APPENDIX

DUNGOWAN DAM AND PIPELINE EIS

Aquatic Ecology Assessment

Dungowan Dam and pipeline project

Aquatic Ecology Assessment

Prepared for Water Infrastructure NSW

September 2022

Dungowan Dam and pipeline project

Aquatic Ecology Assessment

Water Infrastructure NSW

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Version	Date	Prepared by	Approved by	Comments
2	12 August 2022	Thorin Robertson and Dion Iervasi (Austral Ecology)	Chris Holloway	
3	28 September 2022	Thorin Robertson and Dion Iervasi (Austral Ecology)	Chris Holloway	

Approved by

Chris Holloway
Associate Director
28 September 2022

Ground floor 20 Chandos Street
St Leonards NSW 2065
PO Box 21
St Leonards NSW 1590

This report has been prepared in accordance with the brief provided by Water Infrastructure NSW and has relied upon the information collected at the time and under the conditions specified in the report. All findings, conclusions or recommendations contained in the report are based on the aforementioned circumstances. The report is for the use of Water Infrastructure NSW and no responsibility will be taken for its use by other parties. Water Infrastructure NSW may, at its discretion, use the report to inform regulators and the public.

Executive Summary

ES1 Introduction

This aquatic ecology assessment has been undertaken to assess the potential impacts from the construction and operation of the new Dungowan Dam and pipeline on the key aquatic values known or predicted to occur within the project footprint as well as within areas of Dungowan Creek and the Peel River where the operation of the new dam is predicted to cause changes to the flow regime.

This assessment documents the methodology for fieldwork and assessments, present the results of all aquatic investigations undertaken, defines the ecological values and receptors of concern and presents likely impacts and mitigation measures to minimise or offset those impacts.

ES2 Desktop assessment results

A desktop assessment and comprehensive literature review was undertaken to determine potential listed species and associated habitat, threatened ecological communities (TECs), and groundwater dependant ecosystems (GDEs) that may be impacted by the project. The results of the desktop assessment indicated that one TEC listed as endangered under the *Fisheries Management Act 1994* (FM Act), "the Lowland Darling River aquatic ecological community" occurs within, and downstream of the project footprint and has the potential to be impacted by the project.

The desktop assessment indicated that a total of four threatened aquatic species or species comprising a threatened population, listed under the FM Act and/or the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and the Platypus have the potential to occur in waterways associated with the Namoi catchment. Aquatic species in addition to the platypus included: Southern Purple-spotted Gudgeon (*Mogurnda adspersa*), Silver Perch (*Bidyanus bidyanus*), Murray Cod (*Maccullochella peelii*) and Murray-Darling Basin population of Eel-tailed Catfish (*Tandanus tandanus*).

The literature review revealed that at least 14 stygofauna taxa, which rely on Groundwater Dependent Ecosystems (GDEs) for survival have previously been recorded within the Namoi catchment. These taxa included subterranean representatives from the orders Ostracoda, Copepoda, Syncarida, Malacostraca, Oligochaeta and Acarina. Only common species of macrophytes and algae have previously been recorded within the Peel River. No information was available for Dungowan Creek.

ES3 Field Surveys

ES3.1 Survey coverage

Aquatic surveys were undertaken at a total of 26 sites in August 2020 with an additional 25 sites surveyed in February-March 2022. The study area included tributaries within the inundation area of the new Dungowan Dam, Dungowan Creek and associated tributaries from the site of the new Dungowan Dam wall to the confluence of Dungowan Creek and the Peel River, and the Peel River (and associated tributaries) extending from immediately downstream of the Chaffey Dam wall to Tamworth.

Surveys included an assessment of key fish habitat, water and sediment quality, aquatic flora (including algae), macroinvertebrates and aquatic invertebrates. Survey methods involved direct observation of key fish habitat, laboratory analysis of water, sediments and algae, macroinvertebrate analysis, eDNA analysis of fish and Platypus and electrofishing and netting for aquatic vertebrates.

