptoceridae were both recorded at 14 out of 15 edge habitat sites, the Chironominae and the Tanypodinae were recorded at 13 out of 15 edge habitat sites, and the Gomphidae were recorded at 12 out of 15 edge habitat sites (Table 40).

Aquatic invertebrate abundance was variable within edge habitat sites, ranging from 30 individuals (DD2, BPW1 and BC1) to one individual (all sites) with the dominant taxa within edge habitat sites including the Corixidae (135 individuals), Leptophlebiidae (128 individuals), Leptoceridae (125 individuals) and Chironominae (120 individuals) (Table 40).

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

The State of the Catchments (SOTC) for the Northern Rivers region reports that macroinvertebrate condition for the Tweed River catchment ranged from moderate to very good, with the overall Northern Rivers catchment macroinvertebrate condition 'good' (Department of Environment, Climate Change and Water, 2010c).

Taxa with a > 0.5 probability of occurrence provide the best compromise between predicting taxa that are unlikely to occur at a site, regardless of aquatic health, and predicting taxa that will occur even at moderately impacted sites. Therefore, the results based on observed and expected scores represent the best way to assess the data to detect impacts on aquatic health. A score of anything below one is representative of a less than expected score and may indicate disturbance or pollution impacts. The sites for Commissioners Creek (CC1 and CC2) had lower OE50 (number of families), OE50 (signal) and EPT number of families present, which suggests that there was evidence of disturbance or pollution at these sites (Table 19). A large amount of algae was observed at CC1 and may represent impacts from pollution in the form of nutrient enrichment. Doon Doon Creek below the dam wall (DD4) is impacted by flow mitigation as a result of the dam and is likely temperature stressed as a result of controlled discharges from the dam. These impacts are reflected in the lower OE50 (number of families) and OE50 (signal) scores.

Sites lower in the catchment below TR2 had lower OE50 (number of families) and scores, and number of EPT families, while the OE50 (Signal) scores remained close to one. This suggests that the more sensitive taxa were still present, but the invertebrate diversity had declined, which is to be expected given these sites fall within the weir pool habitat provided by the Bray Park Weir.

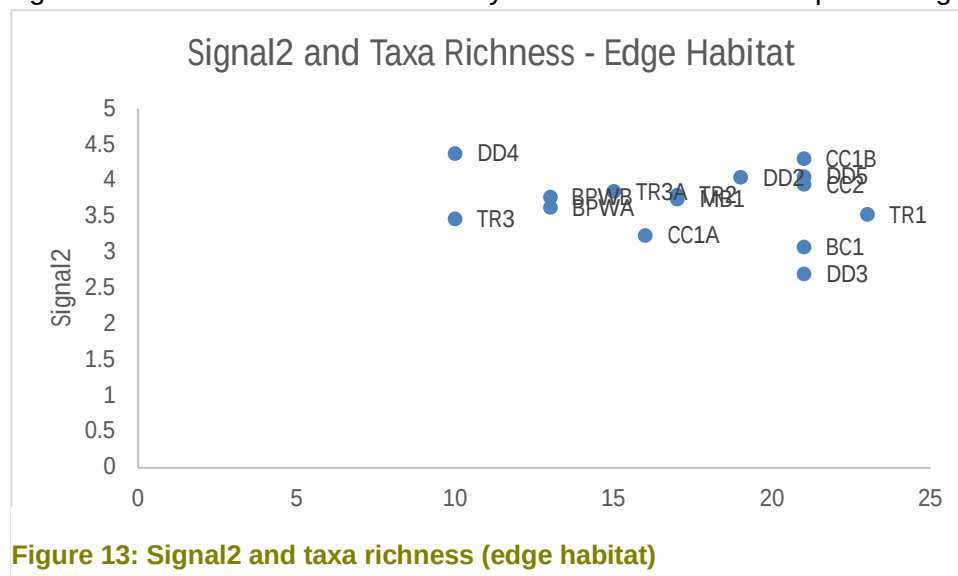
The above observations are broadly reflected in the AUSRIVAS banding scores, with lower scores at sites lower down the catchment and at the site immediately below the dam wall DD4.

Table 19: AUSRIVAS modelling results for edge samples collected from Clarrie Hall Dam EIS sites. Data is presented from furthest upstream to furthest downstream sites

Site	Number of families	OE50 (number of families)	OE50 Signal	Signal 2	EPT	Band
CC2	21	0.86	0.88	3.947368	1	A
CC1A	16	0.78	0.90	3.238095	2	B
CC1B	21	0.86	0.84	4.304348	2	A
BC1	21	1.01	0.91	3.076923	5	A
DD2	19	0.78	0.97	4.047619	5	B
DD3	21	0.94	0.95	2.7	7	A
MB1	17	0.98	0.94	3.73913	5	A
Clarrie Hall Dam						
DD4	10	0.46	0.74	4.380952	0	C
DD5	21	0.9	1.00	4.058824	6	A
TR1	23	0.91	0.96	3.529412	4	A
TR2	17	0.66	0.89	3.8	2	B
TR3	10	0.4	1.05	3.466667	1	C
TR3A	15	0.53	0.99	3.846154	2	B
BPWA	13	0.4	0.94	3.625	2	C
BPWB	13	0.4	1.17	3.769231	1	C

Note: Where an A and B is presented in the table it indicates that 2 edge samples were collected from the site. Orange shading indicates that the model results are nearly outside of the experience of the model.

Whilst SIGNAL2 scores give an indication of water quality in the river from which the sample was collected, combining the score with the richness score (how many different macroinvertebrate families are present), can provide an indication of the types of pollution and other physical and chemical factors that are affecting the macroinvertebrate community. This is shown in the plot in Figure 13, where



quadrant boundaries are defined according to Chessman (2003). The top right quadrant contains the healthiest sites, and the bottom left quadrant containing sites that may be subject to urban, industrial or agricultural pollution or the downstream effect of dams. Often the number of sensitive taxa present (EPT) can help to define quadrant boundaries but there is a mix across all sites for the current survey. Higher macroinvertebrate diversity was associated with higher numbers of sensitive taxa (EPT). The macroinvertebrate data collected provides a baseline data set that may assist with future waterway monitoring including monitoring the impacts of the Proposal.

10.6.2. Riffle habitat results

A total of 52 taxa were identified from the aquatic invertebrate assemblage within riffle habitat within the Tweed River, Doon Doon Creek and Commissioners Creek during the September 2023 field survey (Table 20). The most diverse taxa were those belonging to the order Diptera (flies and mosquitos), recording taxa from 12 different families (Table 20). Although the most diverse order, the Diptera were the third most abundant order recorded across all sites surveyed within riffle habitat (Table 20). The most dominant order recorded in riffle habitat was the Ephemeroptera (mayflies), with 357 individuals recorded from 4 taxa (Table 20). The Trichoptera (caddisflies) were the second most abundant order, with 291 individuals recorded within riffle habitat (Table 20), followed by the Diptera (267 individuals) and the Odonata (dragonflies and damselflies) (122 individuals). The abundance of all other orders fell below 100 individuals across all sites (Table 20).

Diversity varied between sites – CC2 (Commissioners Creek) and MB1 (Doon Doon Creek) supported the highest diversity, with 27 taxa recorded at each site (Table 20). BC1 (Big Creek) and DD2 (Doon Doon Creek) each supported 25 taxa, and DD2A (Doon Doon Creek) was the next most abundant site, supporting 24 taxa (Table 20). TR1 (Tweed River) supported 21 taxa, and DD5 (Doon Doon Creek) and TR2 (Tweed River) supported 20 taxa each. All other riffle habitat sites supported less than 20 taxa (Table 20). The Orthocladiinae, Baetidae, Hydrobiosidae and Hydropsychidae were the only taxa to be recorded at all riffle habitat sites (Table 20).

Aquatic invertebrate abundance was variable within riffle habitat sites, ranging from 48 individuals (DD2) to one individual (all sites) with the dominant taxa within edge habitat sites including the Leptophlebiidae (204 individuals), Hydropsychidae (154 individuals) and Orthocladiinae (127 individuals). All other taxa supported fewer than 100 individuals (Table 20).

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

Table 20: Aquatic invertebrate taxa recorded in riffle habitat during the September 2023 field survey

Taxonomic name	BC1	CC2	DD2	DD2A	DD4	DD5	MB1	TR1	TR2	Total
Acarina										
Mites	6	2	6							14

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Taxonomic name	BC1	CC2	DD2	DD2A	DD4	DD5	MB1	TR1	TR2	Total
Amphipoda										
<i>Talitridae</i> sp.	2									2
Coleoptera										
<i>Dytiscidae</i>							3			3
<i>Elmidae</i>		1	4	1		1	1	3	2	13
<i>Gyrinidae</i>							1			1
<i>Hydrophilidae</i>			1	1						2
<i>Scirtidae</i> sp.		1		1			1			3
Decapoda										
<i>Atyidae</i>				1	2	1			6	10
<i>Palaemonidae</i>								2		2
Diptera										
<i>Athericidae</i>	3	7	1	3						14
<i>Ceratopogonidae</i>		3	2				1			6
<i>Chironominae</i>	13		2	1	10	1	5		2	34
<i>Culicidae</i>		2								2
<i>Dixidae</i>	4	7		1						12
<i>Dolichopodidae</i>				1			4			5
<i>Empididae</i>						1				1
<i>Muscidae</i>							1			1
<i>Orthoclaadiinae</i>	18	27	7	2	23	15	16	13	6	127
<i>Simuliidae</i>	16			3	1	1	14		1	36
<i>Tanypodinae</i>	2	4		3		2	2	1	1	15
<i>Tipulidae</i>			3	3	2	1	1	2	2	14
Ephemeroptera										
<i>Ameletopsidae</i>	1			1						2
<i>Baetidae</i>	13	6	7	21	12	15	5	8	6	93
<i>Caenidae</i>	3	3	11		22	6	1	10	2	58
<i>Leptophlebiidae</i>	27	11	48	19		32	26	17	24	204
Gordioidea										
<i>Gordiidae</i>		3	3				1			7
Hemiptera										
<i>Corixidae</i>	6		3	1			4			14
<i>Gelastocoridae</i>	1						1			2
<i>Gerridae</i>								2		2
<i>Veliidae</i>	1	2	8					1		12
Isopoda										
<i>Sphaeromatidae</i>									1	1
Lymnophila										
<i>Lymnaeidae</i>	1	1	1				1			4
<i>Psephenidae</i>	3	6				1				10

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Taxonomic name	BC1	CC2	DD2	DD2A	DD4	DD5	MB1	TR1	TR2	Total
Megaloptera										
<i>Corydalidae</i>	7		6		3		10	3	5	34
Odonata										
<i>Aeshnidae</i>			1							1
<i>Corduliidae</i>		15		8	1	6	1			31
<i>Diphlebiidae</i>		3						1		4
<i>Gomphidae</i>	17	3	17	12			2		1	52
<i>Libellulidae</i>	2		2			7		4	3	18
<i>Telephlebiidae</i>	1	12		3						16
Plecoptera										
<i>Eustheniidae</i>		1								1
<i>Gripopterygidae</i>	3		1	2				6	2	14
Trichoptera										
<i>Calamoceratidae</i>					1					1
<i>Ecnomidae</i>		1								1
<i>Hydrobiosidae</i>	1	6	17	13	1	12	10	4	2	66
<i>Hydropsychidae</i>	5	9	3	6	26	15	34	20	36	154
<i>Hydroptilidae</i>		1					1			2
<i>Leptoceridae</i>			4	1		5	2	7	2	21
<i>Philopotamidae</i>	1		1	1	1	13		26	3	46
Tricladida										
<i>Dugesidae</i>		6						1		7
Venerida										
<i>Corbiculidae</i>						1		1	3	5
Unknown Order										
<i>Oligochaeta</i>		6	5		1	1	5	1		19
Diversity	25	27	25	24	14	20	27	21	20	
Grand Total	157	149	164	109	106	137	154	134	110	1220

Results and analysis from the riffle samples reflected similar patterns to the edge samples, with depressed results in Commissioners Creek (CC2) and immediately downstream of the dam wall (DD4) (Table 20Table 21). However, the differences were not as great as indicated by the AUSRIVAS bandings, which did not decline as dramatically in a downstream gradient and were likely a result of the riffle habitat being maintained and supporting the more sensitive species across the surveyed sites.

Table 21: AUSRIVAS modelling results for riffle samples collected from Clarrie Hall Dam raising EIS sites. Data is presented from most upstream to downstream sites. Not all sites are represented as there was not always riffle habitat present

Site	Number of families	OE50 (number of families)	OE50 Signal	Signal 2	EPT	Band
CC2	27	0.71	0.98	4.962963	8	B

Site	Number of families	OE50 (number of families)	OE50 Signal	Signal 2	EPT	Band
BC1	24	0.85	1.02	5.24	8	A
DD2	25	0.98	1.03	4.8	8	A
DD3	24	0.87	1.04	5.458333	8	A
MB1	27	0.88	0.97	4.444444	6	A
Clarrie Hall Dam						
DD4	14	0.78	0.9	5.071429	6	B
DD5	20	1.03	0.94	5.05	7	A
TR1	22	0.89	1.05	4.954545	8	A
TR2	20	1.02	1.03	5.2	8	A

Note: Orange shading indicates that the model results are nearly outside of the experience of the model.

The results from the macroinvertebrate data analysis reflect the impacts that can be observed across the site. In general, Commissioners Creek is in a poorer ecological condition than Doon Doon Creek. The sites in the poorest ecological condition are the sites immediately downstream of Clarrie Hall Dam (DD4), which is not unexpected given the impacts that are present at this site. There is a general decline in ecological condition heading downstream in the catchment across all metrics. The lowest scores were recorded at the Bray Park Weir. Despite some sites being in poorer ecological condition, Figure 14 shows that all sites fell within the upper right quadrant when Signal2 is plotted against taxa richness. Sites that fall within the upper right quadrant are considered the 'healthiest' with regard to water quality.

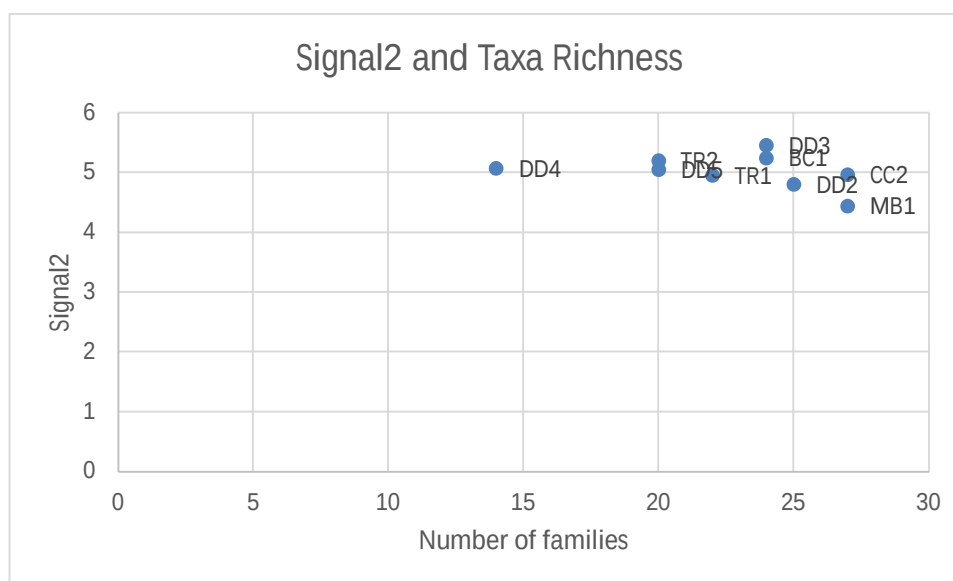


Figure 14: Signal2 and taxa richness (riffle habitat)

10.7. Aquatic vertebrates

10.7.1. Fish surveys

Aquatic surveys were undertaken by Austral at 15 sites in September 2023 (Figure 2; Table 30) (Appendix C - Field survey design). A total of 18 fish species and 2 invertebrate species were recorded during the surveys (Table 41) (Appendix K – Aquatic vertebrates (field assessment)). Fish species consisted of 3 exotic species (common carp, eastern gambusia and pearl cichlid (*Geophagus brasiliensis*)), with the remainder all native species (Table 41). Abundance, but not diversity, was highest at McCabes Bridge, primarily due to the presence of large numbers of an unknown gudgeon species (Table 41). Abundance and diversity were observed to increase in the lower reaches of Doon Doon Creek and the Tweed River. It should be noted that the sites that support higher fish abundance and diversity are also wider stretches of water relative to sites that supported lower abundance and diversity. Sites that supported wider stretches of water also supported more instream fish habitat. Additionally, it is common to observe an increase in diversity and abundance moving downstream. Estuaries typically showed the highest diversity.

Native fish species recorded during the September 2023 surveys with the highest abundance included an unidentified juvenile carp gudgeon species (*Hypseleotris* spp.) (2,494 individuals). This genus comprises the empire gudgeon (*Hypseleotris compressa*), firetail gudgeon (*Hypseleotris galii*) and carp gudgeon (*Hypseleotris klunzingeri*). Sea mullet, Australian smelt and freshwater catfish were also recorded in higher abundances (402, 145 and 159 individuals respectively) (Table 41). Sea mullet and Australian smelt typically engage in schooling behaviours, frequently resulting in higher abundances when detected. *Hypseleotris* spp. was encountered more frequently than any other fish species. It was recorded at 14 out of 15 sites and was only absent from Big Creek (Table 41). Longfin eels were also detected at 14 out of 15 sites albeit in smaller numbers. Longfin eels were absent from CHD1 only, which is an arm of Clarrie Hall Dam; however, the species was detected at other sites within Clarrie Hall Dam, which indicates the species was present within all surveyed waterways (Table 41). The least common native fish species was the flathead gudgeon, which was recorded in the lower reaches of the Tweed River only (**Error! Reference source not found.**). Flathead gudgeon is typically a relatively common species and is frequently encountered in large numbers (Native Fish Australia, 2022). Bullrout (*Notesthes robusta*) were also recorded in low numbers (5 individuals) and were also only recorded in the Tweed River (Table 41). Bullrout frequently inhabit the lower reaches of rivers and streams and are known to be a sedentary species (Gomon, et al., 2023). A total of 4 individuals of Duboulayi rainbowfish were detected during the September 2023 surveys. The species was recorded in the lower reaches of the Tweed River and at one site (DD4) on Doon Doon Creek only (Table 41). Duboulayi rainbowfish is known to inhabit freshwater environments in sandy coastal areas and inland forest habitats (Gomon & Bray, 2022a).

Australian bass are stocked by DPI Fisheries within Clarrie Hall Dam (Department of Primary Industries, 2023h). A total of 68 Australian bass were recorded across 6 sites and 3 waterways (Table 41). The species was detected in Clarrie Hall Dam, Doon Doon Creek and the Tweed River. Australian bass are catadromous, which means they migrate to saline waters to spawn. Individuals recorded within Clarrie Hall Dam will be unable to make the downstream spawning migration due to Clarrie Hall Dam wall. As such, the population is not considered a self-sustaining population and would require regular stocking to persist in Clarrie Hall Dam (Department of Primary Industries, 2023h) .

Three exotic species – common carp, eastern gambusia and pearl cichlids – were recorded in relatively low numbers (Table 41). Common carp were detected at the Bray Park Weir on the Tweed River only. A total of 9 individuals were recorded (Table 41). Common carp are now considered common throughout NSW and are well known for their destructive bottom feeding habits that are known to disturb macrophytes and cause waters to become turbid (Department of Primary Industries, 2023j). Eastern gambusia were recorded at 6 sites across the Tweed River, Commissioners Creek and at McCabes Bridge on Doon Doon Creek (Table 41). A total of 100 individuals were recorded across these sites. Eastern gambusia are widespread throughout NSW and thrive in slow-moving, shallow waterbodies. Eastern gambusia can tolerate a range of temperatures and water quality and can reproduce several times in a year throughout the warmer months. Eastern gambusia are known to be particularly aggressive (Department of Primary Industries, 2023k). A single pearl cichlid, which had been reported to be present by the Tweed Shire Council, was detected at the Bray Park Weir on the Tweed River (Table 41). The pearl cichlid is an aggressive freshwater species native to South America. The species is popular in the aquarium trade; however, in the wild, the species can become a significant pest based on their size, hardiness and aggression. Pearl cichlids were first recorded in NSW in a tributary of the Tweed River in 2008 and continue to be recorded in various locations within the Tweed River catchment (Department of Primary Industries, 2023l).

eDNA samples were collected at all 15 sites by Austral during the September 2023 survey and submitted to the laboratory for analysis. Results (presence/absence) of the analysis are shown in Table 42. Of particular note in the eDNA analysis results is the presence of platypus at 7 sites across Doon Doon Creek, Big Creek, Commissioners Creek and the Tweed River (Table 42) (Enviro DNA, 2023).

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, undercut 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, et al., 2019). Foraging is undertaken in both low-flow pools and high-flow riffle habitat within streams, preferably less than 5 m deep, with coarse bottom substrates (Bino, et al., 2019). Studies conducted by the Australian Platypus Conservancy (Serena, 1998) indicate that there is a correlation between platypus numbers, foraging activity and the presence of higher numbers of indigenous trees within the riparian zone. A similar relationship was demonstrated for the amount of cover provided by vegetation

and lower-growing plants undercut the water and platypus abundance. Despite many sites supporting a minimal riparian zone, a number of sites supported banks capable of supporting platypus burrows. Many sites also supported appropriate feeding habitat and resources required by platypus. While the platypus is not currently listed under the FM Act or the EPBC Act, the species is included on the DCCEEW (2020) provisional list of animal species identified as requiring urgent management intervention following the 2019–2020 bushfire season. There is a lack of knowledge regarding species abundance at a local catchment level, and the species is subject to similar impacts as threatened fish, including waterway bank erosion, channel sedimentation, regulated waterways, barriers to water flow (e.g. dams and weirs), riparian zone degradation and loss of riparian vegetation (Grant & Temple-Smith, 2003; Hawke, et al., 2021).

Based on the results of the eDNA analysis, and the presence of appropriate habitat within the study area, platypus should be considered prevalent within Clarrie Hall Dam and associated waterways.

The eDNA analysis also revealed one record of a genus of pygmy perch (*Nannoperca* sp.) (Table 42). Trace DNA from the species could be identified to genus level only (Enviro DNA, 2023); however, a review of the known and historical ranges of pygmy perch species that have potential to occur within the Tweed catchment indicate the unidentified detection is likely to be Oxleyan pygmy perch (Department of Climate Change, Energy, the Environment and Water, 2023d; Department of Primary Industries, 2016). Trace amounts of DNA for unidentified pygmy perch were detected in the lower reaches of the Tweed River only (TR3) (Table 42) (Appendix K – Aquatic vertebrates (field assessment)). The Oxleyan pygmy perch was included on the DCCEEW (2020) provisional list of animal species identified as requiring urgent management intervention following the 2019–2020 bushfire season. The Oxleyan pygmy perch is also listed as 'endangered' under both the FM Act and EPBC Act (Department of Climate Change, Energy, the Environment and Water, 2023d). DPI Fisheries confirmed that targeted surveys were an appropriate response to the eDNA detection however they confirmed that if Oxleyan pygmy perch was not detected during targeted surveys then no further action was required.

10.7.2. DPI Fisheries surveys

DPI Fisheries undertook fish surveys at 8 sites within Clarrie Hall Dam (Figure 15) in September 2023, funded by the Recreational Fishing Trust. The results of the surveys are presented in Table 43 (Appendix K – Aquatic vertebrates (field assessment)). Surveys undertaken by DPI Fisheries in September 2023 identified 10 fish species or species' complexes including 9 native species or species complexes and 1 exotic species (Table 43). The carp gudgeon species complex was the most abundant, with 4,855 individuals recorded from 5 out of 8 sites (Table 43). Carp gudgeons are widespread and common at mid to lower altitudes and are frequently found in coastal streams throughout coastal NSW (Murray-Darling Basin Authority, 2009). Firetail gudgeons were also highly abundant at the time of the surveys, with 3,416 individuals recorded from 3 out of 8 sites (Table 43). The firetail gudgeon is found in coastal drainages of eastern Australia from central Queensland to the Georges River, central NSW. The species prefers coastal freshwater streams, large rivers, floodplains,

coastal wetlands, dune lake systems and dams and weirs, often around aquatic vegetation (Gomon & Bray, 2022b). Australian smelt were detected at 5 out of 8 sites, with 199 individuals recorded (Table 43). The abundance of exotic species was low, with Eastern gambusia detected at 5 out 8 sites, and 55 individuals were recorded (Table 43). Australian bass are stocked within Clarrie Hall Dam by DPI Fisheries (Department of Primary Industries, 2023h). During the September 2023 surveys in Clarrie Hall Dam, Australian bass were detected in low to moderate numbers at 7 out of 8 sites. Australian bass were last stocked in Clarrie Hall Dam in 2020–21 and appears to be persisting well (Department of Primary Industries, 2023h).

10.7.3. Targeted Oxleyan pygmy perch surveys

From 13 to 16 January 2024, targeted Oxleyan pygmy perch surveys were undertaken at 13 sites located downstream of Clarrie Hall Dam (

). The surveys were initiated in response to the eDNA analysis results that revealed one record of a genus of pygmy perch (*Nannoperca* sp.), considered likely to be Oxleyan pygmy perch. A total of 25 sites were scheduled to be surveyed; however, negative responses to requests for access and flood conditions at the time of the surveys resulted in 13 sites being surveyed (

). The survey results are presented in Table 44. Targeted Oxleyan pygmy perch surveys *did not* detect Oxleyan pygmy perch. Targeted Oxleyan pygmy perch surveys detected 7 aquatic species from 13 survey sites (Table 44). Fish species detected during the surveys comprised 5 native species or species

complex and 1 exotic species. One invertebrate species was detected also (PP4) (**Error! Reference source not found.**). Species detected were similar as in other surveys undertaken as part of the EIS process. Eastern gambusia were detected in high abundance (1,742) and was detected at 9 out of 13 sites (Table 44). Carp gudgeon species complex (*Hypseleotris* sp.) was also detected in high abundance (781 individuals) and was detected at 11 out of 13 sites (Table 44). All other native fish species were detected in low to moderate numbers. At least one species was detected at all sites except PP9 (**Error! Reference source not found.**). One freshwater crayfish (*Euastacus valentulus*) was detected at site PP4.

Overall, no species listed under the EPBC Act or FM Act were detected during the surveys.



Figure 15: Sites surveyed by DPI Fisheries in September 2023 as part of the Recreational Fishing Trust

11. Ecological values

11.1. Aquatic ecology

The September 2023 field survey provided background data on the aquatic ecological values within Clarrie Hall Dam, Doon Doon Creek, the Tweed River, Big Creek and Commissioners Creek (Figure 2). 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 were assigned for all sites because the sites contained in-stream snags or native aquatic plants, and there was the potential for the waterway to provide habitat for threatened aquatic species (i.e. Oxleyan pygmy perch and southern purple-spotted gudgeon) based on the modelled distribution, or historical distribution of the species.

- During the September 2023 field survey, water and sediment quality varied between sites (Table 36; Table 37). The pH of surface water ranged from circumneutral to alkaline and no sites were outside the trigger values for the ANZECC and ARMCANZ (2000) guideline trigger values (ANZECC and ARMCANZ, 2000).
- TDS varied between sites and ranged from 65 mg/L to 123 mg/L. Water containing concentrations in this range can be considered 'hard water'.
- Conductivity fell outside the ANZECC and ARMCANZ (2000) guideline trigger values at all sites. Conductivity measured higher in the Tweed River than all other waterbodies, followed by Clarrie Hall Dam and then Doon Doon Creek (Table 36).
- Dissolved Oxygen concentrations were within the allowable values for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs) but exceeded the ANZECC and ARMCANZ (2000) guideline trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers) at McCabes Bridge, the Tweed River, DD4 on Doon Doon Creek and Commissioners Creek (Table 36).
- Surface water turbidity was consistently low across sites and waterways (Table 36). Turbidity concentrations fell below the acceptable limits for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs) in Clarrie Hall Dam.
- Nutrients and metals were generally either low or below detection limits or below ANZECC and ARMCANZ (2000) trigger values and/or DGVs (ANZECC and ARMCANZ, 2000; Water Quality Australia, 2018) at all sites; however, some higher concentrations of metals were observed in

sediment samples (Table 36). This indicates that the majority of sites are considered to be in moderate condition despite existing adjacent land use and disturbance.

- Aquatic habitat such as macrophytes was present at all sites and multiple species of macrophyte were observed at most sites (Table 39). Habitat complexity was sufficient to support the requirements of many aquatic species, and no sites supported habitat critical to the survival of a species.
- A total of 77 taxa were identified from the phytoplankton (free-floating algae) assemblage in the surface water at 15 sites during the September 2023 survey (Table 38), and 22 macrophytes, 81 aquatic invertebrates and 30 aquatic vertebrate taxa (including 3 exotic species, 1 stocked species and 26 native species) were recorded via direct observation by either Austral or DPI Fisheries (**Error! Reference source not found.**; Table 41) or via eDNA analysis across 23 sites within 5 waterways (Table 42).
- A diverse range of aquatic invertebrates was recorded in all waterways, regardless of the number of sites surveyed (**Error! Reference source not found.**; Table 40). One listed species was recorded during the September 2023 field surveys – the platypus.
- A total of 14 phytoplankton genera that have the potential to be bloom-forming and/or toxic were recorded during the September 2023 field surveys (Table 38). The occurrence of these taxa can be attributed, in part, to anthropogenic influences. Overall, none of the taxa recorded are considered to be threatened or of restricted distribution.