A total of 26 sites were assessed for key fish habitat during the August 2020 aquatic surveys and an additional 25 sites were assessed in the February-March 2022 aquatic surveys. Waterways ranged from 3rd to 6th (Strahler) order with streams of a range and combination of key fish habitat types and classifications and includes Type 1 highly sensitive key fish habitat and Class 1 major key fish habitat.

ES3.2 Water and sediment quality

Water quality analysis was undertaken at 13 sites during the August 2020 surveys and included Jones Oaky Creek, Paradise Creek, Terrible Billy Creek, Dungowan Creek, the Peel River, Big Oaky Creek, Johnson Oaky Creek and an unnamed waterway. pH, suspended solids, turbidity and dissolved oxygen were outside the ANZECC and ARMCANZ trigger values for a number of sites during the August 2020 surveys. A result below the trigger value is considered low concentration/unhealthy and above the trigger value is considered high concentration/ unhealthy for a specific ecosystem or group of waterways with similar characteristics. All other parameters were within the relevant trigger values.

Water quality analysis was undertaken at 11 sites during the February-March 2022 aquatic surveys. All sites were located on either Dungowan Creek or the Peel River. pH, electrical conductivity and dissolved oxygen were outside the ANZECC and ARMCANZ trigger values for a number of sites during the February-March 2022 surveys. All other parameters were within the relevant trigger values.

Sediment analysis was undertaken at 14 sites during the August 2020 aquatic surveys and included Jones Oaky Creek, Paradise Creek, Terrible Billy Creek, Dungowan Creek, the Peel River, Big Oaky Creek, Hell Hole Gully, Johnson Oaky Creek and an unnamed waterway. Only Nickel was recorded as exceeding the relevant Australian and New Zealand guidelines for fresh and marine water quality default guideline values (ANZG DGV) at nine sites; however, the water quality guideline values (GV) High values were not exceeded. Sediment analysis was undertaken at five sites during the February-March 2022 aquatic surveys on the Peel River only. Only Nickel exceeded the ANZG DGVs trigger values, and met the GV-High value at one site.

ES3.3 Algae, macrophytes and macroinvertebrates

Phytoplankton and periphyton was assessed at eight sites (Jones Oaky Creek, Paradise Creek, Terrible Billy Creek, Dungowan Creek, the Peel River) during the August 2020 aquatic surveys and five sites (Peel River) during the February-March 2022 aquatic surveys. A potentially toxic, bloom forming algae was recorded in Dungowan Creek during the 2020 aquatic surveys and was also detected at four sites on the Peel River in 2022. None of the taxa recorded were considered to be threatened or of restricted distribution. Three potentially toxic, bloom forming periphyton algae species were recorded across four sites on the Peel River in 2022 aquatic surveys only. None of the taxa recorded during either survey was considered to be threatened or of restricted distribution.

Aquatic macrophytes have a limited diversity and distribution the study area and are not a dominant habitat feature. Macrophytes were recorded at two sites during the August 2020 aquatic survey and at two sites during the February-March 2022 aquatic surveys. None of the taxa recorded are considered to be threatened or of restricted distribution.

Macroinvertebrates were assessed at sites on Dungowan Creek, the Peel River, Terrible Billy Creek, Jones Oaky Creek and Paradise Creek during the August 2020 aquatic surveys and on Dungowan Creek and the Peel River during the February-March 2022 aquatic surveys. Results were pooled and the SIGNAL2 score (biotic index based on the tolerance or intolerance of biota (macroinvertebrates) to water pollution) and taxa richness showed that macroinvertebrate health was lowest immediately downstream of the Chaffey Dam wall and that all sites were likely impacted by agricultural pollution or the downstream effect of dams.