Overall, it is considered that Clarrie Hall Dam, Doon Doon Creek, the Tweed River, Big Creek and Commissioners Creek are of 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 moderate to high quality key fish habitat features
- the presence of diverse and abundant macroinvertebrate assemblages
- the presence of one threatened species – the platypus.

11.2. 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:

- surface water and sediment quality
- groundwater level and water quality
- key fish habitat
- surface water aquatic biodiversity (ie algae, macrophytes, aquatic invertebrates)
- riparian vegetation
- the platypus.

12. Impact assessment

12.1. Impacts on 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 Proposal.

12.2. Construction

- Direct impacts:
 - o inundation and direct loss of riparian habitat for Clarrie Hall Dam and Doon Doon Creek and downstream areas of Commissioners Creek through raising the Clarrie Hall Dam wall and increasing the footprint of Clarrie Hall Dam
 - o a decrease in water quality within Clarrie Hall Dam and Doon Doon Creek as a result of construction of the dam wall arising from run off from construction activities and increased sedimentation.
- Indirect impacts:
 - o erosion and sedimentation smothering aquatic biota and their propagules as a result of construction earthworks
 - o overflows from site water treatment systems
 - o changes to surface hydrology associated with the location of infrastructure, influencing water flow and pooling, which may affect aquatic biota emergence and persistence
 - o seepage of potential contaminants into groundwater, which (dependent on local hydrogeology) may subsequently be discharged to the lake's surface or riparian zone, posing an ecotoxicity risk to aquatic biota and riparian vegetation
 - o dust from blasting decreasing water quality.

12.2.1. Direct

In terms of direct impacts, the raising of Clarrie Hall Dam (construction) would result in the direct loss of aquatic and riparian habitat due the increased capacity of Clarrie Hall Dam. This has the potential to

increase the area of habitat available to aquatic biota (including the platypus). Increases in water level may result in a period of decreased water quality as inundated terrestrial vegetation breaks down within the expanded area of Clarrie Hall Dam. Decreases in water quality may also occur within Clarrie Hall Dam, and downstream of Clarrie Hall Dam due to construction activities. While unlisted aquatic biota may be impacted by the raising of dam wall, the desktop assessment and September 2023 field survey indicate that aquatic species listed under the EPBC Act and/or FM Act are unlikely to be present within Clarrie Hall Dam or downstream in Doon Doon Creek or the Tweed River. The platypus is prevalent within the study area and must be considered as part of the EIS process. Minimisation and mitigation measures are to be implemented during construction and would minimise impacts on the platypus. Overall, it is considered that the construction of the dam wall would not cause a significant impact to any listed species and impacts on non-listed species could be minimised through strategic management and implementation of mitigation measures. No new impacts on fish passage would occur as a result of the Proposal.

12.2.2. Indirect

Indirect impacts resulting from the raising of Clarrie Hall Dam (construction) may occur in the form of erosion and sedimentation smothering non-listed aquatic biota (vertebrates/invertebrates and macrophytes) as a result of earthworks. There is the potential for overflows from site water treatment plants/systems to occur and enter either Clarrie Hall Dam or Doon Doon Creek. Changes to surface hydrology may occur as a result of the installation of infrastructure associated with the Proposal. If any alterations to flow and pooling occur, there is the potential for negative impacts on aquatic biota emergence and/or persistence. There is potential for spilled contaminants to enter waterways or groundwater systems that may subsequently impact aquatic biota and riparian vegetation. Dust from blasting has the potential to impact aquatic flora and fauna because of a decrease in water quality.

It is considered likely that impacts on aquatic biota and habitat would be minimal, should appropriate minimisation and mitigation measures be implemented consistently before and during the construction phase.

12.3. Operation

- Direct
 - o Extremely minor increases to flows downstream of Clarrie Hall Dam due to the raised Clarrie Hall Dam wall and increased capacity

- o no impacts to GDE (EMM Consulting Pty Limited, 2024b)
- o no negative impacts on aquatic biota resulting from CWP associated with the Clarrie Hall Dam raising.

- Indirect

- o potential for increased native fish including Australian bass mortalities due to (minor) increases in flow.

12.3.1. Direct

Direct impacts on aquatic biota are likely to be minimal. It was considered that changes to flows and water level elevation within Doon Doon Creek and the Tweed River may negatively impact non-listed aquatic fauna and flora, and the platypus. It was also considered that alterations to the thermal profile within Doon Doon Creek and the Tweed River resulting from changes to CWP may negatively impact non-listed fauna and flora and the platypus. Assessments undertaken by EMM Consulting Pty Limited (2024b) confirmed that impacts from these factors were nil to negligible.

Overtopping of Clarrie Hall Dam may result in the loss and mortality of native fish that are washed over the outlet during high flow events.

12.3.2. Indirect

Modelled changes to flows within Doon Doon Creek suggest a minor increase in migration cues which may result in a minor increase in Australian bass migrations upstream in Doon Doon Creek, potentially resulting in slightly more frequent fish mortality events.

12.4. Threatened species and communities

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 Proposal 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 G (FM Act) and Appendix H (EPBC Act), and brief summaries are provided below. Habitats, communities, populations and/or species that are considered unlikely to occur within, or in the waterways associated with, Clarrie Hall Dam (Appendix C), have not been considered further.

Assessments of significance have been provided for listed, threatened species:

- o platypus
- o southern purple-spotted gudgeon.

12.4.1. FM Act

- southern purple-spotted gudgeon.

Implementation of the Proposal condition would not have a direct or indirect impact on the southern purple-spotted gudgeon, as:

- it is unlikely that Clarrie Hall Dam or associated waterways support populations of southern purple-spotted gudgeon
- the southern purple-spotted gudgeon is currently considered to be extremely rare in inland NSW, and no public records for southern purple-spotted gudgeon have been reported within the Northern Rivers catchment (Department of Environment and Heritage, 2023).
- despite the presence of appropriate habitat and all aquatic surveys being undertaken in accordance with 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), the southern purple-spotted gudgeon was *not* detected within Clarrie Hall Dam or associated waterways
- exotic species known to impact, or compete with the southern purple-spotted gudgeon have been recorded within Clarrie Hall Dam and associated waterways.

12.4.2. EPBC Act

Matters under the EPBC Act include:

- I. Oxleyan pygmy perch

Construction and operation of the Proposal is unlikely to significantly impact on the Oxleyan pygmy perch given that:

- despite targeted Oxleyan pygmy perch surveys being undertaken in accordance with both 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) and *A sampling protocol for the endangered freshwater fish, Oxleyan Pygmy Perch (Nannoperca oxleyana) Whitley* (Knight, et al., 2007), Oxleyan pygmy perch was *not* detected within the Tweed River, or tributaries of the Tweed River

- it is considered *unlikely* that Oxleyan pygmy perch would be impacted by the Proposal.

II. Platypus (listed on the *Revised provisional list of animals requiring urgent management intervention* (Department of Climate Change, Energy, the Environment and Water, 2020)

- records for the platypus occur within Clarrie Hall Dam, Doon Doon Creek, Commissioners Creek and the Tweed River from as recently as 2006 (Department of Environment and Heritage, 2023);
- aquatic surveys and eDNA analysis revealed that the platypus was present in Doon Doon Creek, Big Creek, Commissioners Creek and the Tweed River at the time of the surveys (**Error! Reference source not found.; Error! Reference source not found.**);
- the platypus should be considered prevalent within the Proposal area; however,

Construction and operation of the Proposal is unlikely to significantly impact on the platypus given that:

- changes to flows resulting from the Proposal are modelled to be minimal
- CWP is modelled to improve marginally with the raised dam in place.

12.5. Impacts

12.5.1. Construction

12.5.1.1. Direct loss of key fish habitat

Direct loss of key fish habitat will occur as a result of the construction of the dam wall. These losses are associated with the construction of ancillary infrastructure and construction of infrastructure directly related to the dam wall raising.

Calculations provided by KBR indicate that 260 m² of key fish habitat would be lost during the construction, in addition to 23,200 m² associated with the increased capacity of Clarrie Hall Dam resulting in a total loss of 23,460 m² of Type 1 Class 1 key fish habitat to be lost as a result of the Proposal (Table 25).

13. Offsets associated with the loss of key fish habitat are discussed further in section 9: Risk assessment for the Proposal

Table 22 outlines the risk matrix adopted when assessing Proposal impacts. Potential consequences resulting from an impact, along with the likelihood of an impact occurring assist in determining the 'risk' associated with the impact.

Table 23 outlines the consequence criteria for the construction impacts. Based on the risk as determined in Table 22,

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Table 23 allows for a more detailed assessment of specific impacts.

Table 24 shows the specific risk assessment for the Proposal.

Table 22: 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 23: 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
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

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	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
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 is up to 1 year	Changes to surface water quality due to activity; recovery is 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)
CWP	No detectable change in CWP magnitude or frequency	Short-term changes in CWP magnitude or frequency (>2°C)	Long-term changes in CWP magnitude or frequency (>2°C)	-	-

Table 24: Risk assessment for the Proposal impacts

Proposal phase	Consequence criteria	Risk activity	Risk Issue- What can happen & How can it happen	Existing control measures (planned Controls)	Consequence (C)	Likelihood (L)	Risk (R)	Comments incl uncertainty
Construction – raising dam wall	Surface water – water quality	Construction activities	Decreased water quality within Doon Doon Creek and/or Clarrie Hall Dam	Appropriate sediment and erosion control measures Assumes CEMP developed and measures in place for all construction activities	Mo	U	M	Poor water quality due to increased possible if CEMP not adhered to. Risk lowered if all mitigation and management measures followed including ongoing water quality monitoring
Construction – raising dam wall	Surface water – water quality	Seepage of wastewater	Decreased water quality within Doon Doon Creek and/or Clarrie Hall Dam	Assumes CEMP developed and measures in place for all construction activities (eg, swales/diversions)	Mo	U	M	Poor water quality due to contamination by wastewater possible if CEMP not adhered to. Risk lowered if all mitigation and management measures followed including ongoing water quality monitoring

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Proposal phase	Consequence criteria	Risk activity	Risk Issue- What can happen & How can it happen	Existing control measures (planned Controls)	Consequence (C)	Likelihood (L)	Risk (R)	Comments incl uncertainty
Construction – raising dam wall	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 – raising dam wall	Surface water – water quality	Concrete dust or slurry entering waterways	Decrease in water quality due to contamination with concrete dust/slurry.	Assumes CEMP developed and measures in place for all construction activities Appropriate measures to catch dust or slurry. Dust not to be generated on windy days.	Mo	U	M	Poor water quality due to contamination with concrete dust/slurry.possible if CEMP not adhered to. Risk lowered if all mitigation and management measures followed including ongoing water quality monitoring
Construction – cleared land	Surface water – water quality	Increased sedimentation from runoff across	Decrease in water quality due to increased runoff	Assumes CEMP developed and measures in place for all construction activities	Mo	U	M	Poor water quality due to increased possible if CEMP not adhered to. Risk lowered if all

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Proposal phase	Consequence criteria	Risk activity	Risk Issue- What can happen & How can it happen	Existing control measures (planned Controls)	Consequence (C)	Likelihood (L)	Risk (R)	Comments incl uncertainty
		areas cleared of vegetation		Appropriate erosion and sediment fencing to be installed				mitigation and management measures followed including ongoing water quality monitoring
Construction	GDE	Land excavations.	Temporary dewatering may be required	No proposed mitigation measures in place	IN	R	L	Risk to GDEs nil to negligible
Construction	Aquatic fauna	Construction (raising) of the dam wall	Fauna salvage and dewatering may be 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. Listed species are unlikely to be present
Operation	Surface water – depth	Changes to flows resulting from the raising of the dam wall	Changes to hydrology within Doon Doon Creek and the Tweed River	A surface water assessment has been undertaken to assess impacts to hydrology	Ma	U	M	Changes to depth within Doon Doon Creek and the Tweed River considered nil to negligible. Potential increase of water level by 0.1 m

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Proposal phase	Consequence criteria	Risk activity	Risk Issue- What can happen & How can it happen	Existing control measures (planned Controls)	Consequence (C)	Likelihood (L)	Risk (R)	Comments incl uncertainty
Operation	Surface water – CWP	Changes to thermal profile resulting from the raising of the dam wall	Changes to thermal profile within Doon Doon Creek and the Tweed River	An assessment of temperature has been undertaken to assess impacts to Doon Doon Creek and the Tweed River resulting from CWP	Ma	U	M	Effects of CWP within Doon Doon Creek and the Tweed River predicted to improve marginally as a result of the proposal

Indicative offsets approach.

13.1.1.1. Water quality

There is the potential for water quality to decrease as a result of construction activities and the installation of ancillary infrastructure as discussed by KBR (2024a). Specific activities that may result in a decrease in water quality include:

- generation of concrete which may enter waterways resulting in increased alkalinity
- wet concrete entering waterways resulting in increased alkalinity
- increased sedimentation from runoff across areas cleared of vegetation
- seepage of wastewater (including sewage) from plumbed storage tanks or wastewater treatment facilities
- wastewater from quarry operations, including dust control, the washing of products and the cleaning of equipment entering Doon Doon Creek or Clarrie Hall Dam
- refuelling.

Preparation of a Construction Environmental Management Plan (CEMP) will be prepared before the construction phase commences and will address potential impacts to water quality.

Additional mitigation measures are discussed in section 11: Mitigation measures.

Risks to aquatic ecology are considered likely to be minimal, assuming appropriate minimisation and mitigation measures are implemented and water quality is monitored correctly throughout the construction phase of the Proposal.

13.1.2. Operation

13.1.2.1. Depth

13.1.2.1.1. Doon Doon Creek riffle habitat

The *Clarrie Hall Dam Raising EIS: Surface Water Assessment* report prepared by EMM Consulting Pty Limited (2024b) reports that the Proposal may increase the frequency of minimum releases from Clarrie

Hall Dam and subsequently increase the frequency of minimum flow depth over riffles within Doon Doon Creek from 38% of the time to 47% of the time. The report also states that there may be an increase in depth of up to 0.1 m for about 20% of the time when the riffle depth is approximately 0.5 to 0.6 m (EMM Consulting Pty Limited, 2024b).

Error! Reference source not found. shows the water surface elevation for riffle habitat within Doon Doon Creek as reported by EMM Consulting Pty Limited (2024a). The difference in water surface elevation for both current infrastructure with current demand and proposed infrastructure with future demand is nil to negligible. Approximately 1% of the time the water surface elevation (m AHD) is predicted to be 26.2 m, before reducing in height to approximately 24.8 m in height from approximately 22% of the time to approximately 40% of the time. The water surface elevation then decreases to approximately 24.6 m and is predicted to remain at that height for the remainder of the time (Figure 16).

Changes in depth within riffle habitat in Doon Doon Creek resulting from the Proposal are considered to be nil to negligible.

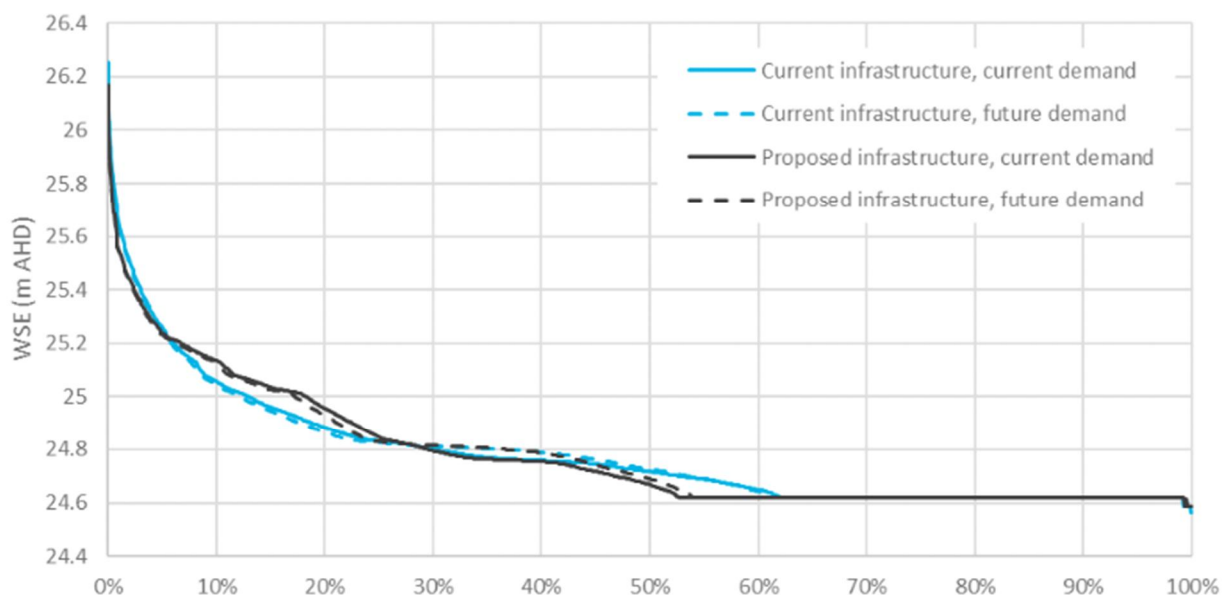


Figure 16: Water surface elevation, Doon Doon Creek riffles

Source: (EMM Consulting Pty Limited, 2024b)

13.1.2.1.2. Doon Doon Creek pool habitat

Depth of water in pools within Doon Doon Creek may vary by ± 0.1 m due to alterations to the flow regime as a result of the Proposal. Average flow velocities are expected to remain below 1 m/s almost 100% of the time (EMM Consulting Pty Limited, 2023).

Figure 17 shows the water surface elevation for pool habitat within Doon Doon Creek as reported by EMM Consulting Pty Limited (2024a). The difference in water surface elevation for both current infrastructure with current demand and proposed infrastructure with future demand is considered nil to negligible. Approximately 1% of the time the water surface elevation (m AHD) is predicted to be approximately 27 m, before reducing in height to approximately 25.6 m for approximately 5% of the time (Figure 17). With the current infrastructure in place and current demand, the surface water level then decreases to approximately 25 m for 25% of the time, before decreasing to approximately 24.6 m in height for the rest of the time (Figure 17). With the proposed infrastructure in place, approximately 1% of the time the water surface elevation (m AHD) is predicted to be approximately 27 m before reducing in height to approximately 25.6 m for approximately 5% of the time, as is also seen with the current infrastructure in place (Figure 17). Surface water elevation continues to decrease with the proposed infrastructure in place; however, water levels are modelled to be approximately 0.1 m higher than with the current infrastructure in place from approximately 6 to 26% of the time before realigning with the same water levels with the current infrastructure in place, 25 m approximately 26% of the time (Figure 17). Water levels with the proposed infrastructure in place then match current water levels from 27% of the time to 41% of the time, before decreasing below current levels by approximately 0.1 m from 42 to 62% of the time. Water levels then remain the same the remainder of the time (Figure 17).

Changes in depth within pool habitat in Doon Doon Creek resulting from the Proposal are considered to be nil to negligible.

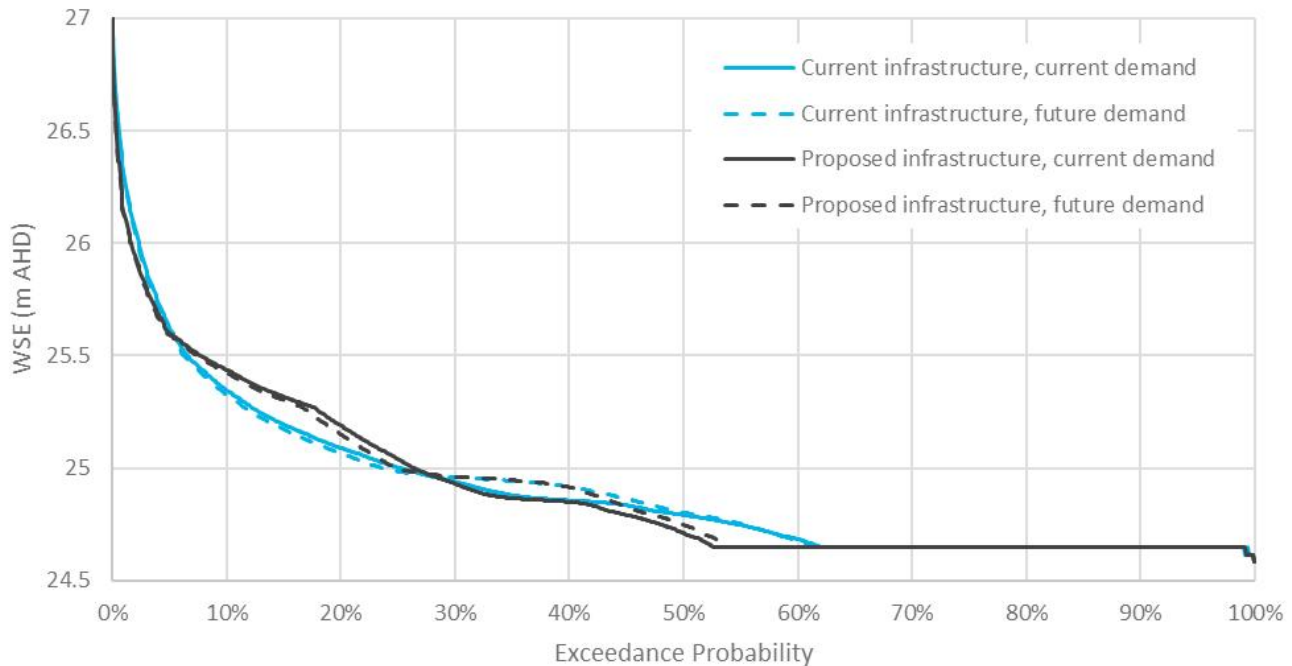


Figure 17: Water surface elevation, Doon Doon Creek pool habitat

Source: (EMM Consulting Pty Limited, 2024b)

13.1.2.1.3. Tweed River riffle habitat

The *Doon Doon Creek and Tweed River Geomorphology modelling report* prepared by (EMM Consulting Pty Limited (2023) reports that riffle water levels are not expected to be materially affected by the Proposal. Figure 18 shows no change in surface water elevation within riffle habitat in the Tweed River with the proposed infrastructure in place.

Changes in depth within riffle habitat in the Tweed River resulting from the Proposal are considered to be nil to negligible and are unlikely to impact aquatic ecology.

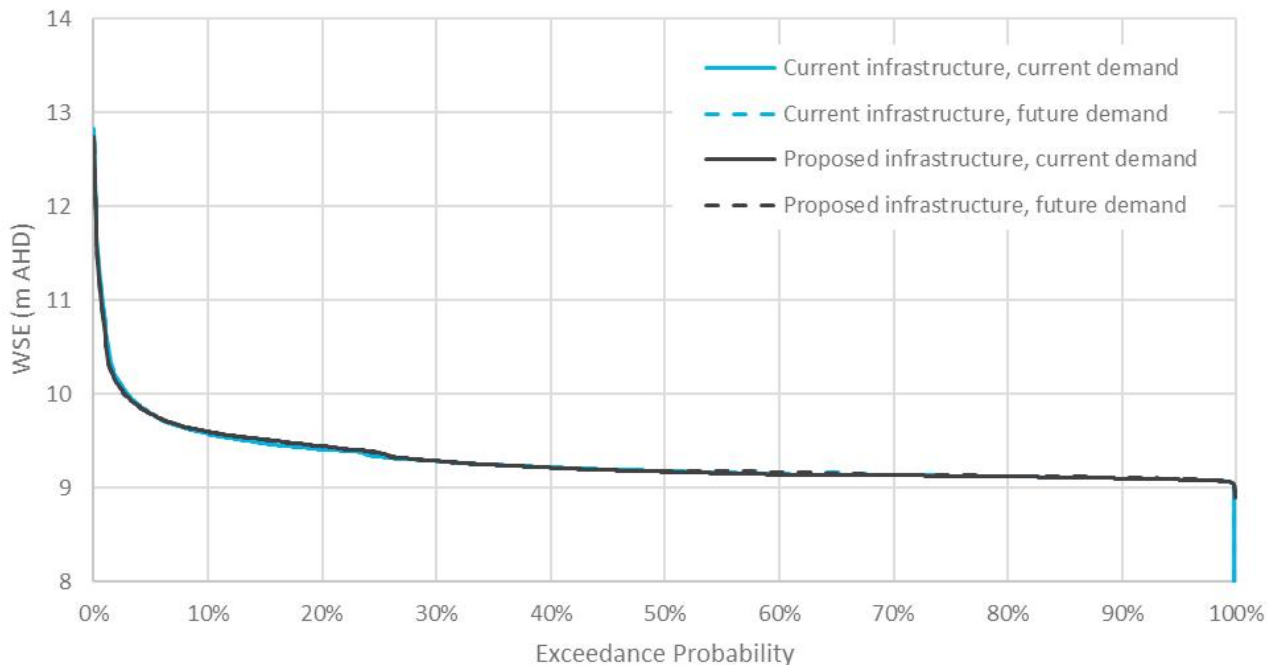


Figure 18: Water surface elevation, Tweed River riffle habitat

Source: (EMM Consulting Pty Limited, 2023)

13.1.2.1.4. Tweed River pool habitat

EMM Consulting Pty Limited (2023) reported that pool surface water elevation within the Tweed River is not expected to be materially affected by the Proposal. Figure 19 shows modelled changes in surface water elevation within pool habitat in the Tweed River with the proposed infrastructure in place are nil to negligible.

Changes to depth within pool habitat in the Tweed River resulting from the Proposal are considered to be nil to negligible and are unlikely to impact aquatic ecology.

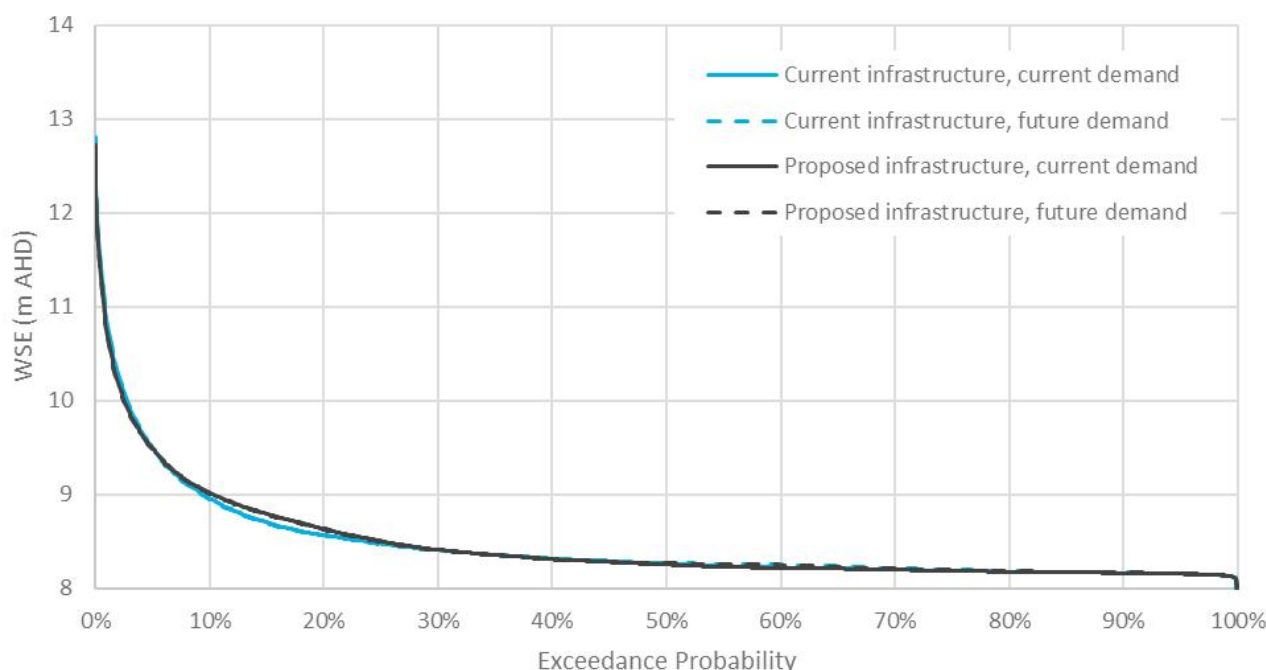


Figure 19: Water surface elevation, Tweed River pool habitat

Source: (EMM Consulting Pty Limited, 2023)

13.1.2.2. Cold water pollution

A detailed assessment of the potential for CWP resulting from the Proposal was undertaken by EMM Consulting Pty Limited and is presented in *Clarrie Hall Dam Raising EIS: Surface Water Assessment* (EMM Consulting Pty Limited, 2024a).

Hydronumerics (2023) reported that with the larger dam, the cold portion of a stratified water column in the reservoir may be between 0 to 1°C warmer than occurs within the existing dam. The report states that this difference in starting temperature would create a *minor reduction* to the magnitude of CWP and negligible reduction to the extent of CWP (EMM Consulting Pty Limited, 2024a).

Figure 20 shows the modelled change to magnitude of cold water pollution releases as reported in EMM Consulting Pty Limited (2024a). With the current infrastructure in place, the magnitude of CWP releases when water is drawn from 15 m depth is a change of approximately 11°C occurring approximately 45% of the time (Figure 20). When water is drawn from 7 m depth, the magnitude of CWP releases is 5°C and occurs approximately 45% of the time. With the raised dam wall, when water is drawn from 15 m

depth, the magnitude of CWP releases is modelled to be 9°C – which is 2°C less than with the current infrastructure in place Figure 20. These releases are predicted to occur more frequently with the raised dam wall, occurring approximately 55% of the time (EMM Consulting Pty Limited, 2024b). When water is drawn from 7 m depth with the current infrastructure in place, the magnitude of CWP releases is 5°C, whereas with the raised dam wall the magnitude of CWP releases is 3°C, which is 2°C less than with the current infrastructure in place (Figure 20). The frequency of cold water releases with the current infrastructure in place is approximately 45% of the time. However, with the raised dam wall, the frequency of the decreases magnitude cold water releases is modelled to be 55% of the time (Figure 20).