ES3.4 Aquatic vertebrates

Electrofishing, netting and eDNA analysis was undertaken at eight sites (Jones Oaky Creek, Paradise Creek, Terrible Billy Creek, Dungowan Creek, the Peel River) during the August 2020 aquatic surveys and electrofishing and netting was undertaken at 25 with eDNA analysis undertaken at 11 sites (Dungowan Creek and the Peel River) during the February-March 2022 aquatic surveys. August 2020 aquatic surveys Murray Cod were captured in the Peel River, Eel-tailed Catfish and Platypus were detected via eDNA at one site on Dungowan Creek. A number of species that comprise the Lowland Darling River aquatic ecological community were also detected. During the February-March 2022 aquatic surveys Murray Cod was detected at 12 sites across Dungowan Creek and the Peel

River via direct observation and eDNA analysis. Silver Perch was detected at two sites on the Peel River via direct observation and eDNA analysis. Eel-tailed Catfish was detected at 11 sites on the Peel River via direct observation. Platypus was recorded at ten sites across both Dungowan Creek and the Peel River via eDNA analysis. A number of species that comprise the Lowland Darling River aquatic ecological community were also detected.

ES4 Impacts to aquatic values

A range of existing impacts to aquatic values are present in the project area. These include river regulation, cold water pollution (CWP), agricultural impacts, exotic species, stock access and agricultural impacts, erosion, and fish passage. The project will result in additional impacts during construction and operation of the new Dungowan Dam and pipeline.

The construction impacts will include a loss of key fish habitat as the new Dungowan Dam is located downstream of the existing dam with direct construction impacts to areas of Dungowan Creek. Construction of the pipeline will result in temporary impacts to aquatic values in the form of, barriers to fauna passage, habitat removal and/or modification as a result of trenching activities and general construction impacts.

Operational impacts will be more complex than construction impacts. Operational impacts are associated with the reduction in flow volume and water depth as a result of the new operating requirements in both Dungowan Creek and the Peel River. The changed operation of the project will result in an altered hydrological regime in Dungowan Creek and also reduced run of river flows in the Peel River below Chaffey Dam due to the prioritisation of the new Dungowan Dam for town water supply to Tamworth.

The primary operational impacts will be as a result of habitat modification, fish passage and CWP. These will impact the aquatic values but are not expected to preclude the successful recruitment and persistence of the species in Dungowan Creek and the Peel River.

The extent of the operational impact of the project as a result of modified/or available habitat, primarily riffle habitat, is less certain based on the available data. Changes in flow will be expected to impact fish passage over natural barriers in the study area more often under the new operational regulations of the project compared to the existing conditions. CWP impacts are not expected to change in the Peel River and will extend approximately 5km downstream of the new Dungowan Dam wall under a worst case scenario. CWP impacts will be most significant in spring and summer during key spawning and recruitment times for aquatic species. CWP impacts will be dependent on dam operation and local weather or seasonal conditions.

ES5 Offsets and mitigation

The management of the project impacts would be addressed by both offsets (for unavoidable impacts) and mitigation measures (for impacts that can be managed).

ES5.1 Offsets

Offsets would be required for the impacts to fish passage as a result of the new Dungowan Dam (which does not have any fishway provision) as well as for the direct impacts to key fish habitat as a result of construction impacts and the inundation of the new Dungowan Dam.

Fish passage offsets have been agreed with NSW Department of Primary Industries (Fisheries NSW) (DPI Fisheries) and would include the modification to four known fish barriers on the Peel River downstream of the new Dungowan Dam. This would facilitate fish passage to an additional 94.7km of waterway within the Peel River and Dungowan Creek. These fish passage offsets would be completed prior to the operation of the new Dungowan Dam and pipeline project.

Offsets for the direct impact to key fish habitat have been calculated in accordance with the *NSW Biodiversity Offsets Policy for Major Projects Fact sheet: Aquatic biodiversity* (DPI 2014), which requires that a minimum 2:1 offset occurs for Type 1 to Type 3 key fish habitats. The project is estimated to impact approximately 210,563 m^2 of corresponding key fish habitat and therefore would be required to pay up to approximately $22.3M into the Fish Conservation Trust Fund, or agree other supplementary offset approaches with DPI Fisheries, including utilising off site offset areas or the rehabilitation of Dungowan Creek upstream of the existing Dungowan Dam, which would be rehabilitated as part of the project.