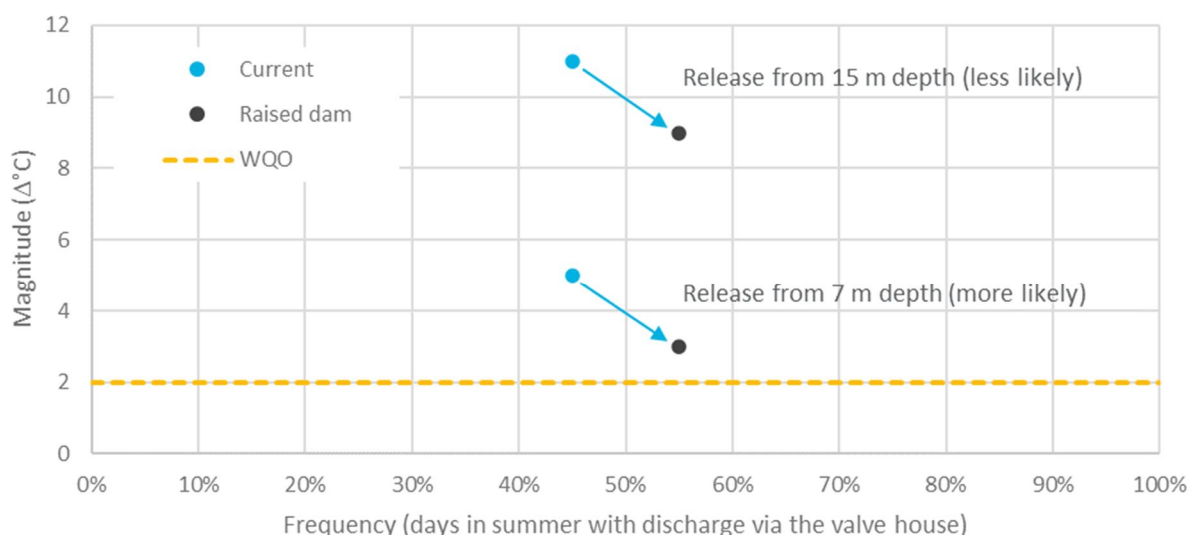


Figure 20: Change in magnitude and frequency of cold water pollution releases

Source: (EMM Consulting Pty Limited, 2024b)

Figure 21 is taken from EMM Consulting Pty Limited (2024b) and shows a 5-day rolling average of cold water pollution at the Doon Doon Creek – Tweed River junction. The figure shows the current 5-day rolling average versus the modelled 5-day rolling average with a raised dam wall (Figure 21).

The 5-day rolling average (CWP – degree days) with the current infrastructure in place is approximately 7.5 to 10 degree days higher than the modelled 5-day rolling average with the raised dam wall on 8 out

of 11 days, as shown in Figure 21. The figure shows clearly that there will be a reduction in CWP degree days with the raised dam wall (Figure 21).

Based on the modelled data provided by EMM Consulting Pty Limited (2024b), there will be no new negative impact to aquatic ecology with regard to CWP resulting from the Proposal. There is also the potential for a decrease in the magnitude of temperature change in the vicinity of 2°C with the raised dam wall, which may have minor positive effects on aquatic ecology within Doon Doon Creek.

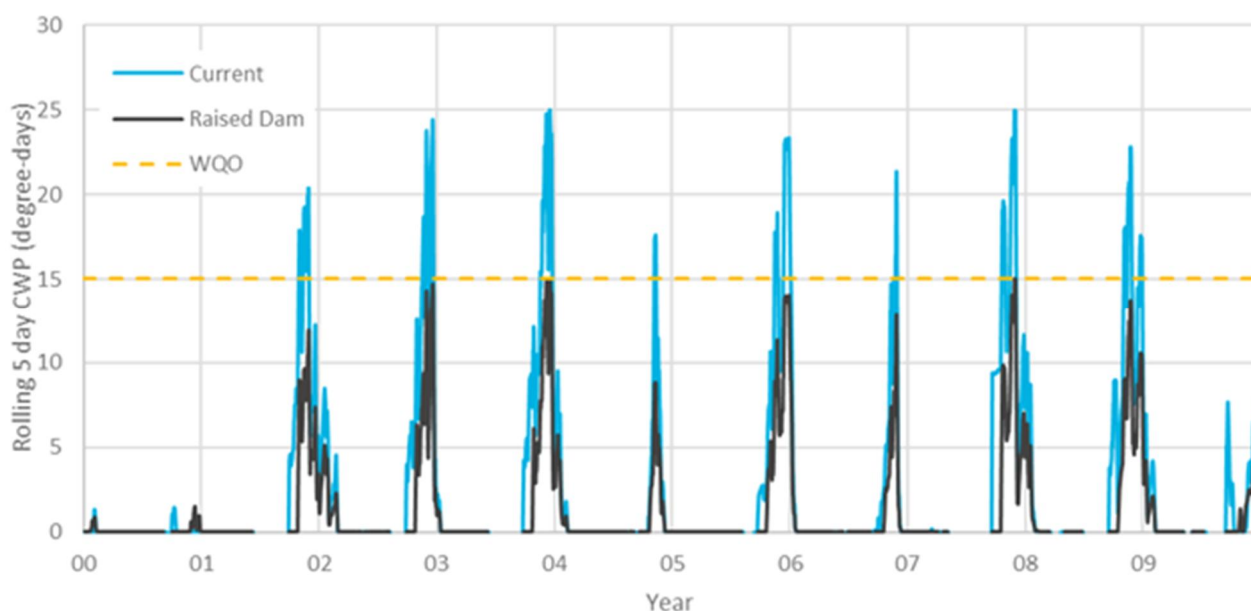


Figure 21: Rolling simulated five day cold water pollution at Doon Doon Creek – Tweed River junction
Source: (EMM Consulting Pty Limited, 2024b)

13.1.3. Australian bass

The Australian bass is a catadromous, migratory species, known from Western Australia, South Australia through to Queensland (McGruther, 2020). Individual Australian bass are known to have complex movement patterns and may move frequently and rapidly around any catchment they may occupy (Brown, 2009). Some Australian bass have been observed to be 'nomadic', making repeated transitions from estuarine to fresh waters (Brown, 2009). Often, movements and migrations will coincide with increased flows and temperature, which is thought to trigger upstream migrations such as those migrations undertaken by juveniles in spring to summer (Brown, 2009).

Flows from Clarrie Hall Dam are thought to induce Australian bass to migrate up Doon Doon Creek; however, the presence of the dam restricts the species to the lower 1.5 km of Doon Doon Creek, with the dam wall forming an impassable barrier. When flows from Clarrie Hall Dam cease, Australian bass may become trapped in pool refugia in high densities and must endure decreasing water quality over time. Eco Logical Australia (2019) reported that cessation of flows from Clarrie Hall Dam has previously led to deoxygenation in Doon Doon Creek immediately below the dam wall. This decrease in oxygen is reported to have caused mortalities in Australian bass attempting to migrate up Doon Doon Creek (Bishop, 2008). Large fish mortality events have also been recorded within Doon Doon Creek in September 2003 and February 2004. A total of 450 Australian bass were recorded during the September 2003 mortality event (Eco Logical Australia, 2019). DPI Fisheries suggested the origin of the fish involved in the mortality event was downstream migrants, which passed over the spillway in May to June. However, Bishop (2008) suggested that a controlled release of 80 ML/d that occurred immediately prior to the mortality event was responsible for inducing the fish up Doon Doon Creek to the base of the dam wall where they became trapped. It is thought that the same situation occurred in August 2004 after controlled releases of 85 ML/d occurred in November to December 2003, the period when Australian bass migrate upstream (Eco Logical Australia, 2019).

Australian bass are cued by increases in flow to undertake downstream spawning migrations (Brown, 2009). It is not possible to determine whether Australian bass involved in previous mortality events originated downstream of Clarrie Hall Dam or moved over the spillway in response to increased flows.

Additionally, large flows from Clarrie Hall Dam cannot be avoided at all times and it is not possible to stop water travelling over the spillway in times of flood, which has the potential to induce Australian bass to move over the spillway and down Doon Doon Creek.

The *Clarrie Hall Dam Raising EIS: Surface Water Assessment* report prepared by EMM Consulting Pty Limited (2024b) states that 5+ day moderate flow releases from Clarrie Hall Dam are supportive of upstream Australian bass migrations. Currently, these releases occur in 86% of years (EMM Consulting Pty Limited, 2024b). With the raised dam wall, the frequency of these types of flows is predicted to increase to 87% of years. If Australian bass are, in fact, cued to migrate upstream when these flows are released, the frequency of upstream migrations is likely to increase only marginally. As such, it is considered that the raising of the dam wall will create no new negative impacts to Australian bass.

It would be possible to stop the upstream migration of Australian bass into Doon Doon Creek by installing a barrier to fish passage at the mouth of Doon Doon Creek. However, this is considered undesirable and would have the effect of impeding the movement of *all* fish into Doon Doon Creek. This

option would also generate costs associated with the loss of key fish habitat between the mouth of Doon Doon Creek and Clarrie Hall Dam. This option may also impact the downstream migration of Australian bass coming over the spillway, essentially interrupting the breeding cycle of the species.

There may be the potential to minimise large flows through management of water releases from Clarrie Hall Dam; however, this option will not entirely stop Australian bass entering Doon Doon creek given the nomadic behaviour of the species.

Ultimately, even if access to Doon Doon Creek were blocked, it would not be possible to exclude Australian bass from the waterway. It is considered unlikely that mortality events can be completely avoided while the species is present within the catchment.

14. Risk assessment for the Proposal

Table 22 outlines the risk matrix adopted when assessing Proposal impacts. Potential consequences resulting from an impact, along with the likelihood of an impact occurring assist in determining the 'risk' associated with the impact.

Table 23 outlines the consequence criteria for the construction impacts. Based on the risk as determined in Table 22,

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Table 23 allows for a more detailed assessment of specific impacts.

Table 24 shows the specific risk assessment for the Proposal.

Table 22: Risk matrix adopted for the risk assessment for construction impacts

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

Table 23: 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
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

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	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
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 is up to 1 year	Changes to surface water quality due to activity; recovery is 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)
CWP	No detectable change in CWP magnitude or frequency	Short-term changes in CWP magnitude or frequency (>2°C)	Long-term changes in CWP magnitude or frequency (>2°C)	-	-

Table 24: Risk assessment for the Proposal impacts

Proposal phase	Consequence criteria	Risk activity	Risk Issue- What can happen & How can it happen	Existing control measures (planned Controls)	Consequence (C)	Likelihood (L)	Risk (R)	Comments incl uncertainty
Construction – raising dam wall	Surface water – water quality	Construction activities	Decreased water quality within Doon Doon Creek and/or Clarrie Hall Dam	Appropriate sediment and erosion control measures Assumes CEMP developed and measures in place for all construction activities	Mo	U	M	Poor water quality due to increased possible if CEMP not adhered to. Risk lowered if all mitigation and management measures followed including ongoing water quality monitoring
Construction – raising dam wall	Surface water – water quality	Seepage of wastewater	Decreased water quality within Doon Doon Creek and/or Clarrie Hall Dam	Assumes CEMP developed and measures in place for all construction activities (eg, swales/diversions)	Mo	U	M	Poor water quality due to contamination by wastewater possible if CEMP not adhered to. Risk lowered if all mitigation and management measures followed including ongoing water quality monitoring

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Proposal phase	Consequence criteria	Risk activity	Risk Issue- What can happen & How can it happen	Existing control measures (planned Controls)	Consequence (C)	Likelihood (L)	Risk (R)	Comments incl uncertainty
Construction – raising dam wall	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 – raising dam wall	Surface water – water quality	Concrete dust or slurry entering waterways	Decrease in water quality due to contamination with concrete dust/slurry.	Assumes CEMP developed and measures in place for all construction activities Appropriate measures to catch dust or slurry. Dust not to be generated on windy days.	Mo	U	M	Poor water quality due to contamination with concrete dust/slurry.possible if CEMP not adhered to. Risk lowered if all mitigation and management measures followed including ongoing water quality monitoring
Construction – cleared land	Surface water – water quality	Increased sedimentation from runoff across	Decrease in water quality due to increased runoff	Assumes CEMP developed and measures in place for all construction activities	Mo	U	M	Poor water quality due to increased possible if CEMP not adhered to. Risk lowered if all

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Proposal phase	Consequence criteria	Risk activity	Risk Issue- What can happen & How can it happen	Existing control measures (planned Controls)	Consequence (C)	Likelihood (L)	Risk (R)	Comments incl uncertainty
		areas cleared of vegetation		Appropriate erosion and sediment fencing to be installed				mitigation and management measures followed including ongoing water quality monitoring
Construction	GDE	Land excavations.	Temporary dewatering may be required	No proposed mitigation measures in place	IN	R	L	Risk to GDEs nil to negligible
Construction	Aquatic fauna	Construction (raising) of the dam wall	Fauna salvage and dewatering may be 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. Listed species are unlikely to be present
Operation	Surface water – depth	Changes to flows resulting from the raising of the dam wall	Changes to hydrology within Doon Doon Creek and the Tweed River	A surface water assessment has been undertaken to assess impacts to hydrology	Ma	U	M	Changes to depth within Doon Doon Creek and the Tweed River considered nil to negligible. Potential increase of water level by 0.1 m

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Proposal phase	Consequence criteria	Risk activity	Risk Issue- What can happen & How can it happen	Existing control measures (planned Controls)	Consequence (C)	Likelihood (L)	Risk (R)	Comments incl uncertainty
Operation	Surface water – CWP	Changes to thermal profile resulting from the raising of the dam wall	Changes to thermal profile within Doon Doon Creek and the Tweed River	An assessment of temperature has been undertaken to assess impacts to Doon Doon Creek and the Tweed River resulting from CWP	Ma	U	M	Effects of CWP within Doon Doon Creek and the Tweed River predicted to improve marginally as a result of the proposal

15. Indicative offsets approach

15.1. Key fish habitat

The NSW Biodiversity Offsets Policy for Major Proposals Fact Sheet: Aquatic Biodiversity (Department of Primary Industries, 2014) states that offsets for aquatic biodiversity must have a relationship to the biodiversity values being lost. Offsets can be targeted to a higher conservation priority but must still relate to the biodiversity being lost. Offset sites can include the **same or a similar habitat in the same catchment** that is more threatened than the habitat being impacted upon (Department of Primary Industries, 2014).

Chapter 3 of the *policy and guidelines* outlines the requirements for environmental compensation to ensure there is a 'no net loss' of KFH (Department of Primary Industries, 2014). It allows for both site-based offsets to compensate for the loss of each aquatic habitat type or the payment of an amount to compensate for the value of the aquatic habitat being lost to be considered.

The policy and guidelines require a minimum 2:1 offset for Type 1–3 KFHs to help redress both direct and indirect impacts of developments (Department of Primary Industries, 2014). An indicative cost for a 2:1 offset of Type 1 Class 1 KFH is \$138.58 p/m²; however, this is considered a *minimum* cost and should be discussed with DPI Fisheries.

Calculations provided by KBR indicate that 23,460 m² of Type 1 Class 1 KFH will be lost as a result of the Proposal (Table 25). Based on the calculations provided and the indicative cost per/m² an indicative starting price for offsetting KFH for the Proposal is \$ 3,251,086.80. The Tweed Shire Council has met with DPI Fisheries and is in the process of determining potential barriers to fish passage which may be upgraded or removed as an offsets pathway to offset the direct loss of KFH associated with the Proposal.

Table 25: KFH to be lost as a result of the Proposal

Key fish habitat area	Area lost (m ²)
Creekline through inundation	23,200
Dam wall area	260
Total	23,460

There are available options for Proposals within the Tweed River catchment that may fulfill offset requirements.

15.2. Fish passage

The Proposal triggers Section 218 (Fishways to be provided in construction of dams and weirs) of the FM Act, which states:

(5) a public authority that proposes to construct, alter or modify a dam, weir or reservoir on a waterway

–

a) must notify the Minister of the Proposal, and

b) must, if the Minister so request, include as part of the works for the dam, weir or reservoir, or for its alteration or medication, a suitable fishway or fish by-pass.

DPI Fisheries assessed the scope of the raising of the Clarrie Hall Dam Proposal and has recommended the application of Section 218, which requires the provision of suitable fish passage.

Section 4.8 (Fish Passage Trade-Offs) of the *NSW Policy and guidelines for fish habitat conservation and management* (2013) provides provisions for transferring Section 218 fish passage requirements to alternative high priority sites. DPI Fisheries proposed that Section 218 fish passage requirements for Clarrie Hall Dam be transferred to the construction of suitable fish passage at Bray Park Weir.

It is understood that the Tweed Shire Council viewed the proposal favourably and that the Bray Park Weir is to be upgraded and will include the construction of appropriate fish passage, as proposed by DPI Fisheries.

16. Mitigation measures

A Flora and Fauna Management Plan (FFMP) and a Construction Environmental Management Plan (CEMP) would be prepared, should the Proposal proceed. The mitigation measures provided within this section are additional measures that would need to be documented and incorporated into the construction and operational environmental documentation.

16.1. Water quality

The development of a CEMP and installation of sediment and erosion control measures would mitigate the risks associated with the construction activities. Mitigation measures would include:

- the development of a site-specific CEMP
- the development of a soil and water management plan (SWMP)
- installation of sediment and erosion control measures that meet best management practises (BMPs) and may include silt fencing, sediment ponds, diversion swales and drains
- development of a monitoring program to monitor downstream impacts on water quality during construction and site rehabilitation; turbidity and pH will be key monitoring parameters
- instream sediment management measures to be put in place.

16.2. Aquatic fauna

An FFMP would be prepared for all aspects of the Proposal's construction. In addition to the CEMP, the following specific mitigation measures would be included:

- platypus nesting period of October to March should be avoided where possible during construction (dam wall and McCabes Bridge). If construction is to be undertaken at this time, site inspections are essential
- Site inspections by a qualified ecologist along the creek banks (construction area only) should be conducted prior to riparian vegetation clearing for platypus burrows.
- Construction periods would be kept to a minimum to limit disruption to aquatic fauna. Construction timing should be scheduled for low flow periods, although the Tweed Shire Council would have some control over flows via controlled dam releases during the construction period.

- Daily inspections of the works site (particularly around the waters edge) would be completed to check for aquatic fauna that may become entrapped in the works site after overnight foraging.

16.3. Fauna salvage

Should any areas require dewatering during construction, a qualified and experienced ecologist would be present on site to assist with the salvage and translocation of any aquatic fauna caught within the area to be dewatered. Specific permits and animal ethics approval would be required before undertaking fauna salvage.

16.4. Summary of mitigation measures

The proposed mitigation measures to be included in the development of the Proposal CEMP are summarised in

Table 26.

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Table 26: Safeguards and mitigation measures

Aspect/impact	Mitigation measure	Responsibility	Timing
Aquatic ecology			
Flora and Fauna Management Plan	A Flora and Fauna Management Plan (FFMP) must be prepared prior to construction commencing. The FMP will be included in the CEMP and will detail measures and management actions should aquatic fauna or fauna habitat be disturbed pre-, during, and post-construction.	Contractor	Pre-construction Construction Post-construction
Dewatering	A FMP must be prepared prior to any dewatering occurring. The FMP must detail measures and management actions should aquatic fauna or fauna habitat be disturbed pre-, during, and post-construction. A qualified ecologist must be on site during any dewatering activities to assist with fauna salvage. Appropriate permits and animal ethics approvals will be required. The removal of instream habitat structures (e.g. cobbles, boulders, vegetation, snags) must be minimised. Snags are not to be removed from waterways but should be realigned or relocated (ideally replaced) in accordance with the Policy and Guidelines for Fish Habitat Conservation and Management (2013). No removal of native riparian vegetation beyond those areas defined in the BDAR. Where required, ensure bed, banks and riparian zone is progressively rehabilitated as soon as practicable following disturbance, in accordance with a Rehabilitation Work Method Statement (RWMS) to be developed by the contractor	Contractor	Pre-construction Construction Construction
		Contractor	Pre-construction Construction Post-construction

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Aspect/impact	Mitigation measure	Responsibility	Timing
Sedimentation	Sedimentation management protocols must be installed and utilised at each trenching site in accordance with the endorsed CEMP and SWMP.	Contractor	Pre-construction
Water quality	Downstream water quality must be monitored during construction. The CEMP will include water quality monitoring requirements and outline a trigger action response plan to minimise downstream water quality and aquatic ecology impacts (e.g. turbidity, dissolved oxygen, salinity, metals). Installation of instream silt curtains may be required to reduce downstream transport of sediment. Erosion and sediment controls should be installed in accordance with the SWMP to mitigate the risk of turbid water being generated and entering the waterway. Any dewatering activities should meet best management practices for construction. Diversion or swales should be constructed around onsite water treatment plants to ensure untreated water does not enter waterways.	Contractor	Construction
Groundwater Administrative controls	A surface and groundwater management plan (SWMP) will be developed for the Proposal to support construction activities. The SWMP will be a sub-plan of the environmental management system. The SWMP will document the proposed mitigation and management measures for the approved Proposal, and will include the surface and groundwater monitoring program, reporting requirements, spill management and response, water quality trigger levels, corrective actions, contingencies, and responsibilities for all management measures.	Contractor	Construction

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Aspect/impact	Mitigation measure	Responsibility	Timing
	Reporting frameworks for the above will be prepared in accordance with licensing and agency requirements. Trigger levels for water quality parameters will be developed as part of the SWMP to assist in early identification of water quality trends. The monitoring program will be prepared in accordance with the approved Proposal's environment protection licence (EPL), once enacted.		

17. Summary and recommendations

17.1. Summary

This document details the aquatic ecology assessment undertaken as part of the Clarrie Hall Dam raising EIS. A range of biotic and abiotic components associated with the Proposal were assessed including aquatic habitat and presence/absence, and the distribution and abundance of aquatic fauna that may be present within the broader study area. After aquatic surveys were undertaken in accordance with the *Survey guidelines for Australia's threatened fish: Guidelines for detecting fish listed as threatened under the EPBC Act* (Department of Sustainability, Environment, Water, Population and Communities, 2011), it was found that the only listed, threatened species recorded within the broader study area was the platypus. The platypus is listed under the *Revised provisional list of animals requiring urgent management intervention* released in March 2020 following the 2019–20 bushfires (Department of Climate Change, Energy, the Environment and Water, 2020).

EMM Consulting Pty Limited undertook a number of assessments, which have been used as part of the aquatic ecology component of the EIS. A full list of these technical reports is presented in section 1.1.2 – Other relevant reports.

Based on the reports provided by EMM Consulting Pty Limited and the assessment detailed in this report, the following statements can be made regarding impacts to aquatic ecology resulting from the Proposal:

- Impacts to water quality may occur during the construction phase. A CEMP and a range of other management documents would be prepared to minimise and mitigate impacts resulting from the construction phase. Assuming the CEMP and other documents are implemented correctly, impacts resulting from the construction phase would be minimal and would easily be monitored and managed.
- Based on the modelled data provided by EMM Consulting Pty Limited, downstream impacts resulting from operation of the Proposal are considered to be nil to negligible and are limited to the following:
 - o There may be a 0.1 m increase in depth in riffle habitat within Doon Doon Creek (EMM Consulting Pty Limited, 2024b).

- o CWP will decrease in magnitude by 2°C and increase in frequency by 10% (EMM Consulting Pty Limited, 2024b).
- o Native fish mortality events (including events primarily related to Australian bass) will be likely continue to occur but will be in the same frequency as has been observed historically.
- A total of 23,460 m² of key fish habitat will be lost as part of the Proposal and must be offset accordingly.
- Impacts to the platypus will be nil to negligible.
- No impacts to the southern purple-spotted gudgeon will occur as a result of the Proposal.
- Impacts to GDEs will be nil to negligible, as reported by EMM Consulting Pty Limited (2024b).

Based on the aquatic assessments detailed in this report and the assessments undertaken by EMM Consulting Pty Limited, the Proposal **does not pose a significant impact to aquatic ecological values** associated with the Proposal.

17.2. Recommendations

The Tweed Shire Council is currently considering a range of biodiversity offset strategies to ensure biodiversity values are maintained or improved in the long term. Several recommendations that are relevant to aquatic and riparian ecology are provided below for consideration. The recommendations provide guidance on future research, monitoring (where applicable) and environmental management:

- Ensure water quality monitoring is undertaken downstream of the Proposal area during the construction phase. This will assist in minimising impacts to aquatic ecology that may result from construction of the Proposal.
- Ensure appropriate swales and sediment fencing are installed prior to commencing construction.
- Ensure an appropriate offsets pathway is implemented to offset losses to aquatic biodiversity associated with the loss of key fish habitat. There is the potential for enhancement proposals to be undertaken within the Tweed River catchment that would fulfill this requirement.

- Continue consultation with DPI Fisheries to determine the most appropriate aquatic habitat offsets, in alignment with the NSW Biodiversity Offsets Policy for Major Proposals and the accompanying fact sheet (*Biodiversity Offsets Policy for Major Proposals – Fact sheet: Aquatic biodiversity*).
- Ensure water is released in a strategic manner during the warmer months to minimise the risk of algal blooms occurring downstream of Clarrie Hall Dam.
- Monitor cold water releases in warmer months to ensure CWP does not exceed impacts associated with the current infrastructure.
- in addition to the CEMP and management plans to be prepared, follow mitigation measures provided in this document to ensure an extra level of security with regard to aquatic ecology associated with the Proposal.

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1. Appendix A – Database search summary

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Table 27: BioNet database search results (Northern Rivers catchment)

	Vernacular	Species	# Records
Fish			
Native			
Anguillidae	Short-fin Eel	<i>Anguilla australis</i>	19
Anguillidae	Long-fin Eel	<i>Anguilla reinhardtii</i>	52
Galaxiidae	Mountain Galaxias	<i>Galaxias olidus</i>	31
Percichthyidae	Eastern Freshwater Cod	<i>Maccullochella ikei</i>	3
Percichthyidae	Australian bass	<i>Macquaria novemaculeata</i>	12
Percichthyidae	Oxleyan Pygmy Perch	<i>Nannoperca oxleyana</i>	16
Eleotridae	Striped Gudgeon	<i>Gobiomorphus australis</i>	40
Eleotridae	Cox's gudgeon	<i>Gobiomorphus coxii</i>	12
Eleotridae	Empire Gudgeon	<i>Hypseleotris compressa</i>	13
Eleotridae	Firetail Gudgeon	<i>Hypseleotris galii</i>	46
Eleotridae	Flathead gudgeon	<i>Philypnodon grandiceps</i>	9
Mugilidae	Fresh Water Mullet	<i>Trachystoma petardi</i>	5
Exotic			
Cyprinidae	Goldfish	<i>Carassius auratus</i>	2
Cyprinidae	Common Carp	<i>Cyprinus carpio</i>	1
Poeciliidae	*Eastern Gambusia	<i>Gambusia holbrooki</i>	95
Crustacean			
Parastacidae	Common Yabby	<i>Cherax destructor</i>	5
Parastacidae	Blue Spiny Crayfish	<i>Euastacus sulcatus</i>	3
Mammal			
Ornithorhynchidae	Platypus	<i>Ornithorhynchus anatinus</i>	1 487

Table 28: PMST database search results (50 km buffer)

Family	Common Name	Scientific Name	Conservation status: EBPC Act	Potential distribution
Habitats				
-	Moreton Bay	-	Wetlands of International Importance	No Connectivity with Clarrie Hall Dam
Fish				
Percichthyidae	Eastern Freshwater Cod	<i>Maccullochella ikei</i>	E	Species or species habitat known to occur within buffer zone

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Family	Common Name		Scientific Name	Conservation status: EBPC Act	Potential distribution
Percichthyidae	Mary River Cod		<i>Maccullochella mariensis</i>	E	Species or species habitat known to occur within buffer zone
Percichthyidae	Oxleyan Perch	Pygmy	<i>Nannoperca oxleyana</i>	E	Species or species habitat may occur within area

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1. Appendix B – Literature review summary

Table 29: Literature review results (aquatic ecology – Northern Rivers catchment)

Reference	Report title	General	Impacts	Aquatic flora & riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology & water quality
(Department of Environment, Climate Change and Water, 2010d)	State of the Catchments 2010: Northern Rivers Region – Overview report	Gives an overview of the conditions of various ecological components with the Northern Rivers catchment	Impact of invasive species is rated moderate. Impacts listed within the report are: land-use, vegetation clearing, feral animals, and recreational facilities in aquatic ecosystems. Also: rapid development in coastal urban and peri-urban areas, mining impacts, ongoing land-use and land management, deforestation and removal of riparian zone, water extraction, climate change, social and economic pressures.	In good condition	In good condition	Insufficient data	-	-
(Department of the	State of the	Riverine ecosystem	Pest fish species, artificial barriers to fish passage,	-	Macroinvertebrate condition	-	-	-

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Reference	Report title	General	Impacts	Aquatic flora & riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology & water quality
of Environment, Climate Change and Water, 2010c)	Catchments 2010: Northern Rivers Region – Riverine ecosystems	condition has been assessed using water quality, macroinvertebrate, fish and hydrology indicators	agricultural and urban development, loss of native vegetation, water management, climate change		for the Tweed River catchment ranged from moderate – very good with the overall Northern Rivers catchment macroinvertebrate condition 'good'.			
(Department of Environment, Climate Change and Water, 2010a)	State of the catchment s 2010: Northern Rivers region – Wetlands	Overall, wetlands in the Northern Rivers region are in very poor condition	Catchment and habitat disturbance caused by land-use and vegetation Clearing, feral animals and recreational facilities in both wetlands and fringing zones. Pressure is typically to be high	-	-	-	-	-
(Department of Environment, Climate Change and Water, 2010a)	State of the catchment s 2010: Northern Rivers region – Wetlands	Northern Rivers region	-	-	-	-	-	-

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Reference	Report title	General	Impacts	Aquatic flora & riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology & water quality
Environment , Climate Change and Water, 2010)	catchment s 2010: Northern Rivers Region – Threatened Species	supports three endangered fish species and one vulnerable fish species. Threatened species recovery is reported as 'very poor'.						
(Department of Environment , Climate Change and Water, 2010)	State of the catchment s 2010: Northern Rivers Region – Capacity to manage natural resources	Tweed River region is a 'lower flood zone' with highly productive sugarcane and dairy industries	Weeds, feral animals and fire	-	-	-	-	-

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Reference	Report title	General	Impacts	Aquatic flora & riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology & water quality
(Department of Environment , Climate Change and Water, 2010)	State of the catchment s 2010: Northern Rivers Region – Groundwater	Within the Northern Rivers region there are alluvial, fractured rock, coastal sands and porous rock aquifer province groundwater management areas (GWMAs)	Pressure on GDEs from long-term and seasonal changes in groundwater levels, including the influence of changes in groundwater levels in highly connected systems; land use. GDEs considered to be experiencing very low to moderate pressure.	-	-	-	-	The groundwater aquifer systems in the Northern Rivers region are generally in good to very good Condition. Specifically, the Tweed River Coastal Sands regional groundwater levels are 'very good', local groundwater levels are 'very good' and the

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Reference	Report title	General	Impacts	Aquatic flora & riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology & water quality
								aquifer integrity is 'very good'. For the Tweed River alluvium is regional groundwater levels are 'very good', local groundwater levels are 'very good' and the aquifer integrity is 'very good'.
(Regional Development Australia, 2013)	Regional Development Australia: Northern	Population statistics provided	A total of 34 key threatening processes are reported to be occurring within the Tweed LGA. Water resources in the	-	-	Invasive aquatic species occurring	Three threatened fish species are reported to occur in	-

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Reference	Report title	General	Impacts	Aquatic flora & riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology & water quality
	Rivers NSW		Northern Rivers region are heavily influenced by human activities within the catchment area and key land uses in our region include agriculture, forestry, recreational and commercial fishing, and tourism			within the Northern Rivers catchment are reported to be eastern gambusia, carp, redfin and goldfish	the Tweed LGA.	
(NSW National Parks and Wildlife Service, 2003)	The North Coast bioregion	Provides a description of the North Coast bioregion	Agriculture, tourism, road construction, urban and agricultural runoff, changes to flow regimes.	-	-	-	-	Jurassic lithic and quartz sandstones and shales exposed in valleys. Tertiary volcanics of the Mt Warning complex. Mainly sheet

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Reference	Report title	General	Impacts	Aquatic flora & riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology & water quality
(Eco Logical Australia, 2019)	Environmental Flow Assessment Raising Clarrie Hall Dam	Investigates environmental flows associated with the proposed raising of Clarrie Hall Dam	Low DO within pools in Doon Doon creek; Accumulations of iron flocs were noted in 2019; Cold water releases potentially deterring fish moving into Doon Doon Creek from the Tweed River; Current infrastructure does not allow for bulk-water releases from Clarrie Hall Dam to mimic natural flows in the Tweed River system. Due to the dam wall and	-	-	Native – Australian bass, freshwater mullet, sea mullet, eel-tailed catfish, oxeye herring, freshwater herring, short-finned eel, long-	Southern purple spotted gudgeon (not in Doon Doon but in the Tweed catchment)	basalts, with minor rhyolite and tuffs. Major syenite and gabbro plug – remnant of the caldera explosion

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Reference	Report title	General	Impacts	Aquatic flora & riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology & water quality
			the absence of a fishway, aquatic fauna are restricted to the lower 1.5 km of Doon Doon Creek			finned eel, Australian smelt, Duboulayi rainbowfish, Pacific blue-eye, bullrout, olive perchlet, empire gudgeon, western carp gudgeon, fire-tailed gudgeon, striped gudgeon, Cox's gudgeon, flathead gudgeon,		

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Reference	Report title	General	Impacts	Aquatic flora & riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology & water quality
(North Coast Local Land Services, 2021)	North Coast Local Strategic Plan 2021–2026 (Extended plan)	Discusses focuses and efforts of the North Coast Local Strategic Plan 2021–2026	Climate change, land use, funding uncertainty, degradation of natural systems, biosecurity.	-	-	estuary perchlet Exotic – eastern mosquitofish, goldfish	-	-
(North Coast Local Land Services, 2018)	North Coast Regional Strategic Pest Animal Management Plan	Details strategies for managing feral animals in the North Coast region	Feral animals	-	-	Common carp, Mozambique tilapia (<i>Oreochromis mossambicus</i>)	-	-

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Reference	Report title	General	Impacts	Aquatic flora & riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology & water quality
(Department of Environment, Climate Change and Water NSW, 2010b)	2018–2023 Northern Rivers Regional Biodiversity Management Plan, National Recovery Plan for the Northern Rivers Region	The Northern Rivers Regional Biodiversity Management Plan (the Plan) constitutes the national regional recovery plan under the Environment Protection and Biodiversity Conservation Act 1999 for threatened species and ecological communities	Habitat loss, habitat modification, loss of individuals, loss of genetic integrity. Specific to hydrology and water quality: Alteration to natural flow regimes of wetlands from habitat modification and degradation, pollution from stormwater, activation of acid sulphate soils, blackwater events	Wetland vegetation in coastal floodplains is usually dominated by <i>Eleocharis</i> species, and swales in coastal dune systems are usually dominated by <i>Baumea</i> species. On the tablelands, sedgeland dominated by <i>Carex gaudichaudian</i> a form fens	Little known about the majority of invertebrates in the region; however, a study on macro-invertebrates in the region found that waterways in the coastal plains are in 'poor health', with those in the eastern fringe being the poorest. Waterways in the midland		The aquatic biodiversity of the region includes a diverse assemblage of fish species, including the threatened eastern cod (<i>Maccullochella ikei</i>), Purple Spotted Gudgeon and Oxleyan Pygmy Perch (<i>Nannoperca</i>	All present: Acid volcanics (rhyolite and trachyte), basalt. Granite meta-sediments including serpentine, sandstone, claystone, conglomerate, limestone, mudstone and siltstone. Unconsolidated sediments-alluvial,

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Reference	Report title	General	Impacts	Aquatic flora & riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology & water quality
		principally distributed in the Northern Rivers Region of NSW		when associated with herbs, grasses and species in the Cyperaceae family; or bogs when associated with sphagnum and other Cyperaceae species on more acid soils. The most diverse mangrove community is in the Tweed River, which supports 5 species of mangrove: grey	hills are in better condition and those in the escarpment ranges are near to optimal condition; waterways in the tablelands are less healthy.		<i>a oxleyana</i>). In addition, the Region supports Platypus and Water-rat (<i>Hydromys chrysogaster</i>).	estuarine, coastal barrier sand. Six types of groundwater-dependent ecosystems have been identified, including terrestrial vegetation, river base flow systems, aquifer and cave ecosystems, wetlands, terrestrial fauna, and estuarine and

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Reference	Report title	General	Impacts	Aquatic flora & riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology & water quality
				mangrove (<i>Avicennia marina</i>), stilt-rooted mangrove (<i>Rhizophora stylosa</i>), black mangrove (<i>Bruguiera gymnorhiza</i>), river mangrove (<i>Aegiceras corniculatum</i>) and milky mangrove (<i>Excoecaria agallocha</i>).				near-shore marine ecosystems
(NSW Office of Water, 2010)	Water Sharing Plan: Tweed River Area	Water sharing plan for the Tweed River area	Increased frequency and duration of drying in waterways	-	-	-	-	Coastal sands, up-river alluvial, coastal floodplain alluvial,

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Reference	Report title	General	Impacts	Aquatic flora & riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology & water quality
(Department of Primary Industries, 2006)	Unregulated and Alluvial Water Sources – Background document Reducing the impact of road crossings on aquatic habitat in coastal waterways – Northern Rivers, NSW	Detailed environmental assessments were conducted for over 2500 waterway crossings in the Northern Rivers Catchment Management Authority region	Structures such as causeways and pipe and box culverts can prevent fish passage due to excessive headloss (> 100 mm), increased flow velocities, and shallow flow depths (< 100 mm) that segregate upstream and downstream populations and habitats. Road crossings are also linked to increased sediment loads from point (unsealed		Insects, prawns, crayfish and freshwater mussels	Platypus and water rats, bony herring, fork-tailed catfish	Eastern freshwater cod and Oxleyan pygmy perch	fractured rock,

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Reference	Report title	General	Impacts	Aquatic flora & riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology & water quality
			roads) and diffuse sources (adjacent floodplains and slopes). Moreover, some structures can adversely affect fish by altering natural flow patterns, disrupting localised erosion and sedimentation processes, and affecting instream habitat condition.					

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2. Appendix C - Field survey design

Table 30: Location of, and components sampled at, each aquatic ecology site during the September 2023 field survey

Waterway	Site	Strahler (1952) order	Coordinates	Sample date	Key fish habitat	Water quality	Sediment quality	In situ Water Quality	Macrophytes	Algae	Aquatic invertebrates	Aquatic vertebrates	eDNA
Clarrie Hall Dam	CHD2	5th	-28.455283 153.288878	20-9-2023	ü	ü	ü	ü	ü	ü	-	ü	ü
Clarrie Hall Dam	CHD1	5th	-28.454118 153.309486	20-9-2023	ü	ü	ü	ü	ü	ü	-	ü	ü
Doon Doon Creek	DD5	5th	-28.432497 153.314202	17-9-2023	ü	ü	ü	ü	ü	ü	ü	ü	ü
Doon Doon Creek	DD4	5th	-28.436108 153.306278	17-9-2023	ü	ü	ü	ü	ü	ü	ü	ü	ü
Doon Doon Creek	MB1	5th	-28.484401 153.302034	18-9-2023	ü	ü	ü	ü	ü	ü	ü	ü	ü
Doon Doon Creek	DD3	5th	-28.477278 153.301233	20-9-2023	ü	ü	ü	ü	ü	ü	ü	ü	ü
Doon Doon Creek	DD2	5th	-28.496786 153.301947	19-9-2023	ü	ü	ü	ü	ü	ü	ü	ü	ü
Doon Doon Creek	DD1	4th	-28.505100 153.309328	19-9-2023	ü	ü	ü	ü	ü	ü	ü	ü	ü
Tweed River	TR1	6th	-28.423848 153.317895	18-9-2023	ü	ü	ü	ü	ü	ü	ü	ü	ü
Tweed River	TR2	6th	-28.392844 153.332638	22-9-2023	ü	ü	ü	ü	ü	ü	ü	ü	ü
Tweed River	TR3	6th	-28.369433 153.349297	21-9-2023	ü	ü	ü	ü	ü	ü	ü	ü	ü
Tweed River	BPW	7th	-28.343657 153.374587	21-9-2023	ü	ü	ü	ü	ü	ü	ü	ü	ü
Big Creek	BC1	3rd	-28.520814 153.314116	19-9-2023	ü	ü	ü	ü	ü	ü	ü	ü	ü
Commissioners Creek	CC1	4th	-28.487414 153.318768	19-9-2023	ü	ü	ü	ü	ü	ü	ü	ü	ü
Commissioners Creek	CC2	3rd	-28.495728 153.329879	19-9-2023	ü	ü	ü	ü	ü	ü	ü	ü	ü

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3. Appendix D – Habitat characteristics

Table 31: Habitat characteristics at each aquatic ecology site assessed during the September 2023 field survey

Waterway	Site	Strahler (1952) order	Key fish habitat: waterway type	Key fish habitat: waterway class	Description
Clarrie Hall Dam	CHD1	5th	Type 1	Class 1	CHD1 is located on Clarrie Hall Dam, within an arm that is connected to an unnamed 5th order stream (Error! Reference source not found.). At the time of the survey, the site was 2–40 m wide, with no flow. The substrate was dominated by sand and silt, with sections of bedrock above the waterline. Fish habitat present at the site at the time of the surveys included flooded trees, instream woody debris, macrophytes and trailing bank vegetation. The riparian zone was intact within the adjacent national park. The overstory, understory and ground cover comprised unidentified forest species and pasture grasses. A large amount of native and exotic macrophyte species were present including <i>Nymphoides</i> sp., <i>Typha</i> sp., <i>Ludwigia</i> sp., <i>Cabomba</i> , <i>Salvinia</i> , <i>Eleocharis</i> sp. and <i>Cyperus</i> sp.
Clarrie Hall Dam	CHD2	5th	Type 1	Class 1	CHD2 is located on Clarrie Hall Dam, within an arm that is connected to an unnamed 5th order stream (Error! Reference source not found.). The site was 1–40 m wide, with no flow observed at the time of the survey. The substrate was dominated by sand and silt, with sections of bedrock observed above the waterline. The site supported fish habitat in the form of small amounts of snag habitat, trailing bank vegetation and macrophytes with the occasional flooded tree. The riparian zone was cleared in one area that is used for grazing and allows stock access down to the dam. The remainder of the site is national park and supports remanent riparian vegetation of forest species. A large amount of native and exotic macrophyte species were present including Mexican water lily (<i>Nymphaea mexicana</i>), <i>Nymphoides</i> sp., <i>Eleocharis</i> sp., <i>Ludwigia</i> sp., <i>Cabomba</i> (<i>Cabomba caroliniana</i>), Parrot's feather (<i>Myriophyllum aquaticum</i>), <i>Salvinia</i> (<i>Salvinia molesta</i>), <i>Azolla</i> sp. and <i>Cyperus</i> sp.
Doon Doon Creek	DD1	4th	Type 1	Class 1	DD1 is located on Doon Doon Creek, at Costellos Road crossing (Error! Reference source not found.). At the time of the surveys, the site supported a series of shallow runs and small pools that were approximately 1–3 m wide with a low flow. The substrate was dominated by cobble and pebble with small amounts of bedrock, gravel and sand present. The riparian zone along the left bank was completely cleared for grazing, and stock have unrestricted access to the creek. The right bank was partially cleared, with isolated clusters of remnant riparian vegetation that had a ground cover of weedy pasture grasses and weeds. Impacts on the site are clearing and grazing. The site supported fish habitat in the form of a small amount of trailing bank vegetation, detritus cover and macrophytes. A small amount of emergent macrophyte species was present including <i>Ludwigia</i> sp., <i>Cyperus</i> sp., <i>Nasturtium</i> sp. and <i>Persicaria</i> sp.
Doon Doon Creek	DD2	5th	Type 1	Class 1	DD2 is located on Doon Doon Creek, at the Doon Doon Road crossing (Error! Reference source not found.). At the time of the survey, the site supported a combination of short runs and larger pools approximately 2–5 m wide with a low flow. Larger pools were present that were approximately 50 m by 10 m and up to 0.8 m deep. The substrate was dominated by cobble and boulder but small amounts of pebble, gravel and sand were present. The riparian zone was largely absent, having been cleared for grazing along the majority of the site, with unrestricted stock access upstream of the road crossing. The remaining clusters of uncleared riparian zone supported an overstory and understory of unidentified tree species and a ground cover of weeds and pasture grasses. The site supported large amounts of filamentous algae. Fish habitat was present in the form of instream woody debris, undercut banks and macrophytes. At a larger pool upstream of the road crossing, a platypus burrow was observed. A mixture of submerged and emergent macrophyte species was present including <i>Cyperus</i> sp., <i>Persicaria</i> sp. and <i>Vallisneria</i> sp.
Doon Doon Creek	DD3	5th	Type 1	Class 1	DD3 is located on Doon Doon Creek, immediately upstream of Clarrie Hall Dam, within an arm of the dam that transitions to Doon Doon Creek (Error! Reference source not found.). The site was 5–30 m wide, and no flow was observed at the time of the survey. The substrate comprised cobble and sand bars, with sections of bedrock.

Waterway	Site	Strahler (1952) order	Key fish habitat: waterway type	Key fish habitat: waterway class	Description
Doon Doon Creek	DD4	4th	Type 1	Class 1	The site contained large amounts of habitat in the form of instream woody debris and sections of undercut bank, trailing bank vegetation and macrophytes. The right bank of the arm supported an intact riparian zone, with an overstory and understory of unidentified tree species and a ground cover of pasture grasses and weeds. The left bank was clear of native vegetation and was utilised for agricultural grazing and a pine plantation at the time of the surveys. A large amount of native and exotic macrophyte species were present including <i>Nymphoides</i> sp., <i>Ludwigia</i> sp., <i>Cabomba</i>, <i>Myriophyllum</i> sp. and <i>Juncus</i> sp. DD4 is located on Doon Doon Creek, immediately downstream of the Clarrie Hall Dam wall (Error! Reference source not found.). The site supported a series of pools and riffles ranging from 1 m to 10 m wide, with low flow at the time of the survey. The substrate directly below the dam wall was dominated by bedrock and boulder from the construction of the dam wall. Moving downstream, the substrate was mainly comprised of cobble and pebble. The riparian zone was intact along both banks, with an overstory, midstory and understory of unidentified tree species. The ground cover was dominated by pasture grasses, and weeds. Fish habitat was present in the form of detritus and high amounts of filamentous algae, and small quantities of macrophytes, undercut bank and trailing bank vegetation. Impacts on the site were a change in natural hydrology due to the construction of the dam and the presence of small amounts of recreational and public space. A number of submerged and emergent macrophyte species were present including <i>Nymphoides</i> sp., <i>Persicaria</i> sp., <i>Ludwigia</i> sp., <i>Myriophyllum</i> sp., <i>Salvinia</i>, river club rush (<i>Schoenoplectus validus</i>), basket sedge (<i>Carex tereticaulis</i>) and <i>Cyperus</i> sp.
Doon Doon Creek	DD5	5th	Type 1	Class 1	DD5 is located on Doon Doon Creek, approximately 1,300 m downstream from the Clarrie Hall Dam wall and 400 m upstream from the Tweed River confluence (Error! Reference source not found.). At the time of the survey, the site supported a large pool approximately 100 m long, 15 m wide and up to 1 m deep with shallow riffle sections upstream and downstream of the pool. The flow at the site was low at the time of the survey. The substrate was dominated by cobble and pebble, but small amounts of other substrate types were present. The riparian zone was absent in sections along the right bank but was otherwise intact. The riparian overstory, midstory and understory supported unidentified species of forest trees, and the ground cover comprised pasture grasses and weeds. Impacts on the site was clearing and agriculture. Fish habitat was present in the form of undercut banks, macrophytes, trailing bank vegetation and detritus. Macrophyte species observed at the site included <i>Cyperus</i> sp. and Floating primrose-willow (<i>Ludwigia peploides</i>).
Doon Doon Creek	MB1	5th	Type 1	Class 1	MB1 is located on Doon Doon Creek, at McCabes bridge upstream of the full supply level of Clarrie Hall Dam (Error! Reference source not found.). At the time of the surveys, the site supported a series of pools, riffles and runs 1–10 m wide with a low flow. The substrate was dominated by cobble and pebble, with smaller amounts of gravel, sand and silt. Fish habitat present at the site included macrophytes, undercut banks, trailing bank vegetation and instream woody debris. Large amounts of filamentous algae and biofilm were also present. The riparian zone was completely cleared for grazing along the entirety of the site with unrestricted stock access to the creek. A number of submerged and emergent macrophyte species were present including <i>Juncus</i> sp., <i>Persicaria</i> sp., <i>Ludwigia</i> sp., curly pondweed (<i>Potamogeton crispus</i>), parrot's feather, river club rush, <i>Carex</i> sp., <i>Vallisneria</i> sp. and <i>Cyperus</i> sp.
Tweed River	TR1	6th	Type 1	Class 1	TR1 is located on the Tweed River, at Tarcoola Lane crossing approximately 700 m downstream of the confluence with Doon Doon Creek (Error! Reference source not found.). At the time of the surveys, the site supported a mixture of pools and riffles with an average width of 15 m. There was low flow at the time of the survey. The substrate is dominated by bedrock, cobble and sand, with small amounts of other substrate types. Fish habitat present at the site comprised undercut banks, instream woody debris, trailing bank vegetation and macrophytes.

Waterway	Site	Strahler (1952) order	Key fish habitat: waterway type	Key fish habitat: waterway class	Description
Tweed River	TR2	6th	Type 1	Class 1	The riparian zone was intact and supported an overstory, midstory and understory of unidentified forest species. The groundcover was dominated by pasture grasses and weeds. Submerged, emergent and floating macrophyte species were present at the site and included <i>Cyperus</i> sp., <i>Nymphoides</i> sp. and aquatic mosses. TR2 is located on the Tweed River, upstream from the Mount Warning Road crossing (Error! Reference source not found.). At the time of the surveys, the site supported a series of large pools and riffles, with low flow. The substrate was dominated by sand, cobble and boulder in the pool sections but less sand was present in the riffle zones. Fish habitat at the site consisted of undercut banks, macrophytes, instream woody debris and trailing bank vegetation. The riparian zone was largely intact except for a small section cleared along the road reserve on Kyogle Road. The overstory, midstory and understory consisted of unidentified forest tree species. The groundcover was dominated by pasture grasses and weeds. A variety of macrophyte species was present at the site including <i>Potamogeton</i> sp., <i>Cyperus</i> sp., <i>Juncus</i> sp., <i>Persecaria</i> sp. and aquatic moss.
Tweed River	TR3	6th	Type 1	Class 1	TR3 is located on the Tweed River, approximately 2,000 m upstream from the Byangum Bridge (Error! Reference source not found.). The site has been altered by the Bray Park Weir, which is located downstream and is a part of the upstream extent of the weir pool. At the time of the surveys, the site was around 35 m wide, with a predominately sand and gravel substrate and smaller amounts of other substrate types. Fish habitat at the site consisted of undercut banks, gravel beds, macrophytes, instream woody debris and trailing bank vegetation. Impacts at the site consisted of agriculture, grazing and clearing, with rural residential and road reserve land use along the banks. Slumping and erosion were present along sections of the site. The riparian zone was cleared in small sections but was largely intact, with an overstory, midstory and understory of forest tree species. The groundcover was dominated by pasture grasses and weeds. A variety of macrophyte species were present at the site including <i>Potamogeton</i> sp., <i>Nymphoides</i> sp., <i>Cyperus</i> sp., <i>Persecaria</i> sp. and tall flatsedge (<i>Cyperus eragrostis</i>).
Tweed River	BPW	7th	Type 1	Class 1	BPW is located on the Tweed River, upstream of the Bray Park Weir (Error! Reference source not found.). The site is a weir pool with no flow evident and is up to 50 m wide. The substrate was dominated by cobble and sand, while a small amount of other substrate types was present. The site is adjacent to urban and agricultural areas and was visibly impacted by stormwater inputs, rubbish, stock access, weeds and other urban influences. The site supported fish habitat in the form of large snags, undercut banks, detritus cover, macrophytes and trailing bank vegetation. The riparian zone had been cleared for agricultural use along the right bank, with stock access down to the river. The riparian zone was present and predominately intact along the left bank. Impacts from residential and urban development were present. The riparian zone overstory was dominated by <i>Eucalyptus</i> spp. while supporting other, unidentified tree species. The understory was dominated by unidentified tree species. The ground cover comprised weedy pasture grasses and weeds. Submerged macrophyte species were present at the site in the form of <i>Potamogeton</i> sp.
Big Creek	BC1	3 rd	Type 1	Class 1	BC1 is located on Big Creek at the Nightcap Road crossing (Error! Reference source not found.). The creek is 1–3 m wide and had low flow at the time of the survey. The substrate was bedrock, boulder and cobble primarily, with a mix of shallow runs and small pools. The site had been heavily scoured by floods. The riparian zone had been cleared completely for grazing, and stock had unrestricted access to the creek. At the time of the surveys, habitat present at the site was limited to macrophytes and detritus cover. Impacts on the site were agriculture, grazing, stock access and clearing. Emergent macrophyte species were present at the site and included <i>Juncus</i> sp., <i>Persicaria</i> sp. and <i>Nasturtium</i> sp.

Waterway	Site	Strahler (1952) order	Key fish habitat: waterway type	Key fish habitat: waterway class	Description
Commissioners Creek	CC1	4 th	Type 1	Class 1	CC1 is located on Commissioners Creek, at Commissioners Creek Road crossing (Error! Reference source not found.). At the time of the surveys, the site supported a series of pools and shallow runs around 4 m wide with very low flow. The substrate is predominately comprised of pebble, gravel and silt, with a small amount of other substrate types. Riffle and run sections were dominated by cobble with pools dominated by sandy substrate. The left bank had been cleared for agricultural use, and stock had unrestricted access to the creek. The right bank supported remanent riparian vegetation, with an overstory and understory dominated by unidentified tree species and the ground cover dominated by weedy pasture grasses and weeds. A small amount of trailing bank vegetation, macrophytes and undercut bank with large amounts of filamentous algae was present at the time of the survey. Impacts on the site were agriculture, in the form of clearing and grazing, and a septic/anoxic odour was present in the upstream pools. Emergent macrophyte species were present, in the form of <i>Carex</i> sp. and <i>Persicaria</i> sp.
Commissioners Creek	CC2	3 rd	Type 1	Class 1	CC2 is located on Commissioners Creek, at Commissioners Creek Road crossing approximately 2,200 m upstream of CC1 (Error! Reference source not found.). At the time of the surveys, the site supported a series of shallow runs and small pools approximately 2 m wide with a low flow. The flow at CC2 was higher than observed at CC1. A small flowing spring was observed on the creek that likely maintains water in the pools at CC2. The substrate was dominated by cobble and pebble but small amounts of other substrate types were present. The banks along the site showed signs of erosion. The riparian zone overstory was mostly absent and had largely been cleared for grazing and rural residential use. A riparian understory of unidentified tree species was present in patches, and the ground cover was dominated by weeds, with small amounts of pasture grasses. Impacts on the site were clearing and grazing. Small amounts of submerged and emergent macrophyte species were present in the form of <i>Carex</i> sp. and <i>Persicaria</i> sp.

Table 32: Habitat descriptions for sites surveyed during the January 2024 targeted Oxleyan pygmy perch surveys

Site	Zone	Coordinates	Description
PP1	56	533401 6858732	Site PP1 was a densely vegetated dam and creek line at the time of the survey. The dam was 25 m by 30 m, with no riparian zone overstory and understory and a ground cover of manicured lawn. The creek bed was incised and deep, with vertical rock along the left bank. Macrophytes present were parrot's feather, Salvinia, Ludwigia and Nymphoides. The habitat present would be capable of supporting Oxleyan pygmy perch.
PP4	56	533924 6858446	Site PP4 was an on-stream dam with a silt and sand substrate at the time of the survey. The dam was 25 m by 70 m and densely vegetated with a riparian zone of rainforest trees and ferns. Macrophytes present were Nymphoides, parrot's feather, Salvinia, Azolla, nutsedge and <i>Eleocharis</i> sp. The creek had a substrate of unconsolidated gravel and cobble, with a sequence of pools and riffles. No instream vegetation was present in the creek; however, it was well shaded. The habitat in the dam would be capable of supporting Oxleyan pygmy perch.
PP5a	56	535201 6858835	Site PP5a was a dam on private property located towards the top of the local catchment. The dam was 20 m by 40 m and up to 2 m deep at the time of the survey. Macrophytes were present predominately around the edges. Those macrophytes included Cumbungi, Nymphoides, softstem bulrush, bog bulrush (<i>Schoenoplectiella mucronate</i>) and Potamogeton. Due to location in the catchment and elevation (600 m) the site would be unlikely to support Oxleyan pygmy perch.
PP6	56	532938 6859424	Site PP6 was a 40 m by 40 m dam at the time of the survey, with a dense cover of macrophytes. The riparian zone was well vegetated with mature trees. The macrophytes present included Nymphoides and Azolla sp. The habitat present would be capable of supporting Oxleyan pygmy perch.
PP7	56	533321 6859326	Site PP7 was a small dam and creek line at the time of the survey. The riparian zone was densely vegetated, and a large amount of macrophytes was present. The macrophyte species present included Nymphoides, Potamogeton, Cumbungi, knotweed (<i>Persicaria</i> sp.), softstem bulrush, Ludwigia and giant sedge (<i>Cyperus exaltatus</i>). The habitat present would be capable of supporting Oxleyan pygmy perch.