ES5.3 Mitigation

Mitigation measures would be required to manage impacts resulting from the construction and operation of the project.

The key mitigation measure for the construction period would be the development of a Flora and Fauna Management Plan, that would document the aquatic ecology mitigation measures detailed in this assessment, including for works within waterways. In addition, the preparation of a Construction Environmental Management Plan (CEMP) and other plans to manage soil and water quality impacts will be required to ensure aquatic values are appropriately protected during construction.

Operational measures would also be required to minimise potential impacts to aquatic values, including appropriate operational procedures relating to the use of the multi level offtake to mitigate CWP impacts, and the consideration of additional destratification strategies.

In addition, hydrology modelling has shown that alternative release patterns for translucency flows could further minimise hydrology changes in Dungowan Creek and further reduce the impacts presented in this assessment. The consideration of banking the additional 3 ML/day of translucency release for a pulsed release pattern, such as that presented in this assessment, should be further consulted with key stakeholders and incorporated into operational procedures.

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1 Introduction

1.1 The project

The Peel River, part of the Namoi River catchment, provides water for irrigation as well as being the primary water supply for the city of Tamworth. Prompted by the millennium drought, investigations into the future water supply and demand for bulk water were undertaken for the regional city of Tamworth and the Peel Valley water users. The Dungowan Dam and pipeline project (the project) is a critical project to improving long-term water security for the region. The project includes a new dam at Dungowan (new Dungowan Dam) approximately 3.5 km downstream of the existing Dungowan Dam and a new section of pipeline about 32km long between the proposed Dam outlet and the tie in point to an existing pipeline from Dungowan Showground to the Calala Water Treatment Plant (WTP).

In September 2022, the Minister for Planning and Homes declared the project to be Critical State Significant Infrastructure (CSSI) as it is a development that is essential for the State for economic and social reasons. This requires Schedule 5 of the *State Environmental Planning Policy (Planning Systems) 2021* to be updated to reflect the CSSI status of the project. As CSSI, the project is subject to Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), which requires the preparation of an environmental impact statement (EIS) and the approval of the NSW Minister for Planning and Homes.

The EIS has been prepared for the planning approval application for the project. This Aquatic Ecology Assessment has been prepared to support the EIS.

In addition to requiring approval from the NSW Minister for Planning and Homes, the project has been deemed a controlled action under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and requires approval from the Commonwealth Minister for the Environment and Water. The Minister for the Environment and Water has accredited the NSW planning process for the assessment of the project. Therefore, a single EIS has been prepared to address the requirements set out by the NSW Department of Planning and Environment (DPE) and the Commonwealth Department of Climate Change, Energy, the Environment and Water.