Site	Zone	Coordinates	Description
PP9	56	533320 6861285	Site PP9 was a dam that has been constructed in a gully. The dam was 20 m by 40 m at the time of the survey and flowed downstream into the catchment to PP13 (Error! Reference source not found.). The macrophytes present were Nymphodies, Ludwigia, knotweed and nutsedge. The habitat present would be capable of supporting Oxleyan pygmy perch.
PP9a	56	533351 6860510	Site PP9a was located on a creek line downstream of site PP23 (Error! Reference source not found.). At the time of the survey, the creek was a series of short runs and pools and was generally less than 1 m wide. The substrate was cobble and gravel substrate with overlain silt. The macrophyte species present were parrot's feather, Cumbungi, sedge (<i>Carex</i> sp.) and <i>Azolla</i> sp. The habitat present would be capable of supporting Oxleyan pygmy perch.
PP10	56	533167 6860793	Site PP10 comprised a large lake and a small dam immediately upstream. The lake was constructed on an old watercourse and has little riparian zone, which was dominated by manicured lawns. The small dam was 15 m by 40 m at the time of the survey, with a riparian zone of trees and ferns covering 50% of the area. The waterbodies are fed by springs and runoff from the surrounding terrain. The macrophytes present were parrot's feather, <i>Azolla</i> sp., <i>Salvinia</i> , Cumbungi, <i>Nymphoides</i> , giant sedge and water lettuce (<i>Pistia stratiotes</i>). The habitat present would be capable of supporting Oxleyan pygmy perch.
PP13	56	533707 6861117	Site PP13 was a 40 m by 20 m dam at the time of the survey. The riparian overstory was largely absent but the understory and groundcover were present. The macrophyte species present were <i>Azolla</i> , <i>Nymphodies</i> , nutsedge, <i>Ludwigia</i> and knotweed (<i>Persicaria</i> sp.) The habitat present would be capable of supporting Oxleyan pygmy perch.
PP16	56	532623 6860106	Site PP16 is a small dam located in the flood plain of Korrumbyn Creek on private property. The dam was well vegetated with floating vegetation including <i>Nymphoides</i> and parrots feather.
PP21a	56	532839 6857678	Site PP21a was a dam with a dense cover of macrophytes at the time of the survey. The dam was located within a cleared paddock with unrestricted stock access and is adjacent to the Tweed River. Macrophyte species present were <i>Ludwigia</i> , parrot's feather, <i>Azolla</i> sp., <i>Nymphoides</i> , <i>Juncus</i> (<i>Juncus</i> sp.) and nutsedge. The habitat present would be capable of supporting Oxleyan pygmy perch.
PP22a	56	531757 6856655	This site was an unnamed ephemeral creek that discharges into the Tweed River. The creek was incised and had a gravel and coble substrate and was up to 5 m wide. The creek was a series of pools and small runs. Flows were low and water depth was a maximum of 0.5 m in the pools. No instream vegetation was present.
PP23	56	533372 6860092	Site PP23 was a constructed dam on a creek line, with dense macrophyte cover at the time of the survey. The dam was fed by 3 springs and had a silt substrate. The creek was a series of pools and short runs. The macrophyte species present were Cumbungi, common reed (<i>Phragmites australis</i>), parrot's feather, basket sedge, floating primrose-willow, sedges (<i>Carex</i> spp.), knotweed (<i>Persicaria</i> sp.), giant sedge and <i>Eleocharis</i> sp.. The habitat present in the dam and creek would be capable of supporting Oxleyan pygmy perch.

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4. Appendix E – Water quality data (desktop analysis)

Table 33: Metals and nutrients monitored at site X and site Z monitoring sites.

Parameter	Depth (m)	Range						ANZECC & ARMCANZ (2000) triggers (mg/L)		ANZG 'DGVs for 80% species protection' (mg/L)
		Site X (2001–2023; dates vary)			Site Z (2002–2023; dates vary)			Lower limit	Upper limit	DGV
		Min	Med	Max	Min	Med	Max			
Soluble iron	0	0.001	0.19	1.5	0.01	0.17	4.79			
	4	0.001	0.24	16	0.01	0.23	1.54			
	8	0.001	0.34	4.17	0.01	0.31	4.58			
	12	0.01	0.61	7.35	0.01	0.54	6.84			
	16	0.01	0.94	9.01	0.01	0.88	11	-	-	-
	20	0.01	1.51	53.8	0.01	1.63	40			
	24	1.81	8.89	24.7	0.02	6.44	12			
	28	2.59	9.00	19.6	-	-	-			
	30	14.40	14.40	14.40	-	-	-			
Soluble manganese	0	0.001	0.010	0.50	0.001	0.01	0.432			
	4	0.001	0.013	0.67	0.001	0.01	0.52			
	8	0.001	0.060	1.03	0.001	0.04	0.83			
	12	0.001	0.170	1.47	0.001	0.129	5.25			
	16	0.001	0.259	2.11	0.001	0.24	1.62	-	-	-
	20	0.001	0.370	14.0	0.001	0.42	5.52			
	24	0.33	0.650	1.07	0.001	0.87	2.14			
	28	0.45	0.720	1.21	-	-	-			
	30	0.76	0.76	0.76	-	-	-			
Total Kjeldahl nitrogen	0	1.1*	1.1*	1.1*	-	-	-			
	4	0.2*	0.6*	1.1*	0.2^	0.6^	2.2^			
	8	0.2*	0.6*	1*	0.2^	0.6^	1.4^	-	-	-
	12	0.2*	0.6*	2.4*	0.2^	0.6^	0.9^			
	16	0.2*	0.7*	4.5*	0.2^	0.6^	9.7^			

Parameter	Depth (m)	Range						ANZECC & ARMCANZ (2000) triggers (mg/L)	ANZG 'DGVs for 80% species protection' (mg/L)
		Site X (2001–2023; dates vary)			Site Z (2002–2023; dates vary)			Lower limit	Upper limit
		Min	Med	Max	Min	Med	Max		DGV
Total phosphorus	20	0.2*	1.1*	23.6*	0.2^	0.8^	12.9^		
	24	0.2*	2.1*	14.8*	0.3^	3.2^	10.1^		
	28	1.1*	4.8*	22.5*	-	-	-		
	30	2.7*	2.7*	2.7*	-	-	-		
	0	0.02	0.03	0.29	0.02 ⁺	0.03 ⁺	0.31 ⁺		
	4	0.01	0.04	0.98	0.02 ⁺	0.04 ⁺	1.18 ⁺		
	8	0.02	0.04	0.94	0.02 ⁺	0.04 ⁺	0.9 ⁺		
	12	0.01	0.04	1.17	0.02 ⁺	0.05 ⁺	1.29 ⁺	-	0.01
	16	0.01	0.05	1.14	0.02 ⁺	0.05 ⁺	1.31 ⁺		
	20	0.02	0.05	1.8	0.02 ⁺	0.06 ⁺	1.48 ⁺		
	24	0.06	0.27	5.1	0.03 ⁺	0.66 ⁺	2.5 ⁺		
	28	0.07	0.67	4.5	-	-	-		
	30	0.41	0.41	0.41	-	-	-		
	0	0.14	0.33	1.26	0.16	0.32	1.58		
	4	0.05	0.51	4.68	0.06	0.41	2.5		
	8	0.07	0.45	2.83	0.05	0.4	2.66		
Total nitrogen	12	0.07	0.44	15.01	0.05	0.41	3.38	-	0.35
	16	0.08	0.48	4.5	0.05	0.46	9.7		
	20	0.05	0.53	27.7	0.12	0.54	13		
	24	0.4	2.05	14.9	0.4	3.4	10.2		
	28	1.1	4.8	22.6	-	-	-		
	30	2.7	2.7	2.7	-	-	-		
Nitrogen oxidised	0	0.01 [#]	0.01 [#]	0.01 [#]	-	-	-		
	4	0.01 [#]	0.05 [#]	0.35 [#]	0.01 ^{<}	0.05 ^{<}	0.35 ^{<}		
	8	0.01 [#]	0.05 [#]	0.34 [#]	0.01 ^{<}	0.05 ^{<}	0.34 ^{<}	-	0.01
	12	0.01 [#]	0.05 [#]	0.35 [#]	0.01 ^{<}	0.05 ^{<}	0.34 ^{<}		
	16	0.01 [#]	0.04 [#]	0.38 [#]	0.01 ^{<}	0.05 ^{<}	0.42 ^{<}		

Parameter	Depth (m)	Range						ANZECC & ARMCANZ (2000) triggers (mg/L)		ANZG 'DGVs for 80% species protection' (mg/L)
		Site X (2001–2023; dates vary)			Site Z (2002–2023; dates vary)			Lower limit	Upper limit	
		Min	Med	Max	Min	Med	Max			
Total manganese	20	0.01 [#]	0.03 [#]	0.36 [#]	0.01 ^{<}	0.05 ^{<}	0.39 ^{<}			
	24	0.01 [#]	0.02 [#]	0.36 [#]	0.03 ^{<}	0.06 ^{<}	0.21 ^{<}			
	28	0.01 [#]	0.02 [#]	0.16 [#]	-	-	-			
	30	0.01 [#]	0.01 [#]	0.01 [#]	-	-	-			
	0	0.006 ^{>}	0.04 ^{>}	0.63 ^{>}	0.007 ^{>}	0.03	0.483 ^{>}			
	4	0.009 ^{>}	0.07 ^{>}	0.71 ^{>}	0.008 ^{>}	0.062	0.53 ^{>}			
	8	0.01 ^{>}	0.13 ^{>}	1.09 ^{>}	0.01 ^{>}	0.11	0.95 ^{>}			
	12	-	-	-	0.01 ^{>}	0.17	5.25 ^{>}	-	-	3.6
	16	0.01 ^{>}	0.22 ^{>}	1.59 ^{>}	0.01 ^{>}	0.271	1.67 ^{>}			
	20	0.01 ^{>}	0.30 ^{>}	2.11 ^{>}	0.01 ^{>}	0.45	6.48 ^{>}			
Nitrate	24	0.01 ^{>}	0.39 ^{>}	1.71 ^{>}	-	-	-			
	0	0.19'	0.45'	1.22'	0.02'	0.49'	1.66'			
	4	0.33'	0.53'	3.76'	0.3'	0.48'	1.14'			
	8	0.31'	0.50'	14.9'	0.31'	0.47'	1.35'	-	-	-
	12	0.29'	0.49'	5.49'	0.31'	0.49'	1.14'			
	16	0.35'	0.54'	1.45'	0.32'	0.54'	1.4'			
Total iron	20	0.37'	0.57'	1.58'	0.37'	0.62'	1.66'			
	0	0.01 ^x	0.41 ^x	27.1 ^x	0.03 ^x	0.39 ^x	24.9 ^x			
	4	0.03 ^x	0.55 ^x	61.7 ^x	0.01 ^x	0.52 ^x	46.3 ^x			
	8	0.04 ^x	0.79 ^x	116 ^x	0.03 ^x	0.74 ^x	105 ^x	-	-	-
	12	0.04 ^x	1.29 ^x	133 ^x	0.05 ^x	1.21 ^x	148 ^x			
	16	0.07 ^x	2.10 ^x	164 ^x	0.08 ^x	2.27 ^x	161 ^x			
	20	0.05 ^x	2.65 ^x	187 ^x	0.14 ^x	3.45 ^x	170 ^x			
	0	1.6 ^x	3.69 ^x	8.6 ^x	1.9 ^x	3.6 ^x	6.6 ^x	-	-	-
	4	-	-	-	-	-	-			

Parameter	Depth (m)	Range						ANZECC & ARMCANZ (2000) triggers (mg/L)		ANZG 'DGVs for 80% species protection' (mg/L)
		Site X (2001–2023; dates vary)			Site Z (2002–2023; dates vary)			Lower limit	Upper limit	DGV
		Min	Med	Max	Min	Med	Max			
Total organic carbon	8	1.4 ^x	3.90 ^x	7.6 ^x	1.2 ^x	3.78 ^x	7 ^x			
	12	-	-	-	-	-	-			
	16	-	-	-	0.1 ^x	4 ^x	7.7 ^x			
	20	0.9 ^x	3.90 ^x	7.1 ^x	0.1 ^x	4 ^x	7.7 ^x			
	0	0.71 ^x	3.24 ^x	11 ^x	0.65 ^x	3.42 ^x	10.7 ^x			
Total aluminium	4	1.37 ^x	3.81 ^x	10.8 ^x	1.77 ^x	4.1 ^x	12 ^x			
	8	2.59 ^x	6.68 ^x	12.9 ^x	3.34 ^x	6.67 ^x	24.1 ^x	-	-	pH not known
	12	3.43 ^x	8.27 ^x	21.1 ^x	2.69 ^x	9.54 ^x	16.9 ^x			
	16	5.38 ^x	17.45 ^x	51.0 ^x	5.41 ^x	11.85 ^x	55.7 ^x			
	20	5.05 ^x	35.60 ^x	60.1 ^x	5.39 ^x	14.9 ^x	53.6 ^x			
Soluble aluminium	0	0.16 ^p	0.84 ^p	1.41 ^p	0.26 ^p	0.78 ^p	1.08 ^p			
	4	0.13 ^p	0.88 ^p	1.65 ^p	0.41 ^p	0.79 ^p	1.25 ^p			
	8	0.2 ^p	0.86 ^p	1.31 ^p	0.19 ^p	0.8 ^p	1.29 ^p	-	-	-
	12	0.19 ^p	0.97 ^p	1.58 ^p	0.16 ^p	0.9 ^p	1.25 ^p			
	16	0.06 ^p	0.86 ^p	1.29 ^p	0.16 ^p	0.82 ^p	1.2 ^p			
	20	0.23 ^p	0.88 ^p	1.89 ^p	0.16 ^p	0.84 ^p	1.73 ^p			

Note: All units are mg/L unless otherwise specified. pH unknown for date range so unable to determine appropriate DGV. Pink shading denotes values exceed the ANZECC & ARMCAZ (2000) trigger values; Green shading indicates values exceed the ANZG 'DGVs for 80% species protection. *Denotes date range: 2001-2008; ^ denotes date range: 2002-2009; + denotes date range: 2006-2023; # denotes date range: 2001-2003; < denotes date range: 2002-2003; > denotes date range: 2006-2023; ' denotes date range: 2006-2009; x denotes date range: 2006-2023; p denotes date range: 2022-2023.

Table 34: Physico-chemical parameters, nutrients, metals and metalloids, and coliform readings from Clarrie Hall Dam and the Tweed River.

	Clarrie Hall Dam intake tower (2000–2023)			Doon Doon Creek McCabes Bridge (2016– 2023)			Palmers crossing (2016–2023)			Road upstream Byangum Bridge (2000–2023)			Tweed River of downstream Smiths Creek (2000– 2023)			River of (2000–		ANZECC & ARMCANZ (2000) triggers (mg/L)		ANZG 'DGVs for 80% species protection' (mg/L)
Parameter (mg/L)	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Low	High	DGV		
Alkalinity (CaCO ₃)	2.3	26	78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Aluminium (soluble)	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	0.13	1.04	-	-	-		
Aluminium (total)	0.01	0.05	37.7	-	-	-	-	-	-	-	-	-	<0.01	0.3	5.66	-	-	0.15 (based on pH >6.5)		
Ammoniao	0.01	0.06	11	<0.02	0.02	0.03	<0.02	0.02	0.04	<0.01	0.03	0.1	<0.01	0.03	0.1	-	20 10	2.3		
Biological oxygen demand	1	1.8	4.7	<1.0	1.4	7.8	<1.0	1.3	2.9	<1.0	1.4	4	0.8	1.2	8	-	-	-		
Calcium (total)	1.2	3.6	5.57	-	-	-	-	-	-	-	-	-	3.028	6.8	9.415	-	-	-		
Chlorophyll 'a' (µg/L)	0.01	35	2140	<1	2	90	<1.0	2	16.7	<1.0	2.5	13	<1.0	2	13	-	5 5	-		
Conductivity (µScm ⁻¹)	43.9	101	336	56	146.35	238	73	170.6	212	72	145.1	446	70	142.2	393	200 20	300 30	-		
Dissolved organic carbon	1.6	3.6	9.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Dissolved oxygen (membrane electrode)	4.5	4.5	4.5	5.1	9.3	11.7	5.9	8.9	11	3.5	8	29.3	4.8	8.3	12.6	-	-	-		
Dissolved oxygen (% saturation)	-	-	-	61	103.8	155.6	73	96.8	102	43	91	112	57	92	123	85 90	110 110	-		
Fluoride	0.02	0.07	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Iron (soluble)	0.01	0.22	1.43	-	-	-	-	-	-	<0.01	0.37	1.02	0.25	0.55	1.05	-	-	-		
Iron (total)	0.01	0.32	53	-	-	-	-	-	-	0.02	0.35	0.89	0.11	0.45	1.27	-	-	-		
Magnesium (total)	0.761	2.46	5.469	-	-	-	-	-	-	2.92	5.54	7.92	1.89	4.57	5.8	-	-	-		
Manganese (soluble)	0.001	0.03	0.67	-	-	-	-	-	-	<0.01	0.02	0.13	<0.01	0.03	0.09	-	-	-		
Manganese (total)	0.00514	0.05	0.73	-	-	-	-	-	-	<0.01	0.03	0.13	<0.01	0.03	0.15	-	-	3.6		
Nitrate	0.01	0.05	1.5	<0.02	0.08	0.57	<0.02	0.04	0.73	<0.05	0.06	0.62	0.01	0.05	0.73	-	-	-		
Nitrite	0.02	0.03	0.05	<0.02	0.02	0.02	<0.02	0.02	0.03	<0.05	0.02	0.02	<0.02	0.02	0.02	-	-	-		
Nitrogen (oxidised)	0.02	0.05	1.53	<0.02	0.08	0.59	<0.02	0.04	0.75	<0.05	0.06	0.64	<0.02	0.05	0.75	-	0.04 0.01	-		
Nitrogen (total)	0.21	0.38	4.67	0.06	0.24	1.12	0.13	0.25	1.24	0.1	0.27	1.1	0.15	0.26	1.24	-	0.50 0.35	-		

	Clarrie Hall Dam intake tower (2000–2023)			Doon Doon Creek McCabes Bridge (2016– 2023)			Palmers crossing (2016–2023)			Road Tweed upstream Byangum (2000–2023)			River of Tweed downstream Smiths Creek (2000– 2023)			River of (2000– ANZECC & ARMCANZ (2000) triggers (mg/L)			ANZG 'DGVs for 80% species protection' (mg/L)	
Parameter (mg/L)	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Low	High	DGV		
Orthophosphate	0.01	0.05	0.73	<0.02	0.03	0.07	<0.02	0.02	0.05	<0.01	0.02	0.56	0.01	0.02	0.08	-	-	-	-	-
pH	5.9	7.1	7.3	6.2	7.3	8.5	6.5	7.3	7.9	6.4	7.3	8.7	6.2	7.2	8.1	6.5	8.0	-	-	-
Phosphorus (total)	0.01	0.04	2.8	0.03	0.07	0.21	0.03	0.05	0.14	<0.05	0.05	0.14	<0.01	0.05	0.19	-	0.05	-	-	-
Silica (total)	1.69	14.55	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silica (soluble)	3	13.1	92	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silicon (ottal)	1.07	6.52	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Suspended Solids	1	3	206	<1.0	3.6	77	<1.0	4	65	<1	3.6	46	<1	3	106	-	-	-	-	-
Total dissolved solids	27.2	61	881	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Kjeldahl nitrogen	0.05	0.4	3.14	0.06	0.23	1.05	0.09	0.24	0.65	<0.2	0.27	2	0.11	0.25	0.8	-	-	-	-	-
Total organic carbon	0.3	3.89	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turbidity (NTU)	0.3	2.9	449	1.6	5.5	85	1.1	7.5	104	0.5	4.9	63	0.8	5.05	181	6	50	-	-	-
<i>Escherichia</i> coliforms (cfu/100ml)	1	4	2599	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thermotolerant coliforms (cfu/100ml)	4	1	2599	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total coliforms (cfu/100mL)	1046	36	99315	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

All units are mg/L unless otherwise specified; pink denotes default trigger values for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs) and blue denotes default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers). (ANZECC and ARMCANZ, 2000); Green values exceed the DGVs, DGVs are for the protection of 80% of species representative of highly disturbed systems (Water Quality Australia, 2018).

Table 35: Physico-chemical parameters recorded at Clarrie Hall Dam and the Bray Park Weir.

	Bray Park Weir 2021-2022			Bray Park Weir (2022- 2023)			Bray Park Weir Hole (2020-2022)			Site X (2001-2022; dates vary)			Site Z (2001-2022; dates vary)			ANZECC & ARMCANZ (2000) triggers (mg/L)		ANZG 'DGVs for 80% species protection' (mg/L)	
Depth	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Max	Min	Max
0	12.25	21.03	27.74	16	24.3	27.9	12.25	20.61	27.74	12.22	22.3	30.30	10.4	22.7	29.5				
1	13.74	20.22	27.83	15.4	23.9	27.7	13.74	20.08	27.83	9.00	22.3	35.04	8.8	22.5	30.6				
2	13.66	20.36	27.79	15.4	22.9	27.4	13.66	20.22	27.79	9.10	22.05	34.36	9	22.1	30.3	-	-	-	-
3	13.63	20.35	25.57	15.3	22	27.2	13.63	20.15	25.57	9.20	21.4	34.14	8.1	21.6	29.3				
4	13.61	20.22	27.71	15.1	21.8	27.1	13.61	20.12	27.71	9.20	21.1	33.38	7.6	21.1	28.9				

	Bray Park Weir 2021-2022			Bray Park Weir (2022- 2023)			Bray Park Weir Hole (2020-2022)			Site X (2001-2022; dates vary)			Site Z (2001-2022; dates vary)			ANZECC & ARMCANZ (2000) triggers (mg/L)		ANZG 'DGVs for 80% species protection' (mg/L)	
Depth	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Max	Min	Max
5	13.56	20.18	27.60	14.8	20.9	26.8	13.56	20.10	27.60	9.10	20.5	32.51	7.1	20.6	28.5				
6	13.06	20.02	25.77	14.6	20.5	24.5	13.06	19.93	25.77	9.00	20	31.61	6.8	20.0	27.8				
7	13.03	20.07	27.31	14.5	20.4	22	13.03	19.82	27.31	8.90	19.6	26.80	6.4	19.7	27.1				
8	12.97	19.15	26.89	14.5	20.2	22	12.97	18.90	26.89	8.90	19.233	169.00	6.1	19.3	26.9				
9	12.97	16.19	23.99	14.7	16.95	21.8	12.97	17.18	23.99	8.80	18.7	26.50	5.3	18.9	165				
10	12.96	15.72	23.98	15.8	15.9	21.1	12.96	15.92	23.98	8.30	18.35	26.50	2.9	18.4	26.4				
11	15.26	15.41	15.55	14.7	14.7	14.7	15.26	15.41	15.55	8.70	18	26.40	4.6	18.1	26.3				
12	15.21	15.34	15.47	-	-	-	15.21	15.34	15.47	8.60	17.7	26.30	4.4	17.8	26.3				
13	15.14	15.19	15.24	-	-	-	15.14	15.19	15.24	8.60	17.45	26.30	4	17.5	26.2				
14	15.13	15.16	15.18	-	-	-	15.13	15.16	15.18	5.40	17.1	26.20	3.5	17.2	26.1				
15	15.07	15.10	15.13	-	-	-	15.07	15.10	15.13	7.50	16.7	26.20	1.6	16.9	26.1				
16	14.99	15.00	15.02	-	-	-	-	-	-	3.20	16.5	158.20	3.1	16.6	26				
17	14.92	14.95	14.98	-	-	-	-	-	-	8.30	16.3	25.90	2.6	16.4	25.9				
18	14.91	14.91	14.92	-	-	-	-	-	-	8.20	16.1	25.70	2.3	16.2	25.8				
19	14.88	14.91	14.95	-	-	-	-	-	-	8.10	16	25.70	1.9	16.1	25.7				
20	14.89	14.89	14.89	-	-	-	-	-	-	8.00	15.9	25.50	1.5	16.0	25.5				
24	-	-	-	-	-	-	-	-	-	15.40	15.9	17.60	15.7	16.0	20.2				
28	-	-	-	-	-	-	-	-	-	15.50	15.9	16.20	15.8	15.9	16.5				
30	-	-	-	-	-	-	-	-	-	16.20	16.2	16.20	15.8	15.8	15.9				
0	7.43	8.69	10.8	6.32	8.19	9.99	7.43	8.69	10.8	0.47	7.08	12.01	0	7.06	12.16				
1	7.52	9.27	10.58	4.96	8.14	9.8	7.52	9.10	10.58	0.01	6.64	26.8	0	6.34	16.99				
2	6.44	9.35	11.28	3.63	7.82	9.68	6.44	9.26	11.28	0.02	5.66	25.81	0	4.895	18.5				
3	4.45	9.31	12.18	1.51	6.32	9.67	4.45	9.18	12.18	0.03	3.97	22.3	0	3.37	13.7				
4	2.35	9.33	13.11	0.56	5.82	8.8	2.35	9.32	13.11	0.01	3.04	31.43	0	2.6	17.94				
5	0.85	9.44	14.04	0.39	5.065	8.61	0.85	9.29	14.04	0.01	2.48	28.75	0	2.085	16				
6	1.47	9.41	14.73	0.28	2.42	8.57	1.47	9.28	14.73	0.01	1.83	20.04	0	1.63	16.5				
7	0.75	9.39	15.63	0.26	1.54	8.38	0.75	9.27	15.63	0.01	1.41	16.83	0	1.215	16.12				
8	0.54	8.06	15.21	0.15	1.42	8.29	0.54	7.96	15.21	0.01	1.00	29.66	0	0.87	16.92				
9	0.39	3.41	9.45	0.91	6.215	8.17	0.39	2.13	9.45	0.01	0.69	18.73	0	0.57	17.86				
10	0.31	1.29	9.43	0.35	5.93	8.13	0.31	1.49	9.43	0.01	0.50	18.94	0	0.35	18.77				
11	0.83	0.83	0.83	5.91	5.91	5.91	0.83	0.83	0.83	0.01	0.35	7.92	0	0.24	27.31	-	-	-	-
12	0.7	0.71	0.71	-	-	-	0.7	0.71	0.71	0.01	0.28	8.8	0	0.185	13.2				
13	0.62	0.63	0.63	-	-	-	0.62	0.63	0.63	0.01	0.25	26.81	0	0.14	11.2				
14	0.55	0.56	0.56	-	-	-	0.55	0.56	0.56	0.01	0.21	8.87	0	0.11	25.3				
15	0.47	0.50	0.52	-	-	-	0.47	0.50	0.52	0.01	0.19	7.84	0	0.08	14.52				
16	0.42	0.43	0.43	-	-	-	-	-	-	0.01	0.16	8.15	0	0.06	11.8				
17	0.32	0.36	0.39	-	-	-	-	-	-	0.01	0.14	13.1	0	0.04	13.5				
18	0.29	0.33	0.37	-	-	-	-	-	-	0.01	0.09	8	0	0.03	9.15				
19	0.29	0.32	0.35	-	-	-	-	-	-	0.01	0.08	773	0	0.02	9.16				
20	0.28	0.32	0.35	-	-	-	-	-	-	0.01	0.04	8	0	0.02	9.18				
24	-	-	-	-	-	-	-	-	-	0.1	0.39	1.2	0	0.3	7.6				

Depth	Bray Park Weir 2021-2022			Bray Park Weir (2022-2023)			Bray Park Weir Hole (2020-2022)			Site X (2001-2022; dates vary)			Site Z (2001-2022; dates vary)			ANZECC & ARMCANZ (2000) triggers (mg/L)		ANZG 'DGVs for 80% species protection' (mg/L)	
	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Max	Min	Max
28	-	-	-	-	-	-	-	-	-	0.2	0.39	0.8	0.05	0.31	1.8				
30	-	-	-	-	-	-	-	-	-	0.25	0.35	0.45	0.1	0.2	0.4				
0	88.3	98.65	104.1	-	-	-	88.3	98.65	104.1	11.5*	93.15*	113.2*	14.1*	89.5	112.1*				
1	87.3	96.6	115.6	-	-	-	87.3	96.60	115.6	5.2*	90.5*	115.1*	5*	78.7	117.9*				
2	76.2	96.2	124.8	-	-	-	76.2	96.20	124.8	3.7*	75.1*	126*	0.9*	61.2	124.7*				
3	51.9	94.75	133.3	-	-	-	51.9	94.75	133.3	3.1*	61.35*	133.2*	0.8*	58.3	132.8*				
4	27	94	142.5	-	-	-	27	94.00	142.5	2.1*	56.35*	142.1*	0.7*	52.9	142.7*				
5	9.7	93.6	151.3	-	-	-	9.7	93.60	151.3	1*	39.85*	149.5*	0.7*	39.15	154.3*				
6	15.8	93.5	161	-	-	-	15.8	93.50	161	0.6*	31.9*	158.6*	0.6*	28.6	163.5*				
7	8.1	93.35	169.8	-	-	-	8.1	93.35	169.8	0.5*	25.4*	167.5*	0.6*	23.7	168.1*				
8	5.6	89.5	176	-	-	-	5.6	89.50	176	0.5*	13.9*	174.6*	0.5*	16.6	172.9*				
9	4	38	97.8	-	-	-	4	38.00	97.8	0.4*	8.2*	182.6*	0.3*	17.7	181.6*				
10	3.2	12.9	97.9	-	-	-	3.2	12.90	97.9	0.4*	8*	191.3*	0.3*	13.5	190.9*	85	110	-	-
11	8.2	8.25	8.3	-	-	-	8.2	8.25	8.3	0.4*	6.15*	75.8*	0.2*	11.5	100.5*	90	110		
12	7	7.05	7.1	-	-	-	7	7.05	7.1	0.3*	8.9*	93.2*	0.1*	12.25	100.3*				
13	6.1	6.15	6.2	-	-	-	6.1	6.15	6.2	0.3*	6.9*	63.3*	0*	8.2	100.1*				
14	5.5	5.55	5.6	-	-	-	5.5	5.55	5.6	0.2*	7.9*	53.7*	-0.1*	6.45	99.7*				
15	4.7	4.9	5.1	-	-	-	4.7	4.90	5.1	0.3*	6.5*	54.9*	-0.2*	4.1	99.5*				
16	4.2	4.2	4.2	-	-	-	-	-	-	0.2*	4.55*	54.7*	-0.2*	2.65	99.4*				
17	3.2	3.5	3.8	-	-	-	-	-	-	0*	4.15*	54.4*	-0.2*	2.5	99.3*				
18	2.9	3.3	3.7	-	-	-	-	-	-	0*	5.15*	53.5*	-0.3*	3.4	99.2*				
19	2.9	3.2	3.5	-	-	-	-	-	-	-0.1*	5.1*	53.1*	-0.3*	2	99.1*				
20	2.7	3.05	3.4	-	-	-	-	-	-	-0.1*	3.85*	52.3*	-0.3*	1.9	99*				
0	0.6	130.9	195.2	17.7	150.05	172	-	-	-	-	-	-	-	-	-				
1	0.6	130.1	194.8	103.5	154.5	171	-	-	-	-	-	-	-	-	-				
2	0.6	130.1	194.8	103.5	155.4	171.3	-	-	-	-	-	-	-	-	-				
3	0.7	131.3	194.8	95.5	150.2	171.6	-	-	-	-	-	-	-	-	-				
4	0.6	128.7	190.8	85.5	148.3	173	-	-	-	-	-	-	-	-	-				
5	0.6	124.85	182.3	89.4	145	178	-	-	-	-	-	-	-	-	-				
6	0.8	125.25	174.5	103.5	144.9	189	-	-	-	-	-	-	-	-	-				
7	0.6	122.4	172.8	103.5	150.45	205.6	-	-	-	-	-	-	-	-	-				
8	0.6	123.75	179.7	103.4	159.6	210.8	-	-	-	-	-	-	-	-	-				
9	14.8	126.1	183.5	102.4	145.4	189	-	-	-	-	-	-	-	-	-				
10	53.7	125.7	186.3	99.3	146	189	-	-	-	-	-	-	-	-	-				
11	60.2	62.05	63.9	140	140	140	-	-	-	-	-	-	-	-	-				
12	103.9	106	108.1	-	-	-	-	-	-	-	-	-	-	-	-				
13	108.4	109.25	110.1	-	-	-	-	-	-	-	-	-	-	-	-				
14	108.4	108.45	108.5	-	-	-	-	-	-	-	-	-	-	-	-				
15	107.1	107.2	107.3	-	-	-	-	-	-	-	-	-	-	-	-				
16	106.3	106.65	107	-	-	-	-	-	-	-	-	-	-	-	-				
17	105.2	106.15	107.1	-	-	-	-	-	-	-	-	-	-	-	-				

Depth	Bray Park Weir 2021-2022			Bray Park Weir (2022-2023)			Bray Park Weir (2020-2022)			Hole Site X (2001-2022; dates vary)			Site Z (2001-2022; dates vary)			ANZECC & ARMCANZ (2000) triggers (mg/L)		ANZG 'DGVs for 80% species protection' (mg/L)	
	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Max	Min	Max
18	105	106.15	107.3	-	-	-	-	-	-	-	-	-	-	-	-				
19	104.8	106.25	107.7	-	-	-	-	-	-	-	-	-	-	-	-				
20	104.6	106.2	107.8	-	-	-	-	-	-	-	-	-	-	-	-				
1	0.7	111.6	182.1	-	-	-	0.6	132.10	195.2	0.1	90.7	164	0^	91.2^	144.3^				
2	0.7	113.2	182.4	-	-	-	0.6	133.10	194.8	0.6	80.1	256	0.5^	80.9^	154^				
3	0.6	113.1	182.4	-	-	-	0.6	133.00	194.8	0.6	79.8	256	0.5^	80.2^	137.3^				
4	0.6	113.1	182.3	-	-	-	0.7	132.40	197.7	0.6	79.25	260	0.5^	79.6^	939^				
5	0.6	109.1	171.4	-	-	-	0.6	130.40	430.4	0.6	79.5	242.7	0.5^	79.6^	133.8^				
6	0.6	112.85	161	-	-	-	0.6	129.55	1548	0.6	79.35	219.4	0.5^	79.05^	228.8^				
7	0.7	112.85	146.9	-	-	-	0.8	129.55	2989	0.6	79.25	390.1	0.5^	78.3^	191.8^				
8	0.7	110.85	143.2	-	-	-	0.6	126.30	4274	0.6	79.55	186.4	0.5^	78.2^	986.8^				
9	0.7	112.75	151.6	-	-	-	0.6	127.35	5021	0.6	79.2	185.2	0.6^	77.95^	152.4^				
10	12.3	116.25	152.9	-	-	-	14.8	138.90	5531	0.6	80.05	178.6	0.6^	79.2^	835^				
11	44.2	114.9	154	-	-	-	53.7	149.10	6096	0.1	80.35	166.6	0.1^	80.1^	149.1^	200	300	-	-
12	49	50.7	52.4	-	-	-	60.2	62.05	63.9	0.7	80.9	166.9	1.2^	80.65^	149.8^	20	30	-	-
13	84.5	86.45	88.4	-	-	-	103.9	106.00	108.1	1	81.3	161.7	1.4^	81.25^	152.1^				
14	88.2	88.8	89.4	-	-	-	108.4	109.25	110.1	20.5	82.4	155.7	1.4^	82.4^	155.4^				
15	88.1	88.1	88.1	-	-	-	108.4	108.45	108.5	20.3	82.95	151.9	1.3^	82.55^	165.1^				
16	86.8	86.95	87.1	-	-	-	107.1	107.20	107.3	20.2	83.3	173.3	1.3^	83.5^	168.4^				
17	85.9	86.25	86.6	-	-	-	-	-	-	20.3	84.9	183	1.3^	85.8^	185.5^				
18	85.1	85.75	86.4	-	-	-	-	-	-	3.6	84.7	172.2	1.3^	87.3^	198^				
19	84.7	85.7	86.7	-	-	-	-	-	-	20.7	85.6	184.1	1.3^	88.25^	201.6^				
20	84.7	85.8	86.9	-	-	-	-	-	-	20.8	86.2	243.2	1.3^	89.9^	225.2^				
24	-	-	-	-	-	-	-	-	-	20.9	87.1	250.8	1.3^	93.25^	229^				
28	-	-	-	-	-	-	-	-	-	159.3	159.3	159.3	78.1^	144.65^	211.2^				
1	0	85.5	127	-	-	-	0	85.5	127	0*	57*	78*	0*	58*	94*				
2	0	85	127	-	-	-	0	85.0	127	0*	53.5*	77*	0*	57*	68*				
3	0	85	127	-	-	-	0	85.0	127	0*	55*	77*	0*	57*	69*				
4	0	85.5	127	-	-	-	0	85.5	127	0*	55*	77*	0*	57*	69*				
5	0	84	124	-	-	-	0	84.0	124	0*	55*	77*	0*	58*	70*				
6	0	81.5	118	-	-	-	0	81.5	118	0*	53*	77*	0*	56.5*	71*				
7	1	81.5	113	-	-	-	1	81.5	113	0*	46.5*	77*	0*	59*	76*				
8	0	80	112	-	-	-	0	80.0	112	0*	47*	77*	0*	60*	75*				
9	0	80.5	117	-	-	-	0	80.5	117	0*	53.5*	82*	0*	64*	79*	-	-	-	-
10	10	82	119	-	-	-	10	82.0	119	0*	59*	87*	0*	52*	89*				
11	35	82	121	-	-	-	35	82.0	121	0*	64*	89*	0*	59.5*	88*				
12	39	40.5	42	-	-	-	39	40.5	42	0*	67*	95*	1*	65*	97*				
13	68	69	70	-	-	-	68	69.0	70	0*	69*	95*	1*	66.5*	99*				
14	70	71	72	-	-	-	70	71.0	72	0*	69*	101*	1*	67*	101*				
15	70	70.5	71	-	-	-	70	70.5	71	0*	69*	98*	1*	67.5*	107*				
16	70	70	70	-	-	-	70	70.0	70	0*	68*	99*	1*	69*	109*				

	Bray Park Weir 2021-2022			Bray Park Weir (2022- 2023)			Bray Park Weir (2020-2022)			Hole			Site X (2001-2022; dates vary)			Site Z (2001-2022; dates vary)			ANZECC & ARMCANZ (2000) triggers (mg/L)		ANZG 'DGVs for 80% species protection' (mg/L)	
Depth	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Max	Min	Max
17	69	69.5	70	-	-	-	-	-	-	-	0*	69*	101*	1*	69*	108*						
18	68	69	70	-	-	-	-	-	-	-	0*	68*	105*	1*	70*	104*						
19	68	69	70	-	-	-	-	-	-	-	0*	69*	107*	1*	71*	106*						
20	68	69	70	-	-	-	-	-	-	-	0*	68*	115*	1*	70*	110*						
1	0	0.06	0.09	-	-	-	0	0.06	0.09	0*	0.04*	118*	1*	70*	123*							
2	0	0.06	0.09	-	-	-	0	0.06	0.09	0*	0.04*	0.05*	0*	0.04*	0.05*							
3	0	0.06	0.09	-	-	-	0	0.06	0.09	0*	0.04*	0.05*	0*	0.04*	0.05*							
4	0	0.06	0.09	-	-	-	0	0.06	0.09	0*	0.04*	0.05*	0*	0.04*	0.05*							
5	0	0.06	0.09	-	-	-	0	0.06	0.09	0*	0.04*	0.05*	0*	0.04*	0.05*							
6	0	0.06	0.09	-	-	-	0	0.06	0.09	0*	0.04*	0.05*	0*	0.04*	0.05*							
7	0	0.06	0.08	-	-	-	0	0.06	0.08	0*	0.03*	0.05*	0*	0.04*	0.05*							
8	0	0.06	0.08	-	-	-	0	0.06	0.08	0*	0.03*	0.06*	0*	0.04*	0.05*							
9	0	0.06	0.09	-	-	-	0	0.06	0.09	0*	0.04*	0.06*	0*	0.04*	0.06*							
10	0.01	0.06	0.09	-	-	-	0.01	0.06	0.09	0*	0.04*	0.06*	0*	0.05*	0.06*							
11	0.02	0.06	0.09	-	-	-	0.02	0.06	0.09	0*	0.05*	0.06*	0*	0.04*	0.06*				-	-	-	-
12	0.03	0.03	0.03	-	-	-	0.03	0.03	0.03	0*	0.05*	0.07*	0*	0.05*	0.07*							
13	0.05	0.05	0.05	-	-	-	0.05	0.05	0.05	0*	0.05*	0.07*	0*	0.05*	0.07*							
14	0.05	0.05	0.05	-	-	-	0.05	0.05	0.05	0*	0.05*	0.07*	0*	0.05*	0.07*							
15	0.05	0.05	0.05	-	-	-	0.05	0.05	0.05	0*	0.05*	0.07*	0*	0.05*	0.08*							
16	0.05	0.05	0.05	-	-	-	0.05	0.05	0.05	0*	0.05*	0.07*	0*	0.05*	0.08*							
17	0.05	0.05	0.05	-	-	-	-	-	-	0*	0.05*	0.07*	0*	0.05*	0.08*							
18	0.05	0.05	0.05	-	-	-	-	-	-	0*	0.05*	0.08*	0*	0.05*	0.08*							
19	0.05	0.05	0.05	-	-	-	-	-	-	0*	0.05*	0.08*	0*	0.05*	0.08*							
20	0.05	0.05	0.05	-	-	-	-	-	-	0*	0.05*	0.08*	0*	0.05*	0.08*							
0	6.53	7.49	8.1	6.58	7.22	7.67	6.52	7.48	8.1	0	6.49	0.09	0^	6.75^	0.09^							
1	6.52	7.34	8	6.9	7.34	7.7	6.52	7.34	8	0.11	6.64	10.08	0.19^	6.68^	8.95^							
2	6.53	7.31	7.92	6.99	7.4	7.63	6.53	7.31	7.92	0.34	6.55	9.43	0.3^	6.59^	9.03^							
3	6.53	7.28	7.88	7.0	7.27	7.5	6.53	7.28	7.88	0.39	6.47	9.32	0.45^	6.48^	26.9^							
4	6.51	7.21	7.81	6.95	7.25	7.47	6.51	7.21	7.81	0.02	6.41	9.31	0.24^	6.43^	9.12^							
5	6.48	7.19	7.73	6.92	7.18	7.1	6.48	7.19	7.73	0.17	6.38	9.1	0.38^	6.39^	8.94^							
6	6.52	7.19	7.66	6.87	7.03	7.29	6.52	7.19	7.66	0.28	6.35	8.98	0.42^	6.37^	8.68^							
7	6.4	7.21	7.69	6.84	6.94	7.26	6.4	7.21	7.69	0.1	6.32	9.11	0.5^	6.35^	8.76^							
8	6.44	7.16	7.57	6.79	6.95	7.24	6.44	7.19	7.57	0.05	6.31	9.12	0.6^	6.36^	8.93^				6.5	8.0	-	-
9	6.53	6.93	7.26	6.8	7.01	7.25	6.53	7.08	7.29	0.22	6.30	8.93	0.51^	6.36^	8.86^							
10	6.54	6.87	7.26	6.71	6.96	7.26	6.54	6.97	7.3	0.13	6.31	9.23	0.43^	6.35^	8.91^							
11	6.55	6.56	6.56	7.66	7.66	7.66	6.55	6.56	6.56	0.39	6.31	8.56	0.34^	6.35^	8.95^							
12	6.57	6.58	6.58	-	-	-	6.57	6.58	6.58	0.02	6.32	8.72	0.22^	6.36^	8.98^							
13	6.57	6.58	6.59	-	-	-	6.57	6.58	6.59	0.15	6.33	8.88	0^	6.37^	9.05^							
14	6.56	6.58	6.59	-	-	-	6.56	6.58	6.59	0.24	6.35	9	0.41^	6.39^	9.17^							
15	6.55	6.57	6.58	-	-	-	6.55	6.57	6.58	0.39	6.37	9.07	0.26^	6.42^	9.17^							
16	6.55	6.56	6.57	-	-	-	-	-	-	0.29	6.38	9.12	0.2^	6.43^	9.25^							

Depth	Bray Park Weir 2021-2022			Bray Park Weir (2022- 2023)			Bray Park Weir (2020-2022)			Site X (2001-2022; dates vary)			Site Z (2001-2022; dates vary)			ANZECC & ARMCANZ (2000) triggers (mg/L)		ANZG 'DGVs for 80% species protection' (mg/L)	
	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Max	Min	Max
17	6.53	6.55	6.56	-	-	-	-	-	-	0.26	6.37	9.23	0.21^	6.45^	9.42^				
18	6.54	6.55	6.56	-	-	-	-	-	-	0.28	6.40	9.29	0.31^	6.47^	9.69^				
19	6.54	6.55	6.55	-	-	-	-	-	-	0.2	6.42	9.41	0.11^	6.49^	9.82^				
20	6.54	6.54	6.54	-	-	-	-	-	-	0.04	6.43	8.02	0.14^	6.51^	9.84^				
24	-	-	-	-	-	-	-	-	-	7.55	7.55	7.55	6.15^	6.52^	7.22^				
0	-	-	-	0.5	6.72	42.58	0.0	0.2	0.4	0 ⁺	0 ⁺	146.7 ⁺	-2.2 ⁺	0.95 ⁺	407.5 ⁺				
1	-	-	-	0.24	7.13	43.6	0.0	0.4	0.7	0 ⁺	0.1 ⁺	145.1 ⁺	-2.5 ⁺	1.3 ⁺	410.1 ⁺				
2	-	-	-	0.24	6.28	43.81	0.3	0.6	0.9	0 ⁺	0.5 ⁺	151.6 ⁺	-2.4 ⁺	1.7 ⁺	824.8 ⁺				
3	-	-	-	0.33	7.61	45.9	0.3	0.7	1.1	0 ⁺	0.9 ⁺	216 ⁺	-2.5 ⁺	2.3 ⁺	1207.9 ⁺				
4	-	-	-	-0.04	7.66	62.59	0.0	0.5	1	0 ⁺	1.45 ⁺	228.6 ⁺	-2.4 ⁺	2.8 ⁺	1462.7 ⁺				
5	-	-	-	-0.54	8.37	62.22	0.0	0.4	0.7	0 ⁺	1.9 ⁺	219.4 ⁺	-2.1 ⁺	3.1 ⁺	1582.5 ⁺				
6	-	-	-	-0.6	6.21	37.32	0.0	0.2	0.3	0 ⁺	2.2 ⁺	210.5 ⁺	-1.9 ⁺	3.1 ⁺	1820.4 ⁺				
7	-	-	-	-0.45	6.59	33.56	0.0	0.0	0.0	0 ⁺	2.4 ⁺	207.2 ⁺	-1.8 ⁺	3.55 ⁺	1895 ⁺				
8	-	-	-	-0.5	5.67	40.8	0.0	0.0	0.0	0 ⁺	2.8 ⁺	199.3 ⁺	-2 ⁺	3.55 ⁺	1999.2 ⁺				
9	-	-	-	0.16	19.15	30.6	0.0	0.0	0.0	0 ⁺	2.9 ⁺	185.8 ⁺	-2.1 ⁺	3.3 ⁺	3000 ⁺				
10	-	-	-	0.93	27.38	31.9	0.0	0.0	0.0	0 ⁺	3.1 ⁺	179.5 ⁺	-2.1 ⁺	3.3 ⁺	2081 ⁺	6	50	-	-
11	-	-	-	30.45	30.45	30.45	0.0	0.0	0.0	0 ⁺	3 ⁺	171.6 ⁺	-2.2 ⁺	3.45 ⁺	2151.1 ⁺	1	20		
12	-	-	-	-	-	-	0.0	0.0	0.0	0 ⁺	3.1 ⁺	120.9 ⁺	-2.3 ⁺	3.5 ⁺	2263.2 ⁺				
13	-	-	-	-	-	-	0.0	0.0	0.0	0 ⁺	3.2 ⁺	116.4 ⁺	-2.4 ⁺	3.7 ⁺	2288.2 ⁺				
14	-	-	-	-	-	-	0.0	0.0	0.0	0 ⁺	3.3 ⁺	110.3 ⁺	-2.4 ⁺	3.8 ⁺	2308.4 ⁺				
15	-	-	-	-	-	-	0.0	0.0	0.0	0 ⁺	3.4 ⁺	106.6 ⁺	-2.3 ⁺	3.95 ⁺	2371.7 ⁺				
16	-	-	-	-	-	-	-	-	-	0 ⁺	3.5 ⁺	101.8 ⁺	-2.3 ⁺	4.3 ⁺	2409.1 ⁺				
17	-	-	-	-	-	-	-	-	-	0 ⁺	3.75 ⁺	100 ⁺	-2.3 ⁺	4.45 ⁺	2447.6 ⁺				
18	-	-	-	-	-	-	-	-	-	0 ⁺	3.9 ⁺	100 ⁺	-2.3 ⁺	4.5 ⁺	2516.4 ⁺				
19	-	-	-	-	-	-	-	-	-	0 ⁺	4.15 ⁺	100 ⁺	-2.3 ⁺	4.6 ⁺	2533.2 ⁺				
20	-	-	-	-	-	-	-	-	-	0 ⁺	4.2 ⁺	235.9 ⁺	-2 ⁺	4.7 ⁺	2571.8 ⁺				

Note: *denotes measurements collected from 2021-2022. + denotes measurements collected from 2013-2021. ^ denotes measurements collected from 2002-2022. All units are mg/L unless otherwise specified; DGV for arsenic is AsV; DGV for mercury is inorganic; DGV for selenium is total; DGV species protection level for vanadium is unknown; pink denotes default trigger values for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs); blue denotes default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers). (ANZECC and ARMCANZ, 2000); green values exceed the DGVs; DGVs are for the protection of 80% of species representative of highly disturbed systems (Water Quality Australia, 2018).

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5. Appendix F – Water quality (field assessment)

Table 36: Water quality parameters recorded during the September 2023 field survey

		Clarrie Hall Dam		McCabes Bridge	Tweed River				Doon Doon Creek					Commissioners Creek		Big Creek	ANZECC & ARMCANZ (2000) triggers		'DGVs for 80% species protection'
Water parameters	quality	CHD2	CHD1	MB1	BPW	TR3	TR2	TR1	DD5	DD4	DD3	DD2	DD1	CC2	CC1	BC1	Lower	Upper	
Basic	pH	7.65	7.64	7.88	7.8	7.26	7.76	8.08	6.89	7.64	7.79	6.94	6.93	7.64	7.42	7.50	6.5 6.5	8.5 8.0	-
	Total Dissolved Solids	72	80	109	123	111	112	106	65	74	107	111	94	85	79	84	-	-	-
	Specific Conductivity (µS/cm)	109	108	177	184	180	163	179	117	110	180	169	140	127	115	114	200.0 20.0	300.0 30.0	-
	Turbidity (NTU)	0.9	1.0	3.4	1.5	2.1	2.4	2.6	1.9	2	2.7	4.6	2.1	0.6	3.2	3.9	6.0 1.0	50.0 20.0	-
	Dissolved oxygen (%)	102.42	103.64	132.9	114.61	118.27	114.61	112.17	104.85	121.92	109.73	109.73	106.07	114.61	113.39	87.79	85.0 90.0	110.0 110.0	-
	Biological oxygen demand	<2	<2	<2	<2	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-	-	-
	Sodium	10	10	16	17	15	15	16	11	11	16	17	15	13	11	13	-	-	-
Major Ions	Calcium	6	6	8	11	9	8	8	6	6	9	8	7	7	6	4	-	-	-
	Potassium	2	1	2	2	1	1	2	2	2	2	2	2	2	1	2	-	-	-
	Magnesium	3	4	5	8	6	6	6	4	4	6	5	4	4	4	2	-	-	-
	Chloride	12	12	-	20	20	20	20	12	13		21	17	60	41	58	-	-	-
	Sulphate	1	<1	2	3	2	3	2	<1	1	2	2	2	2	3	2	-	-	-
Nutrients	Total alkalinity	39	38	57	63	55	52	56	37	40	53	40	38	42	36	37	-	-	-
	Nitrogen (total)	0.2	0.2	0.2	0.4	0.2	0.2	0.1	0.1	0.3	0.2	0.2	0.2	4.6	3.0	8.2	-	500.0 350.0	-
	Kjeldahl Nitrogen (total)	0.2	0.2	0.2	0.3	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.2	4.6	3.0	8.2	-	-	-
	Ammonia	0.01	0.02	0.02	0.07	0.01	0.02	0.01	0.02	0.03	<0.01	0.03	0.02	0.05	0.03	0.19	-	-	2.3
	Nitrite	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
	Nitrate	<0.01	<0.01	<0.01	0.07	<0.01	0.01	0.01	<0.01	0.09	<0.01	0.01	0.03	0.03	0.01	<0.01	-	-	-
	Nitrite + Nitrate	<0.01	<0.01	<0.01	0.07	<0.01	0.01	0.01	<0.01	0.09	<0.01	0.01	0.03	0.03	0.01	<0.01	-	-	-

		Clarrie Hall Dam		McCabes Bridge	Tweed River		Doon Doon Creek							Commissioners Creek		Big Creek	ANZECC & ARMCANZ (2000) triggers		'DGVs for 80% species protection'
Water parameters	quality	CHD2	CHD1	MB1	BPW	TR3	TR2	TR1	DD5	DD4	DD3	DD2	DD1	CC2	CC1	BC1	Lower	Upper	
Metals	Phosphorus (total)	<0.01	<0.01	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.02	0.05	0.04	0.23	0.11	0.83	-	50.0 10.0	-
	Aluminium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	0.15 (based on pH >6.5) 0.14
	Arsenic	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	0.14
	Barium	0.007	0.007	0.013	0.015	0.017	0.017	0.014	0.010	0.010	0.019	0.018	0.028	0.016	0.020	0.014	-	-	-
	Beryllium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-
	Boron	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-	2.5
	Cadmium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<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	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	0.0033
	Cobalt	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	-	-	0.0014
	Copper	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.032	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	0.0025
	Iron	<0.05	<0.05	0.54	<0.05	0.13	0.10	0.10	<0.05	0.06	0.41	<0.05	<0.05	0.11	0.22	0.10	-	-	-
	Lead	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	0.0094
	Manganese	0.008	0.026	0.123	0.020	0.055	0.040	0.040	0.047	0.232	0.110	0.053	0.020	0.028	0.168	0.036	-	-	3.6
	Mercury	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	-	0.0054
	Nickel	<0.001	<0.001	<0.001	<0.001	0.006	<0.001	<0.001	<0.001	<0.001	0.671	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	0.017
	Selenium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	0.034
	Vanadium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	0.006
	Zinc	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<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 CrIII; DGV for mercury is inorganic; DGV for selenium is total; DGV species protection level for vanadium is unknown. Pink denotes default trigger values for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs); blue denotes default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers). (ANZECC and ARMCANZ, 2000); green values exceed the DGVs. DGVs are for the protection of 80% of species representative of highly disturbed systems (Water Quality Australia, 2018).

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6. Appendix G – Sediment quality (field assessment)

Table 37: Sediment quality parameters recorded during the September 2023 field survey

		Clarrie Hall Dam		McCabe's Bridge	Tweed River				Doon Doon Creek					Commissioners Creek		Big Creek	'DGVs for 80% species protection'
Water parameters	quality	CHD2	CHD1	MB1	BPW	TR3	TR2	TR1	DD5	DD4	DD3	DD2	DD1	CC2	CC1	BC1	
Basic	pH (unit)	5.1	6.1	6.4	6.0	6.6	6.6	6.3	6.2	5.9	6.0	7.0	6.8	6.8	6.3	6.8	-
	Moisture content (%)	37.7	29.5	26.6	43.0	29.4	24.8	28.3	32.0	35.5	6.1	31.3	29.4	75.7	23.7	47.8	-
	Specific conductivity (µS/cm)	5.0	5.0	11.0	16.0	11.0	9.0	11.0	7.0	5.0	6.0	20.0	13.0	46.0	5.0	38.0	-
Major Ions	Sodium	<10	<10	10	20	10	10	10	<10	<10	<10	20	20	70	<10	40	-
	Calcium	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	90	<10	<10	-
	Potassium	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	40	<10	<10	-
	Magnesium	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	50	<10	<10	-
	Chloride	<10	<10	<10	10	<10	<10	<10	<10	<10	<10	10	<10	50	<10	20	-
	Sulphate	<10	<10	<10	20	<10	<10	<10	<10	<10	<10	<10	<10	30	<10	<10	-
Nutrients	Nitrogen (total)	70	160	150	1020	130	110	60	310	600	40	170	120	1980	1360	1050	-
	Kjeldahl nitrogen (total)	70	160	150	1020	130	110	60	310	600	40	170	120	1980	1360	1050	-
	Ammonium (N)	<0.2	2.6	4.9	23.3	<0.2	<0.2	0.6	9.5	7.7	3.1	0.5	<0.2	30.9	2.1	16.6	-
	Ammonium (NH ₄)	<0.2	3.4	6.3	30.0	<0.2	<0.2	0.8	12.2	9.9	4.0	0.6	<0.2	39.8	2.7	21.3	-
	Nitrite	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-
	Nitrate	<0.1	<0.1	<0.1	0.1	0.2	0.2	0.2	<0.1	<0.1	<0.1	0.7	0.5	0.2	0.1	1.3	-
	Nitrite + Nitrate	<0.1	<0.1	<0.1	0.1	0.2	0.2	0.2	<0.1	<0.1	<0.1	0.7	0.5	0.2	0.1	1.3	-
	Phosphorus (total)	924	96	449	1130	499	557	437	209	280	576	732	976	935	141	1040	-
Metals	Aluminium	5330	3860	4390	11100	4460	3050	7320	4790	2950	3270	8600	8350	4160	5370	21200	0.8 (based on pH <6.5)
	Arsenic	1.77	3.25	1.32	2.08	1.73	<1.0	1.09	5.01	2.36	<1.0	4.04	3.20	3.94	<1.0	2.92	140
	Cadmium	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.01	<0.01	<0.01	<0.1	<0.01	0.8
	Chromium (Total)	9.1	1.2	6.5	21.6	9.0	8.9	23.4	2.9	1.9	5.0	10.1	8.3	5.0	3.4	9.5	3.3
	Hexavalent chromium	<0.5	<0.5	<0.5	<0.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<2.0	<2.0	40
	Trivalent chromium	9	1	6	22	9	9.0	23.0	3.0	2.0	5.0	10	8	5	3	10	3.3
	Cobalt	7.4	1.8	6.5	14.0	6.0	3.9	11.5	3.7	1.4	3.4	17.5	12.3	19.5	2.9	16.3	1.4
	Copper	4.1	1.4	3.2	13.3	5.8	3.4	12.0	2.2	1.5	1.8	8.9	8.0	7.8	1.1	11.1	2.5
	Iron	28000	6650	18500	30600	15900	10300	26900	16300	13500	11300	44900	45100	22300	7830	64500	-

Water parameters	quality	Clarrie Hall Dam		McCabe's Bridge	Tweed River				Doon Doon Creek					Commissioners Creek		Big Creek	'DGVs for 80% species protection'
		CHD2	CHD1	MB1	BPW	TR3	TR2	TR1	DD5	DD4	DD3	DD2	DD1	CC2	CC1	BC1	
Lead		2.0	6.8	1.9	5.1	1.6	1.7	1.2	8.9	12.9	1.2	7.3	2.8	2.4	6.0	5.7	9.4
Manganese		203	88	252	283	193	97	217	188	134	88	909	443	2250	61	768	3600
Mercury		0.01	0.13	<0.01	0.03	<0.01	<0.01	<0.01	0.09	0.13	<0.01	0.01	0.02	0.01	0.05	<0. 01	5.4
Nickel		8.1	<1.0	7.2	16.8	5.4	4.9	15.9	1.9	1.2	4.4	16.0	12.2	10.0	1.6	16.8	17
Selenium		0.6	0.5	0.5	1.2	0.5	0.3	0.4	1.2	1.0	0.4	1.4	1.1	0.9	0.4	1.1	34
Vanadium		19.2	4.7	14.0	38.2	20.5	15.0	27.9	10.6	3.6	7.6	26.8	25.7	13.5	16.4	34.4	6
Zinc		24.4	9.3	22.7	44.6	18.6	15.5	24.3	24.4	37.1	12.5	54.6	44.5	17.4	10.0	56.1	31

Notes: All units are mg/kg unless otherwise specified; DGV for arsenic is AsV; DGV for mercury is inorganic; DGV for selenium is total; DGV species protection level for vanadium is unknown. Pink denotes default trigger values for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs); blue denotes default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers). (ANZECC and ARMCANZ, 2000); green values exceed the DGVs. DGVs are for the protection of 80% of species representative of highly disturbed systems (Water Quality Australia, 2018).

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7. Appendix H – Phytoplankton (field assessment)

Table 38: Phytoplankton taxa recorded during the September 2023 field survey

		Clarrie Hall Dam		McCabes Bridge	Tweed River					Doon Doon Creek					Big Creek	Commissioners Creek	
Phylum	Taxonomic name	CHD2	CHD1	MB1	TR1	TR2	TR3	BPW	DD5	DD4	DD3	DD2	DD1	BC1	CC1	CC2	
Cyanophyta	<i>Anabaena</i>	1820					200				66	64					
Cyanophyta	<i>Aphanocapsa</i>	900	614														
Cyanophyta	<i>Cylindrospermum</i>															1720	
Cyanophyta	<i>Dolichospermum</i> (coiled small)	176															
Cyanophyta	<i>Dolichospermum circinale</i>	300	50														
Cyanophyta	<i>Dolichospermum planctonicum</i>	1110	20					206			66						
Cyanophyta	<i>Dolichospermum</i> (straight)							152									
Cyanophyta	<i>Dolichospermum</i> (straight small)					166	388				60	220	244		84	224	
Cyanophyta	<i>Heteroleibleinia</i> *						132	784									
Cyanophyta	<i>Geitlerinema</i>						106			70		252	94				
Cyanophyta	<i>Komvophoron</i>		40														
Cyanophyta	<i>Lyngbya</i>							378									
Cyanophyta	<i>Merismopedia</i>							1380									
Cyanophyta	<i>Oscillatoria</i>						54			480							
Cyanophyta	<i>Phormidium</i> *			68		44	50	288	80					24	242		
Cyanophyta	<i>Pseudanabaena</i>			50		24											
Cyanophyta	<i>Tapinothrix</i> *				100		124	2590		110				36			
Cyanophyta	<i>Trichodesmium</i>	3320	166				26				668						
Chrysophyta	<i>Dinobryon</i>		8					10			20						
Chrysophyta	<i>Synura</i>					100									10		
Bacillariophyta	<i>Achnantheidium</i>																
Bacillariophyta	<i>Aulacoseira</i>	30	40								748					20	
Bacillariophyta	<i>Bacillaria</i>		16	310	180	1580	150	676	480	32		174	46			40	
Bacillariophyta	<i>Cocconeis</i>													10			
Bacillariophyta	<i>Cyclotella</i>													400			
Bacillariophyta	<i>Cyclotella</i> small_spp										30						
Bacillariophyta	<i>Cymbella</i>				2			4	2	4							
Bacillariophyta	<i>Euglena</i>								2								
Bacillariophyta	<i>Gomphonema</i>								4				10		10		
Bacillariophyta	<i>Gyrosigma</i>	10		12	20	50		2	105	20	26	26	8			8	
Bacillariophyta	<i>Melosira</i>			6				90		8		72	14	50		72	
Bacillariophyta	<i>Navicula</i>				70	50	200	20				24	20	100	14	20	
Bacillariophyta	<i>Naviculoids</i>				2										6	30	
Bacillariophyta	<i>Nitzschia</i>	2		90	24	350	250	60			42	102	62	400	62	210	
Bacillariophyta	Pennate diatoms			8	6	100	60		20			30		200	2	20	
Bacillariophyta	<i>Rhoicosphenia</i>															40	
Bacillariophyta	<i>Rhopalodia</i>				10	50	30	40		4	2	2	4		4	4	

Phylum	Taxonomic name	Clarrie Hall Dam		McCabes Bridge MB1	TR1	Tweed River		BPW	DD5	Doon Doon Creek				Big Creek BC1	Commissioners Creek	
		CHD2	CHD1			TR2	TR3			DD4	DD3	DD2	DD1		CC1	CC2
Bacillariophyta	<i>Staurosira</i>								56							
Bacillariophyta	<i>Surirella</i>									2		2				
Bacillariophyta	<i>Synedra</i>	4	18	12	2		60			140	58	2	16	40	48	
Bacillariophyta	<i>Urosolenia</i>	1520	275								80					
Euglenophyta	<i>Lepocinclis</i>				2						8					
Euglenophyta	<i>Trachelomonas</i>	350	10					10			20					
Chlorophyta	<i>Cladophora</i>				56					12		40				
Chlorophyta	<i>Closterium</i>	10	10						12				8	10	4	
Chlorophyta	<i>Coenochloris</i>	15300	22300								1120					
Chlorophyta	Colonial green algae small_spp			114												
Chlorophyta	<i>Cosmarium</i>	10	6		2					12	2					
Chlorophyta	<i>Crucigenia</i>							40			40					
Chlorophyta	<i>Cylindrocapsa</i>									1230						
Chlorophyta	<i>Desmidium</i>	218	1980							640	52					
Chlorophyta	<i>Elakatothrix</i>	375														
Chlorophyta	<i>Eudorina</i>							74								
Chlorophyta	<i>Geminella</i>	790	1150													
Chlorophyta	<i>Gonatozygon</i>	76	72		6	125	30			100		92			18	
Chlorophyta	<i>Hyalotheca</i>	480														
Chlorophyta	<i>Kirchneriella</i>		120													
Chlorophyta	<i>Klebsormidium*</i>														138	
Chlorophyta	<i>Mougeotia</i>			8					6	10						
Chlorophyta	<i>Oedogonium</i>				26				18	106						64
Chlorophyta	<i>Oocystis</i>			8												
Chlorophyta	<i>Pediastrum</i>										275					
Chlorophyta	Phytoflagellates	575				700	2050			300	625	60	60	400	80	
Chlorophyta	Phytoflagellates small_spp			400	180			1750	250							
Chlorophyta	<i>Pleurotaenium</i>	4									4					
Chlorophyta	<i>Pteromonas</i>														10	
Chlorophyta	<i>Scenedesmus</i>			8							40					
Chlorophyta	<i>Spirogyra</i>			238	16					58		338	2			
Chlorophyta	<i>Staurastrum</i>	1170	166	2					12	16	20					
Chlorophyta	<i>Staurodesmus</i>	22	10							12						
Chlorophyta	<i>Stigeoclonium</i>				20											
Chlorophyta	<i>Ulothrix</i>									132						
Chlorophyta	<i>Zygnema</i>							84		762						
Cryptophyta	<i>Cryptomonas</i>												20		20	
Pyrrhophyta	<i>Peridinales^*</i>												10			
Xanthophyta	<i>Centrtractus</i>	40	8								10					
Unidentified	Unidentified						100									

Phylum	Taxonomic name	Clarrie Hall Dam		McCabes Bridge	Tweed River			BPW	DD5	Doon Doon Creek				Big Creek	Commissioners Creek	
		CHD2	CHD1	MB1	TR1	TR2	TR3			DD4	DD3	DD2	DD1	BC1	CC1	CC2
	Diversity	25	21	15	18	12	17	20	13	23	23	16	15	11	16	13
	Total	28612	27079	1334	724	3339	4010	8638	1047	4260	4082	1500	618	1670	752	2472

Notes: Units are cells/ml. * indicates that the identification for this organism is tentative only. ^ organism is tentatively identified as *Ensiculifera* sp. Brown shading indicates taxa are potentially bloom-forming and/or toxic.

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8. Appendix I – Macrophytes (field assessment)

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Table 39: Macrophyte taxa recorded during the September 2023 field survey

Macrophyte taxa	Clarrie Dam	Hall	Doon Doon Creek						Big Creek		Commissioners Creek	Tweed River				
	CHD2	CHD1	DD5	DD4	DD3	MB1	DD2	DD1	BC1	CC1	CC2		TR1	TR2	TR3	BPW
Alismatales																
Potamogetonaceae																
<i>Potamogeton</i> sp.														ü	ü	ü
Alismatales																
Potamogetonaceae																
<i>Potamogeton crispus</i>						ü										
Alismatales																
Hydrocharitaceae																
<i>Vallisneria</i> sp.						ü	ü									
Asterales																
Menyanthaceae																
<i>Nymphoides</i> sp.	ü	ü		ü	ü								ü	ü	ü	
Brassicales																
Brassicaceae																
<i>Nastrurtium</i> sp.								ü	ü							
Caryophyllales																
Polygonaceae																
<i>Persicaria</i> sp.				ü		ü	ü	ü	ü	ü	ü			ü	ü	
Cyperales																
Cyperaceae																
<i>Cyperus</i> sp.*	ü	ü	ü	ü		ü	ü	ü					ü		ü	
Cyperales																

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Macrophyte taxa	Clarrie Dam	Hall	Doon Doon Creek						Big Creek		Commissioners Creek	Tweed River			
	CHD2	CHD1	DD5	DD4	DD3	MB1	DD2	DD1	BC1	CC1	CC2	TR1	TR2	TR3	BPW
Cyperaceae															
<i>Cyperus eragrostis*</i>													ü	ü	
Cyperales															
Cyperaceae															
<i>Schoenoplectus</i>				ü		ü									
<i>tabernaemontani</i>															
Cyperales															
Cyperaceae															
<i>Carex</i> sp.						ü				ü	ü				
Cyperales															
Cyperaceae															
<i>Carex tereticaulis</i>				ü											
Myrtales															
Onagraceae															
<i>Ludwigia</i> sp.	ü	ü		ü	ü	ü		ü							
Myrtales															
Onagraceae															
<i>Ludwigia peploides</i>			ü												
Nymphaeales															
Cabombaceae															
<i>Cabomba</i>	ü	ü			ü										
<i>caroliniana*</i>															
Nymphaeales															
Nymphaeaceae															

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Macrophyte taxa	Clarrie Dam CHD2	Hall CHD1	Doon Doon Creek DD5 DD4 DD3 MB1 DD2 DD1						Big Creek BC1 CC1		Commissioners Creek CC2	Tweed River TR1 TR2 TR3 BPW			
<i>Nymphaea Mexicana*</i>	ü														
Poales															
Typhaceae															
<i>Typha</i> sp.		ü													
Poales															
Cyperaceae															
<i>Eleocharis</i> sp.	ü	ü													
Poales															
Juncaceae															
<i>Juncus</i> sp.					ü	ü			ü				ü		
Salviniales															
Salviniaceae															
<i>Azolla</i> sp.	ü														
Salviniales															
Salviniaceae															
<i>Salvinia molesta*</i>	ü	ü		ü											
Saxifragales															
Haloragaceae															
<i>Myriophyllum</i> sp.				ü	ü										
Saxifragales															
Haloragaceae															
<i>Myriophyllum aquaticum</i>	ü					ü									

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Macrophyte taxa	Clarrie Dam	Hall	Doon Doon Creek						Big Creek		Commissioners Creek	Tweed River			
	CHD2	CHD1	DD5	DD4	DD3	MB1	DD2	DD1	BC1	CC1	CC2	TR1	TR2	TR3	BPW
Diversity	10	7	2	8	5	9	3	4	3	2	2	2	5	5	1

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9. Appendix J – Macroinvertebrates (edge habitat)

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Table 40: Aquatic invertebrate taxa recorded in edge habitat during the September 2023 field survey

Taxonomic name	BC1	BPW1	BPW2	CC1A	CC1B	CC2	DD2	DD2A	DD4	DD5	MB1	TR1	TR2	TR3	TR3A	Total
Acarina																
Mites		1	11	2	1	8	1			17	3	4		6	4	58
Amphipoda																
Corophiidae															1	1
Basommatophora																
Ancylidae							3	1				1				5
Coleoptera																
Dytiscidae	7				2	2			1		3	2	1			18
Elmidae	1											2				3
Gyrinidae				1	2						1					4
Hydrophilidae	2			4	4		6	1	2	3	4	4	4			34
Psephenidae						1										1
Decapoda																
Atyidae	1	6	3		2	6	1	3	6	7	3	6	5	5	6	60
Palaemonidae		1	3	1	1		1			2	2		1	2	2	16
Diptera																
Ceratopogonidae					1	1				2	2					6
Chironominae	14		14	5	7	13	6	2		7	28	5	2	10	7	120
Culicidae					1											1
Dixidae	11					4	2	3		1		1				22
Orthocladiinae	9		1	1		10					1					22
Tanypodinae	8	1		6	8	12	12	12	7	1	16		1	1	1	86
Ephemeroptera																
Ameletopsidae						1										1

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Taxonomic name	BC1	BPW1	BPW2	CC1A	CC1B	CC2	DD2	DD2A	DD4	DD5	MB1	TR1	TR2	TR3	TR3A	Total
<i>Baetidae</i>	4					2	4	1			1	1				13
<i>Caenidae</i>	7					14	30	11		2	3	2				69
<i>Leptophlebiidae</i>	30		1	14	17	9	19	26		1	4	4	3			128
Gordioidea																
<i>Gordiidae</i>						1										1
Hemiptera																
<i>Corixidae</i>	19	1		19	13	1	25	3	17	5	19	13				135
<i>Gerridae</i>				5	5	1		8	5	1		4	1			30
<i>Naucoridae</i>									1							1
<i>Veliidae</i>	8	3						14		1		2			2	30
Isopoda																
<i>Cirolanidae</i>			1													1
<i>Sphaeromatidae</i>		17	15							3			10	16	29	90
Littorinimorpha																
<i>Hydrobiidae</i>												2				2
Lymnophila																
<i>Lymnaeidae</i>	3			2	1			1	5			1			1	14
<i>Physidae</i>				4	5		1					1	1			12
<i>Planorbidae</i>		1	1													2
Odonata																
<i>Aeshnidae</i>			1													1
<i>Coenagrionidae</i>	4	30	10		1		3		1	1		4	4	3	1	62
<i>Corduliidae</i>							2					5	9			16
<i>Diphlebiidae</i>						1										1
<i>Gomphidae</i>	1			2	2	3	10	10	4	7	1		1	1	3	45
<i>Isostictidae</i>		1	5							7		6	10	8	1	38

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Taxonomic name	BC1	BPW1	BPW2	CC1A	CC1B	CC2	DD2	DD2A	DD4	DD5	MB1	TR1	TR2	TR3	TR3A	Total
<i>Libellulidae</i>	2															2
<i>Megapodagrionidae</i>								1								1
<i>Protoneuridae</i>													1			1
<i>Synthemistidae</i>		1			1											2
Trichoptera																
<i>Calamoceratidae</i>								1		1						2
<i>Calocidae</i>										1						1
<i>Ecnomidae</i>	1					3		5								9
<i>Hydropsychidae</i>								1		2						3
<i>Hydroptilidae</i>						3	2				1				1	7
<i>Leptoceridae</i>	30	4	10	1	3	3	8	4		23	6	16	6	2	9	125
<i>Notonectidae</i>	6			1	4	3	2	6				1				23
Tricladida																
<i>DugesIIDae</i>				2	1			1								4
Venerida																
<i>Corbiculidae</i>												3				3
Unknown order																
<i>Oligochaeta</i>	1	2											1		1	5
<i>Ostracoda</i>						1										1
Diversity	21	13	13	16	21	23	16	21	10	21	17	23	17	10	15	
Grand total	169	69	76	70	82	103	138	115	49	95	98	90	61	54	69	1338

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10. Appendix K – Aquatic vertebrates (field assessment)

Table 41: Aquatic vertebrate (and large invertebrate) species presence/absence and abundance recorded during the September 2023 field survey

		Clarrie Hall Dam			Doon Doon Creek					Big Creek	Commissioners Creek		Tweed River				
Common name	Taxonomic name	CHD2	CHD1	DD5	DD4	DD3	MB1	DD2	DD1	BC1	CC1	CC2	TR1	TR2	TR3	BPW	Total
Fish																	
Agassiz's glassfish	<i>Ambassis agassizii</i>	1	-	3	23	-	63	-	-	-	-	-	-	-	-	1	91
Australian bass^	<i>Percalates novemaculeata</i>	1	1	-	1	-	-	-	-	-	-	-	2	-	31	32	68
Australian smelt	<i>Retropinna semoni</i>	26	37	1	3	6	68	-	2	-	-	2	-	-	-	-	145
Black bream	<i>Acanthopagrus butcheri</i>	-	-	-	1	-	-	-	-	-	-	-	-	-	-	40	41
Bullrout	<i>Notesthes robusta</i>	-	-	-	-	-	-	-	-	-	-	-	1	3	-	1	5
Common carp*	<i>Cyprinus carpio</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	9
Cox's gudgeon	<i>Gobiomorphus coxii</i>	-	-	-	-	-	1	-	-	15	-	-	4	7	2		29
Duboulayi rainbowfish	<i>Melanotaenia duboulayi</i>	-	-	-	2	-		-	-	-	-	-	-	-	1	1	4
Eastern gambusia*	<i>Gambusia holbrooki</i>	-	-	-	-	-	23	-	-	49	25	-	1	-	1	1	100
Flathead gudgeon	<i>Philypnodon grandiceps</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2
Freshwater catfish	<i>Tandanus tandanus</i>	-	9	4	10	7	10	23	26	-	20	5	7	10	10	18	159
Freshwater herring	<i>Alosa pseudoharengus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	19	7	26
Genus of carp gudgeons	<i>Hypseleotris</i> spp.	127	141	213	103	97	747	246	127	-	107	4	202	71	172	137	2 494
Longfin eel	<i>Anguilla reinhardtii</i>	4	-	19	34	4	5	3	4	5	2	1	5	13	10	12	121
Pearl cichlid*	<i>Geophagus brasiliensis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Sea mullet	<i>Mugil cephalus</i>	-	-	50	-	-	-	-	-	-	-	-	-	-	115	237	402
Striped gudgeon	<i>Gobiomorphus australis</i>	-	-	27	44	-	-	-	-	1	-	7	46	27	17	17	186
Invertebrates																	
Inland river prawn	<i>Macrobrachium</i> sp.	7	-	1	2	-	29	8	7	1	16	2	4	4	7	19	107
Powerful crayfish	<i>Euastacus valentulus</i>	2	-	-	-	-	-	1	2	2	-	2	-	-	-	-	9
Total		168	188	318	223	114	946	281	168	73	170	23	272	135	386	534	3999

Note: * indicates exotic species. ^indicates a stocked species.

Table 42: Results of the eDNA analysis from the September 2023 fish surveys

		Clarrie Hall Dam			Doon Doon Creek					Big Creek	Commissioners Creek			Tweed River			
Common name	Taxonomic name	CHD2	CHD2	DD5	DD4	DD3	MB1	DD2	DD1	BC1	CC1	CC2	TR1	TR2	TR3	BPV	
Fish																	
Agassiz's glassfish	<i>Ambassis agassizii</i>	ü	ü			ü	ü										
Australian bass	<i>Percalates novemaculeata</i>			ü	ü			ü					ü	ü	ü	ü	
Australian smelt	<i>Retropinna semoni</i>		ü	ü	ü	ü	ü	ü	ü			ü	ü	ü	ü	ü	
Bony bream	<i>Nematalosa erebi</i>															ü	
Common carp*	<i>Cyprinus carpio</i>	ü	ü	ü	ü	ü	ü	ü		ü	ü	ü	ü	ü	ü	ü	
Dwarf flathead gudgeon	<i>Philypnodon macrostomus</i>														ü	ü	
Eastern gambusia*	<i>Gambusia holbrooki</i>	ü	ü		ü	ü	ü	ü		ü	ü						
Flathead gudgeon	<i>Philypnodon grandiceps</i>													ü		ü	
Flyspecked hardyhead	<i>Craterocephalus stercusmuscarum</i>	ü	ü														
Freshwater catfish	<i>Tandanus tandanus</i>							ü									

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		Clarrie Hall Dam			Doon Doon Creek				Big Creek	Commissioners Creek			Tweed River			
Common name	Taxonomic name	CHD2	CHD2	DD5	DD4	DD3	MB1	DD2	DD1	BC1	CC1	CC2	TR1	TR2	TR3	BPW
Genus of carp gudgeons	<i>Hypseleotris</i> spp.	ü	ü	ü	ü	ü	ü	ü	ü		ü	ü	ü	ü		ü
Genus of pygmy perch	<i>Nannoperca</i> sp.															ü
Genus of rainbowfish	<i>M. duboulayi</i> or <i>M. splendida</i>							ü					ü			
Genus of sleeper gobies	<i>Gobiomorphus</i> spp.		ü						ü	ü						
Longfin eel	<i>Anguilla reinhardtii</i>		ü	ü	ü	ü	ü	ü	ü	ü	ü		ü	ü		
Freshwater mullet	<i>Trachystoma petardi</i>			ü	ü								ü	ü	ü	ü
Sea mullet	<i>Mugil cephalus</i>			ü	ü								ü	ü	ü	ü
Shortfin eel	<i>Anguilla australis</i>				ü											ü
Mammals																
Platypus	<i>Ornithorhynchus anatinus</i>			ü		ü		ü	ü	ü	ü					ü

Note: Bold/green indicates a listed species. * indicates exotic species.

Table 43: Survey results from fish surveys undertaken by DPI Fisheries, funded by the Recreational Fishing Trust

Common name	Taxonomic name	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Total
Agassiz's glassfish	<i>Ambassis agassizii</i>	2	-	1	-	1	-	-	-	4
Australian bass	<i>Percalates novemaculeata</i>	8	4	14	7	16	10	13	-	72
Australian smelt	<i>Retropinna semoni</i>	-	101	50	44	-	2	2	-	199
Carp gudgeon species complex	<i>Hypseleotris</i> spp.	785	-	802	1371	759	1138	-	-	4855
Eastern gambusia*	<i>Gambusia holbrooki</i>	1	33	-	-	9	-	6	6	55
Firetail gudgeon	<i>Hypseleotris galii</i>	-	567	-	-	-	-	2787	62	3416
Freshwater catfish	<i>Tandanus tandanus</i>	2	3	12	-	29	3	-	-	49
Longfin eel	<i>Anguilla reinhardtii</i>	-	-	-	-	-	2	-	-	2
Unspecked hardyhead	<i>Craterocephalus stercusmuscarum fulvus</i>	-	-	2	2	3	-	1	6	14
Western carp gudgeon	<i>Hypseleotris klunzingeri</i>	-	1	-	-	-	-	-	9	10
	Total	798	709	881	1424	817	1155	2809	83	8676

Note: * indicates exotic species.

Table 44: Results of the Targeted Oxleyan pygmy perch surveys undertaken in January 2024

Common name	Taxonomic name	Sites													Total
		PP1	PP4	PP5a	PP6	PP7	PP9	PP9a	PP10	PP13	PP16	PP21a	PP22a	PP23	
Fish															
Agassiz's glassfish	<i>Ambassis agassizii</i>	-	-	-	-	-	-	1	-	-	-	1	-	-	2

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Common name	Taxonomic name	Sites													Total
		PP1	PP4	PP5a	PP6	PP7	PP9	PP9a	PP10	PP13	PP16	PP21a	PP22a	PP23	
Carp gudgeon species complex	<i>Hypseleotris</i> sp.	40	59	40	59	1	-	66	78	136	200	65	-	37	781
Duboulayi rainbowfish	<i>Melanotaenia duboulayi</i>	-	-	-	3	-	-	-	-	-	-	1	-	-	4
Eastern gambusia*	<i>Gambusia holbrooki</i>	49	84	69	-	-	-	2	1 285	91	10	140	-	12	1 742
Longfin eel	<i>Anguilla reinhardtii</i>	-	4	-	-	23	-	1	2	4	-	-	7	2	43
Striped gudgeon	<i>Gobiomorphus australis</i>	25	-	-	-	-	-	46	-	10	-	-	12	102	195
Invertebrates															
Freshwater crayfish	<i>Euastacus valentulus</i>	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Total		114	148	109	62	24	0	116	1 365	241	210	207	19	153	2 768

Note: * indicates exotic species.

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11. Appendix L – Likelihood of occurrence

Table 45: Likelihood of occurrence assessment for the Proposal (Northern 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										
-	Moreton Bay - 63	-	-	-	ü	-	Wetland of International Importance	Negligible	PMST: 125 km north of the Proposal area. In buffer area only	-
-	Subtropical and Temperate Coastal Saltmarsh - 118	-	-	-	ü	-	Community listed as Vulnerable	Negligible	PMST: In buffer area only.	-
Fish										
Percichthyidae	Eastern freshwater cod	<i>Maccullochella ikei</i>	ü	ü	ü	ü	E / PL	Negligible	DPI Fisheries: Predicted distribution indicates that the species has the potential to occur in waterways south of Nightcap National Park and south-east of Jerusalem National Park (~12 km away). BioNet: Only 3 records for the species occur in the Northern Rivers catchment. All were recorded in the late 1900s. The nearest record to Clarrie Hall Dam is in Kangaroo River State Forest near Dorrigo, approximately 200 km south of Clarrie Hall Dam PMST: Species or species habitat known to occur within area.	The only breeding population of the species is in the Mann-Nymboida sub-catchment of the Clarence River. Less than 100 mature individuals are believed to be in the wild. The species is known to prefer clear, rocky streams and rivers with low flow velocity and an abundant instream cover or hard structures such as rocks, timber or tussocks. It is thought that the species prefers deeper holes near cover, especially around rocky islands, large boulders, and pools occurring in fast-flowing water. Large woody debris and rocky overhangs may provide shelter and important spawning sites.
Percichthyidae	Mary River cod	<i>Maccullochella mariensis</i>	-	-	ü	-	E	Negligible	DPI Fisheries: n/a BioNet: n/a PMST: Translocated population known to occur within area.	Distribution of the species is limited to Queensland, from the NSW–Queensland border, north to Maryborough. Preferred habitat for the species is described as deep, shaded, slow-flowing pools with plenty of snags and instream woody debris. The species form pairs and spawns annually around spring. The eggs are thought to be laid in logs in the wild. The male guards the brood until they disperse in search of food.

Family	Common name	Scientific name	Data source				Conservation status	LoO	Rationale for likelihood of occurrence	Habitat requirements
			DPI	BioNet	PMST	Lit.	EPBC Act			
Eleotridae	Southern purple-spotted gudgeon	<i>Mogurnda adspersa</i>	ü	-	ü	ü	-	Moderate	DPI Fisheries: Predicted distribution indicates that the species has the potential to occur within Clarrie Hall Dam and associated waterways. BioNet: n/a PMST: n/a Literature: The species is reported as having been recorded in the Crystal Creek and Smiths Creek in the Richmond River catchment (Brooks, 2009).	Southern purple-spotted gudgeon prefer slow-flowing or still water with a substantial amount of macrophyte coverage or a rocky benthos (Department of Primary Industries, 2017). They are 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 (19–34°C) for spawning, with water releases (cold water pollution, turbidity) a potential impact to its lifecycle if released between late winter/spring though summer. This species requires solid substrates near vegetation on which to lay their eggs.
Percichthyidae	Oxleyan pygmy perch	<i>Nannoperca oxleyana</i>	-	ü	ü	-	E	Low	DPI Fisheries: Predicted distribution indicates that the species has the potential to occur in NSW no further north than Broadwater National Park. BioNet: One record was reported near Wooli in 2013 PMST: May occur.	Species or species habitat is likely to occur, or may occur, from north of Coffs Harbour in NSW to Harvey Bay in Queensland. The species is thought to have a patchy distribution and is reportedly confined to dystrophic, freshwater systems draining through sandy coastal lowlands and Banksia dominated heaths. Specific habitat requirements include slow-flowing, fresh, acidic waters with abundant aquatic vegetation.
Mammals										
Ornithorhynchidae	Platypus	<i>Ornithorhynchus anatinus</i>	-	ü	-	-	PL	Recorded	DPI Fisheries: n/a	The platypus is a semi-aquatic mammal that depends entirely on

Family	Common name	Scientific name	Data source				Conservation status	LoO	Rationale for likelihood of occurrence	Habitat requirements
			DPI	BioNet	PMST	Lit.	EPBC Act			
									BioNet: A number of records occur within Clarrie Hall Dam, Doon Doon Creek, Big Creek, Commissioners Creek and the Tweed River. The most recent records occurred in 2006. PMST: n/a Literature: n/a	freshwater systems, exhibiting a preference for aquatic habitats comprising a riparian zone with consolidated earth banks stabilised by large trees, undercut 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, 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, et al., 2019). Studies conducted by the Australian Platypus Conservancy (Serena, et al., 2014) indicate that a statistically 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 undercut the water. 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: LoO = Likelihood of occurrence; E = Endangered, PL = Department of Climate Change, Energy, the Environment and Water (2000) provisional management list (PL).

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12. Appendix M – Site photographs

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Table 46: Site photographs, September 2023

Site	Upstream	Downstream
BC1	Date & Time: Tue Sep 19 14:51:08 AEST 2023 Position: 028.62082°S / 159.31408°E Altitude: 136m Datum: WGS-84 Azimuth/Bearing: 141° 33'E 2502mils True Zoom: 1X CHD BC1 us 	Date & Time: Tue Sep 19 14:51:22 AEST 2023 Position: 028.62082°S / 159.31405°E Altitude: 136m Datum: WGS-84 Azimuth/Bearing: 141° 33'E 2502mils True Zoom: 1X CHD BC1 ds 

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Site	Upstream	Downstream
BPW	Date & Time: Sun Sep 17 07:54:16 AEST 2023 Position: 028.94432° S ; 159.47548° E Altitude: 4m Datum: WGS-84 Azimuth/Bearing: 263° N07W 5001mils (True) Zoom: 1X GHD Gray back wall BPW 	Date & Time: Sun Sep 17 07:53:50 AEST 2023 Position: 028.94427° S ; 159.47547° E Altitude: 7m Datum: WGS-84 Azimuth/Bearing: 263° 00W 4674mils (True) Zoom: 1X GHD Gray back wall BPW 

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Site	Upstream	Downstream
CC1	Date & Time: Tue Sep 19 13:23:03 AEST 2023 Position: 028°48'19" S / 153°31'50" E Altitude: 105m Datum: WGS-84 Azimuth/Bearing: 354° N06W 6293mils (True) Zoom: 1X CHD CC1 - us 	Date & Time: Tue Sep 19 13:23:41 AEST 2023 Position: 028°48'22" S / 153°31'51" E Altitude: 108m Datum: WGS-84 Azimuth/Bearing: 190° S40E 2689mils (True) Zoom: 1X CHD CC1 - da 

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Site	Upstream	Downstream
CC2	Date & Time: Tue Sep 19 09:45:44 AEST 2023 Position: 163.51633°E, 153.32991°E Altitude: 122m Datum: WGS84 Azimuth/Bearing: 199° S19W 3538mils (True) Zoom: 1X CHD CC2 US 	Date & Time: Tue Sep 19 09:18:05 AEST 2023 Position: 163.51633°E, 153.32991°E Altitude: 122m Datum: WGS84 Azimuth/Bearing: 019° N19E 0338mils (True) Zoom: 1X CHD CC2 DS 

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Site	Upstream	Downstream
CHD1	Date & Time: Mon Sep 18 13:52:29 AEST 2023 Position: 029.48662 S, 153.10147 E Altitude: 53m Datum: WGS-84 Azimuth/Bearing: 157.651E, 282.7mils True Zoom: 1X CHD: 1 CHD1.us 	Date & Time: Mon Sep 18 13:52:40 AEST 2023 Position: 029.48661 S, 153.10145 E Altitude: 53m Datum: WGS-84 Azimuth/Bearing: 321.1432W, 170.2mils True Zoom: 1X CHD: 1 CHD1.ds 

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Site	Upstream	Downstream
CHD2	Date & Time: Mon Sep 18 12:22:14 AEST 2023 Position: 128.45525° S, 159.29011° E Altitude: 72m Datum: WGS-84 Azimuth/Bearing: 248° S49W 43°mils True Zoom: 1X CHD: CHD 1 ue 	Date & Time: Mon Sep 18 12:25:11 AEST 2023 Position: 128.45510° S, 159.29007° E Altitude: 74m Datum: WGS-84 Azimuth/Bearing: 030° N80E 1422mils True Zoom: 1X CHD: CHD 3 ds 

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Site	Upstream	Downstream
DD2	Date & Time: Tue Sep 19 16:09:16 AEST 2023 Position: 029.91689° S, 159.30924° E Altitude: 89m Datum: WGS 84 Azimuth Bearing: 159° 32'E 2827mils (True) Zoom: 1X CHD: DD2-us 	Date & Time: Tue Sep 19 16:08:52 AEST 2023 Position: 029.91689° S, 159.30918° E Altitude: 89m Datum: WGS 84 Azimuth Bearing: 004° N04E 0071mils (True) Zoom: 1X CHD: DD2-ds 

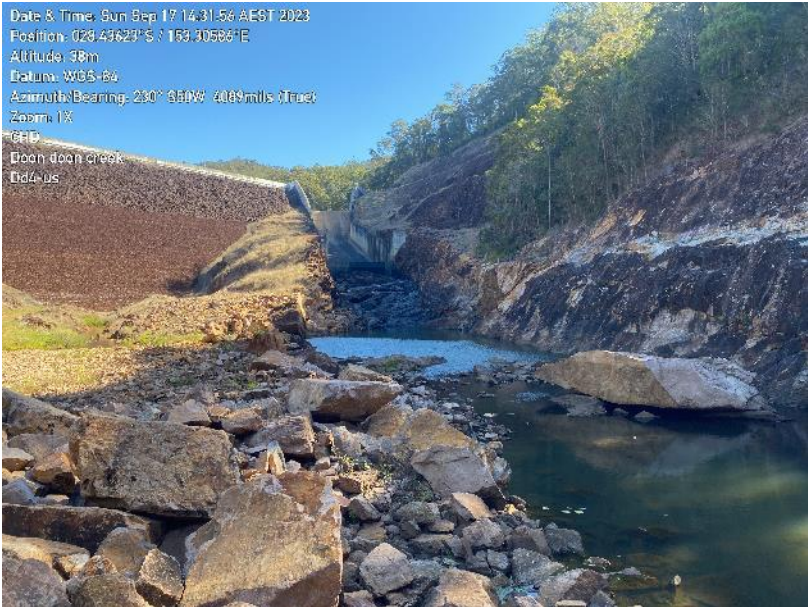
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Site	Upstream	Downstream
DD3	Date & Time: Tue Sep 18 15:38:00 AEST 2023 Position: 028°48'57" S - 159°00'18" E Altitude: 80m Datum: WGS-84 Azimuth/Bearing: 172° S04E 012mils True Zoom: 1X CHD DD3 - us 	Date & Time: Tue Sep 19 16:39:03 AEST 2023 Position: 028°48'57" S - 159°00'18" E Altitude: 80m Datum: WGS-84 Azimuth/Bearing: 016° N16E 0284mils True Zoom: 1X CHD DD3 - ds 

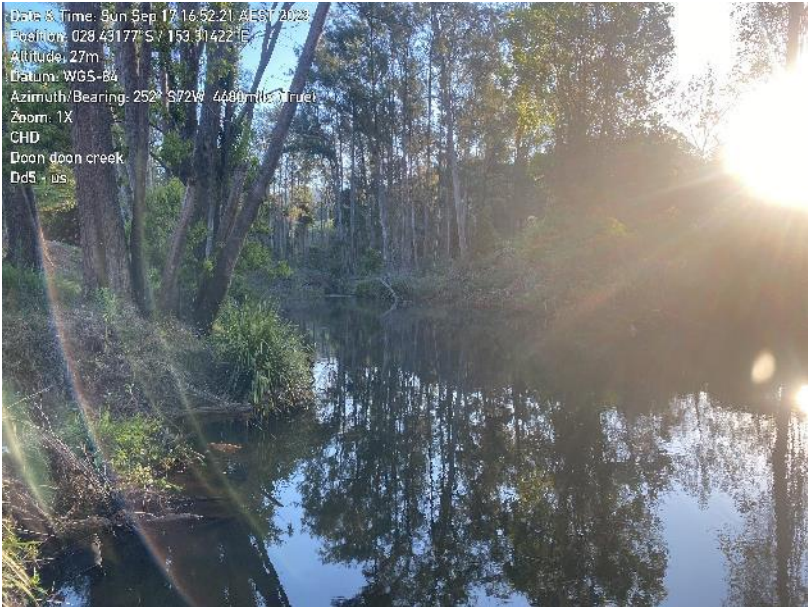
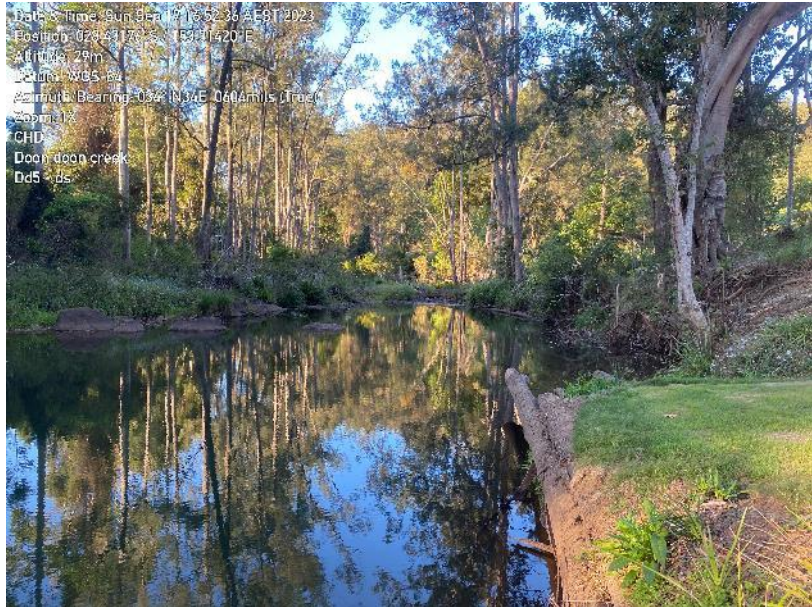
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Site	Upstream	Downstream
DD4	Date & Time: Sun Sep 17 14:31:56 AEST 2023 Position: 028.49629° S / 153.30588° E Altitude: 38m Datum: WGS-84 Azimuth/Bearing: 230° SSW 4089mils (True) Zoom: 1X CHD Doon doon creek DD4-us 	Date & Time: Sun Sep 17 14:32:09 AEST 2023 Position: 028.49629° S / 153.30588° E Altitude: 41m Datum: WGS-84 Azimuth/Bearing: 044° N44E 0782mils (True) Zoom: 1X CHD Doon doon creek DD4-ds 

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Site	Upstream	Downstream
DD5	Date & Time: Sun Sep 17 16:52:21 AEST 2023 Position: 028 43177 S / 153 31422 E Altitude: 27m Datum: WGS-84 Azimuth/Bearing: 252° S72W 4480mils True Zoom: 1X CHD Doon doon creek Dd5 - us 	Date & Time: Sun Sep 17 16:52:36 AEST 2023 Position: 028 43179 S / 153 31420 E Altitude: 29m Datum: WGS-84 Azimuth/Bearing: 034° N34E 0604mils True Zoom: 1X CHD Doon doon creek Dd5 - ds 

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Site	Upstream	Downstream
MB1	Date & Time: Mon Sep 18 15:29:28 AEST 2023 Position: 028.48432° S / 153.30208° E Altitude: 65m Datum: WGS-84 Azimuth/Bearing: 123° S57E 2187mils (True) Zoom: 1X CHD MB1-us 	Date & Time: Mon Sep 18 16:30:00 AEST 2023 Position: 028.48431° S / 153.30212° E Altitude: 66m Datum: WGS-84 Azimuth/Bearing: 299° N61W 5316mils (True) Zoom: 1X CHD MB1-ds 

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Site	Upstream	Downstream
TR1	Date & Time: Sun Sep 17 13:23:24 AEST 2023 Position: 028 42392 S / 153 31784 E Altitude: 29m Datum: WGS-84 Azimuth/Bearing: 160° S20E 284mils (True) Zoom: 1X CHD Tweed River TR1 ds 	Date & Time: Sun Sep 17 13:23:00 AEST 2023 Position: 028 42398 S / 153 31778 E Altitude: 28m Datum: WGS-84 Azimuth/Bearing: 342° N18W 6080mils (True) Zoom: 1X CHD Tweed River TR1 ds 

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Site	Upstream	Downstream
TR2	Date & Time: Sun Sep 17 11:22:57 AEST 2023 Position: 028.99298° S ; 153.43272° E Altitude: 12m Datum: WGS-84 Azimuth Bearing: 138° S42E 2453mils (True) Zoom: 1X CHD: Tweed River TR2 us 	Date & Time: Sun Sep 17 11:04:25 AEST 2023 Position: 028.99288° S ; 153.43321° E Altitude: 10m Datum: WGS-84 Azimuth Bearing: 279° N81W 4960mils (True) Zoom: 1X CHD: Tweed River TR2 ds 

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Site	Upstream	Downstream
TR3	Date & Time: Sun Sep 17 09:59:39 AEST 2023 Position: 028.37207° S ; 153.34741° E Altitude: 11m Datum: WGS-84 Azimuth/Bearing: 231° S51W 4107mils (True) Zoom: 1X CHD: Tweed River TR3 - us 	Date & Time: Sun Sep 17 09:59:53 AEST 2023 Position: 028.37207° S ; 153.34740° E Altitude: 6m Datum: WGS-84 Azimuth/Bearing: 021° N21E 0873mils (True) Zoom: 1X CHD: Tweed River TR3 - ds 

Table 47: Site photographs captured during the January 2024 targeted Oxleyan pygmy perch surveys

Site	Site photograph
PP1	Date & Time: Sun Jan 14 09:09:43 AEDT 2024 Position: 028 39'18" S, 153 34'11" E Altitude: 19m Datum: WGS-84 Azimuth/Bearing: 296° N64W 5262mils (True) Zoom: 1X Tweed river OPP survey PP1 

Site	Site photograph
PP4	Date & Time: Sun Jan 14 11:09:27 AEDT 2024 Position: 028.39969° S / 153.34608° E Altitude: 40m Datum: WGS-84 Azimuth/Bearing: 099° S81E 1760mils (True) Zoom: 1X Tweed river OPP survey PP4 

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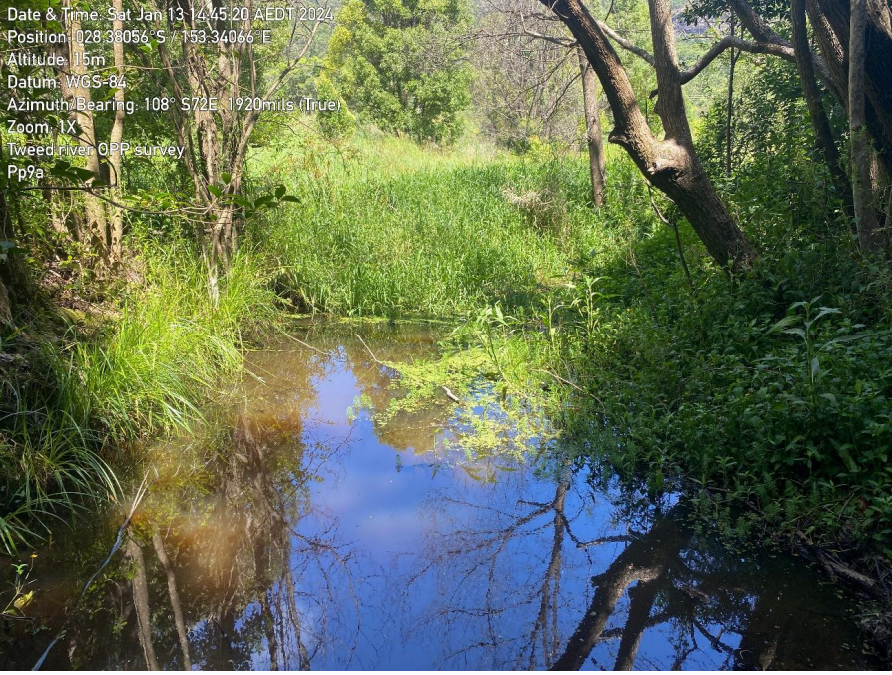
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Site	Site photograph
PP5a	 Date & Time: Sat Jan 13 10:22:22 AEDT 2024 Position: 028.39620° S / 153.35924° E Altitude: 327m Datum: WGS-84 Azimuth/Bearing: 338° N22W / 6009mils (True) Zoom: 1X Tweed river Pp5a 

Site	Site photograph
PP6	Date & Time: Sun Jan 14 10:24:37 AEDT 2024 Position: 028.39082° S / 153.33648° E Altitude: 23m Datum: WGS-84 Azimuth/Bearing: 221° S41W 3929mils (True) Zoom: 1X Tweed river OPP survey PP6 

Site	Site photograph
PP7	Date & Time: Sat Jan 13 12:16:34 AEDT 2024 Position: 028.39201° S / 153.34026° E Altitude: 42m Datum: WGS-84 Azimuth/Bearing: 259° S79W 4604mils (True) Zoom: 1X Tweed river OPP survey Pp7 

Site	Site photograph
PP9	Date & Time: Mon Jan 15 10:24:09 AEDT 2024 Position: 028.37424°S / 153.34080°E Altitude: 84m Datum: WGS-84 Azimuth/Bearing: 247° S67W 4391mils (True) Zoom: 1X Tweed river OPP survey PP9 

Site	Site photograph
PP9a	Date & Time: Sat Jan 13 14:45:20 AEDT 2024 Position: 028.38056° S / 153.34066° E Altitude: 15m Datum: WGS-84 Azimuth/Bearing: 108° S/2E, 1920mils (True) Zoom: 1X Tweed river OPP survey Pp9a 

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Site	Site photograph
PP10	Date & Time: Mon Jan 15 09:27:39 AEDT 2024 Position: 023.37939°S / 153.33725°E Altitude: 19m Datum: WGS-84 Azimuth/Bearing: 039° N39E 0693mils (true) Zoom: 1X Tweed river OPP survey PP10 lake 

Site	Site photograph
PP13	Date & Time: Sun Jan 14 13:25:42 AEDT 2024 Position: 028.37552° S / 153.34465° E Altitude: 15m Datum: WGS-84 Azimuth/Bearing: 251° S71W 7462mils (True) Zoom: 1X Tweed river OPP survey PP13 
PP16	No photo provided.

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Site	Site photograph
PP21a	Date & Time: Sun Jan 14 14:26:58 AEDT 2024 Position: 029.40621°S / 153.33520°E Altitude: 19m Datum: WGS-84 Azimuth/Bearing: 162° S18E 2880m/s (True) Zoom: 1X Tweed river OPP survey PP21a 
PP22a	No photo provided.

Site	Site photograph
PP23	Date & Time: Sat Jan 13 13:02:19 AEDT 2024 Position: 028.38489°S / 153.34094°E Altitude: 18m Datum: WGS-84 Azimuth/Bearing: 262° S82W 4658mils (True) Zoom: 1X Tweed river OPP survey Pp23 

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13. Appendix N – DPI Fisheries key fish habitat assessment pro forma

Table 48: 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	
<i>Posidonia australis</i> (a seagrass)		<i>Zostera</i> , <i>Heterozostera</i> , <i>Halophila</i> and <i>Ruppia</i> 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	
<i>Zostera</i> / <i>Heterozostera</i> / <i>Halophila</i> / <i>Ruppia</i> 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 <i>Ecklonia</i> and <i>Sargassum</i> 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)	
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.		Farm dams on first and second order streams or unmapped gullies	

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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	
		managed in line with an entrance management plan)			
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 49: 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).	

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14. Appendix O – Electrofisher settings, September 2023

Table 50: Electrofisher settings, September 2023

Waterway	Site	Volts	Amps	Frequency (Hz)	Duty cycle (%)	Power set	Impulse set	PPS	Seconds on time
Clarrie Hall Dam	CHD2	600	10	-	-	2	8	80	1080
	CHD1	800	5	-	-	2	6	30	1080
Doon Doon Creek	DD5	320	1.4	30	12	-	-	-	1200
	DD4	320	1.4	30	12	-	-	-	1200
	MB1	320	1.4	30	12	-	-	-	1200
	DD3	320	1.4	30	12	-	-	-	1200
	DD2	320	1.4	30	12	-	-	-	1200
	DD1	320	1.4	30	12	-	-	-	1200
	BC1	300	1.4	30	12	-	-	-	1200
Commissioners Creek	CC1	350	1.4	30	12	-	-	-	1200
	CC2	350	1.4	30	12	-	-	-	1200
Tweed River	TR1	270	1.4	30	12	-	-	-	1200
	TR2	270	1.4	30	12	-	-	-	1200
	TR3	600	15	-	-	2	6	125	1080
	BPW	600	15	-	-	2	6	125	1080

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15. Appendix P – FM Act Significant Impact Assessments

Table 51: Significant impact criteria (endangered species) – southern purple-spotted gudgeon

Criteria	Discussion
1) 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,	Multiple surveys were undertaken by Austral and DPI Fisheries within Clarrie Hall Dam and tributaries of Clarrie Hall Dam. The southern purple-spotted gudgeon <i>was not</i> detected during any surveys. The Proposal <i>will not</i> 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.
2) 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,	Multiple surveys were undertaken by Austral and DPI Fisheries within Clarrie Hall Dam and tributaries of Clarrie Hall Dam. The southern purple-spotted gudgeon <i>was not</i> detected during any surveys. The Proposal <i>will not</i> 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.
3) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: (i) Is likely to have an adverse effect on the extent of the ecological	Not applicable

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Criteria	Discussion
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,	
4) (d) In relation to the habitat of a threatened species, population or ecological community:	While the southern purple-spotted gudgeon was not detected during surveys, the study area and broader catchment supports habitat appropriate for the southern purple-spotted gudgeon.
(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and,	Surface water assessments have shown that changes to surface water are modelled to be nil to negligible. Additionally, impacts resulting from CWP are likely to decrease, marginally improving aquatic ecology values within Doon Doon Creek. The lack of negative impacts to surface water within Doon Doon Creek and the Tweed River suggests that any impacts to southern purple-spotted gudgeon habitat downstream of Clarrie Hall Dam will be nil to negligible. An area of key fish habitat (23,460 m ²) will be lost as a result of the Proposal.
(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and	Not applicable – the southern purple-spotted gudgeon was not detected during surveys undertaken by either Austral or DPI Fisheries. An area of key fish habitat (23,460 m ²) will be lost as a result of the Proposal. All other impacts to aquatic ecology are considered nil to negligible.
(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,	Habitat critical to the survival of the southern purple-spotted gudgeon is considered to be ' <i>rivers, creeks, streams and billabongs with slow-flowing or still waters.</i> ' While these habitat features are present within the study area and broader catchment, the southern purple-spotted gudgeon was not detected by either Austral or DPI Fisheries during surveys.

Criteria	Discussion
	Additionally, impacts to surface water resulting from the proposal are modelled to be nil to negligible. While all habitat for the southern purple-spotted gudgeon should be considered 'important', the species is not present within the study area and as such, habitat within the study area is not considered important to the long term survival of the species.
5) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),	There is no declared critical habitat listed under the FM Act for the southern purple-spotted gudgeon.
6) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,	There are a number of recovery actions stipulated for the southern purple-spotted gudgeon, with 2 potentially being of relevance to the Proposal: <i>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).</i> Applicable to the southern purple-spotted gudgeon. It is acknowledged that the potential exists for downstream impacts to threatened aquatic fauna to occur. However, the likelihood of these impacts occurring are considered nil to negligible. It is not anticipated that a negligible change in water depth will result in significant impacts to the southern purple-spotted gudgeon. CWP impacts are modelled to decrease with the raised dam wall and may marginally improve aquatic ecology values within Doon Doon Creek. <i>Undertake work to identify, restore and protect known and potential ... habitats and address key threats such as habitat degradation and water quality decline from expanding development (high priority).</i> Implementation of the Proposal is unlikely to result in habitat degradation, and management plans will be implemented to ensure that construction impacts are mitigated as far as reasonably practicable. The Proposal will be implemented in a manner that does not contradict relevant Priorities Action Statements, as far as practicable.

Criteria	Discussion
7) Whether the action proposed constitutes or is part of a Key Threatening Process (KTP) 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, 3 may be relevant to the Proposal with regard to the southern purple-spotted gudgeon: <i>Degradation of native riparian vegetation along New South Wales water courses.</i> Overall, much of Clarrie Hall Dam supports native riparian, as does Doon Doon Creek, but less so on the Tweed River. As such, the Proposal is likely to have a large impact on riparian vegetation, mostly restricted to Clarrie Hall Dam and the new area of inundation. Given the area of inundation will increase, and much of the land around Clarrie Hall Dam is forested, the new 'waters edge' will largely be located within forested land, essentially creating a new riparian zone within forested areas. <i>Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams.</i> It is acknowledged that the potential exists for downstream impacts to aquatic fauna to occur. The surface water assessment undertaken by EMM Consulting Pty Limited (2024b) report that changes to surface water (depth) will be nil to negligible. As such, impacts to aquatic fauna downstream of Clarrie Hall Dam will be nil to negligible. <i>Introduction of fish to waters within a river catchment outside their natural range.</i> The eastern gambusia and common carp were recorded at multiple sites across multiple surveys, while the pearl cichlid was detected during one survey only. Therefore, while it is possible that eastern gambusia larvae could be transferred into Clarrie Hall Dam, Doon Doon Creek, the Tweed River or tributaries relevant to the Proposal, it is considered unlikely to occur. In addition, this species is already widespread throughout the local catchment. With regard to native aquatic species, it is unlikely that fish would be transferred outside their natural range, as impacts to aquatic ecology are considered nil to negligible. Apart from the potential for aquatic fauna salvage to be required, no aquatic fauna are to be taken as part of the Proposal. The Proposal will be implemented in a manner that does not contradict key threatening processes, as far as practicable.

Criteria	Discussion
Conclusion	Construction and operation of the Proposal is unlikely to significantly impact the southern purple-spotted gudgeon given that: · despite surveys being undertaken in accordance with the <i>Survey guidelines for Australia's threatened fish: Guidelines for detecting fish listed as threatened under the EPBC Act</i> (Department of Sustainability, Environment, Water, Population and Communities, 2011), the southern purple-spotted gudgeon was <i>not</i> detected within Clarrie Hall Dam or associated waterways · a total of 23,460 m² of key fish habitat is to be lost as a result of the Proposal – primarily as a result of the increased inundation area of Clarrie Hall Dam with the raised dam wall · downstream operational impacts are modelled to be nil to negligible · the magnitude of CWP is modelled to <i>decrease</i> as a result of the Proposal · a CEMP and appropriate mitigation measures will be prepared to minimise and mitigate impacts from construction activities.

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16. Appendix Q – EPBC Act Significant Impact Assessments

Table 52: Significant impact criteria – Vulnerable species – platypus

Species assessed	Platypus
Criteria	Discussion
Lead to a long-term decrease in the size of an important population	The platypus was placed on the provisional list of animals requiring urgent management intervention after the 2019/20 bushfires in southern and eastern Australia (Department of Climate Change, Energy, the Environment and Water, 2020). Given the lack of formal elevated conservation status for platypus no populations of platypus are formally recognised as 'important' populations. As such, the proposed action will not lead to a long-term decrease in the size of an 'important' population.
Reduce the area of occupancy for an important population	Given the lack of formal elevated conservation status for the platypus, no populations of platypus are formally recognised as 'important' populations. As such the proposed action will not lead to a reduction in the area of occupancy for an 'important' population.
Fragment an existing important population into two or more populations	Given the lack of formal elevated conservation status for the platypus, no populations of platypus are formally recognised as 'important' populations. As such, the proposed action will not lead to the fragmentation of an existing 'important' population into two or more populations.
Adversely affect habitat critical to the survival of a species	High-value habitat for the platypus is known to occur within Clarrie Hall Dam and associated waterways. A total of 23,460 m² of key fish habitat will be lost as a result of the Proposal. Downstream impacts to platypus habitat are modelled to be nil to negligible. Platypus habitat will be lost within Clarrie Hall Dam as a result of the increased inundation area; however, the new 'lake edge' will become platypus habitat in time as platypuses establish new burrows within the new 'lake edge' and riparian zone. Impacts to platypus habitat may occur during the construction phase of the Proposal; however, a CEMP and FMP will be prepared to minimise and mitigate impacts to aquatic fauna, including the platypus. While a small area of platypus habitat will be lost due to the Proposal, platypuses are prevalent within the broader catchment, and the habitat to be lost is not considered critical to the survival of the species.

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Disrupt the breeding cycle of an important population	Given the lack of formal elevated conservation status for the platypus, no populations of platypus are formally recognised as 'important' populations. As such the proposed action will not disrupt the breeding cycle of an 'important' population. Platypus burrows within the increased inundation area (Clarrie Hall Dam and immediately upstream in Doon Doon Creek) are likely to be lost due to the increased water level. Platypuses are considered proficient diggers and frequently utilise a number of burrows at any one time. It is expected that new burrows will be established quickly. The Proposal will not decrease the availability habitat to the extent that the species is likely to decline.
Modify, destroy, remove, isolate or decrease the availability habitat to the extent that the species is likely to decline	Aquatic surveys revealed that exotic species known to compete with the platypus for dietary resources, including common carp, eastern mosquitofish, which already occur within the study area. The Proposal will not introduce any new exotic species to the study area.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	
Introduce disease that may cause the species to decline	The Proposal is unlikely to introduce any disease that may cause the platypus population to decline. It should be noted that there is a potential for an increase of bloom-forming and toxic algae to occur within Clarrie Hall Dam and downstream waterways as a result of the Proposal. Water releases during summer must be managed appropriately to minimise the likelihood of increased occurrences of toxic algal blooms.
Interfere substantially with the recovery of the species	There will be a loss of 23,460 m² of key fish habitat resulting from the Proposal. All other aquatic impacts are considered to be minimal, and the magnitude of CWP is modelled to decrease as a result of the Proposal. The Proposal will not interfere with the recovery of the species.
Conclusion	A loss of 23,460 m² of key fish habitat will occur as a result of the Proposal, primarily lost from creek lines as they enter Clarrie Hall Dam. Downstream impacts due to operation of the raised dam wall are modelled to be nil to negligible, and potential impacts resulting from construction would be minimised and mitigated through the preparation of a CEMP, which will include an FMP. The platypus is prevalent throughout the broader catchment. The Proposal will not result in a significant impact to the platypus.

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