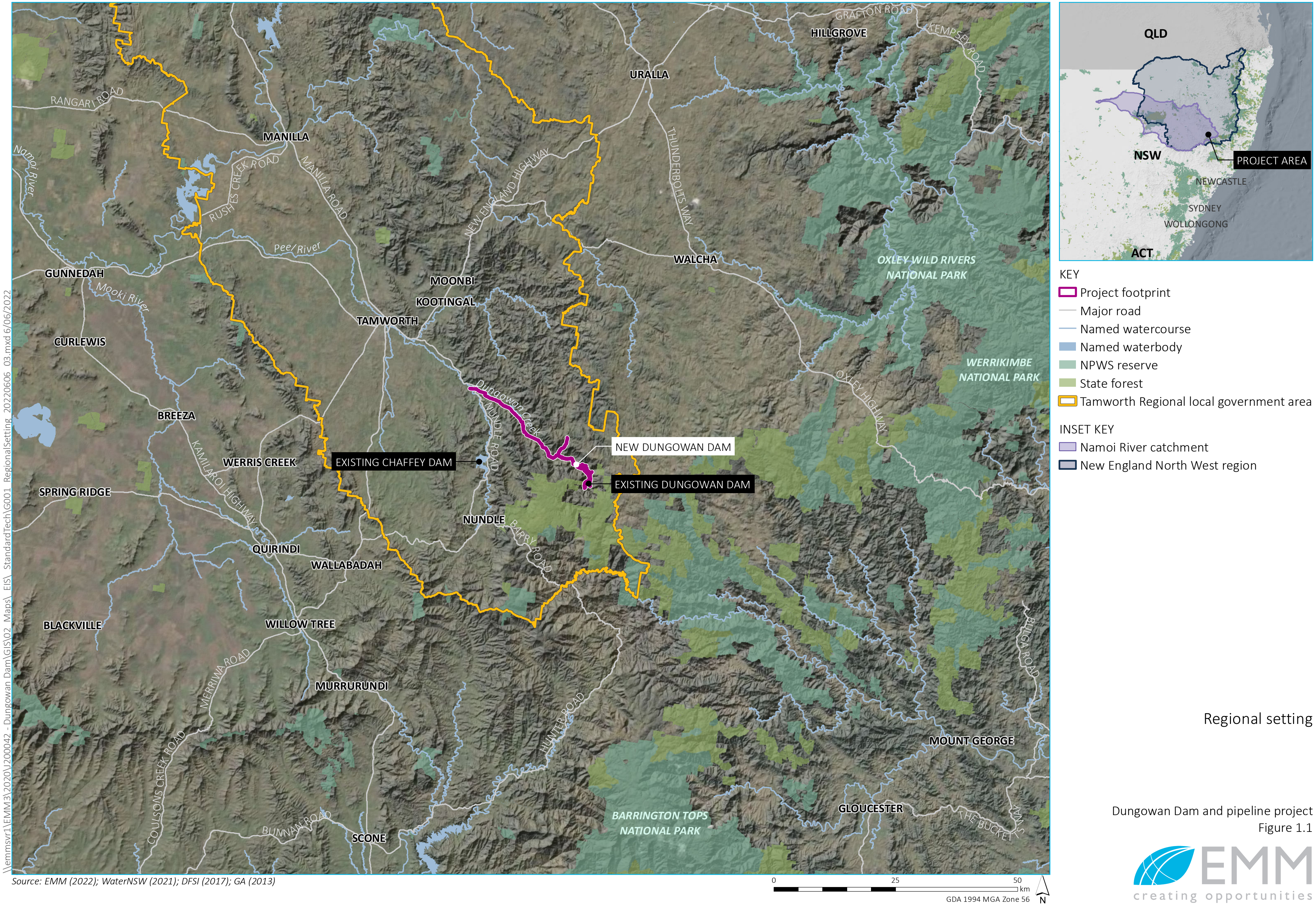
1.2 Project location

The project is located in the Tamworth Regional local government area (LGA), the New England Tablelands bioregion and part of the New England and North West region of NSW, west of the Great Dividing Range (DPE 2017). The New England and North West region is home to approximately 186,900 people and has a total area of around 99,100 km^2 (ABS 2018).

The city of Tamworth is the nearest (and largest) town to the project with over 40,000 residents. Other nearby regional towns include Quirindi (70 km west), Manilla (90 km north-west), Gloucester (90 km south-east), Armidale (100 km north) and Gunnedah (110 km west of the project).

The existing Dungowan Dam is in the Namoi River catchment approximately 50 km south-east of Tamworth in NSW. The Namoi catchment covers 4,700 km^2 and borders the Gwydir and Castlereagh catchments and is bounded by the Great Dividing Range in the east, the Liverpool Ranges and Warrumbungle Ranges in the south, and the Nandewar Ranges and Mount Kaputar to the north.

The existing Dungowan Dam is on Dungowan Creek, which is a tributary of the Peel River. Dungowan Creek is confined by the existing Dungowan Dam, while the Peel River system is regulated by Chaffey Dam, located in the upper catchment near the town of Woolomin, approximately 45 km from Tamworth. The project's regional setting is shown in Figure 1.1.



Source: EMM (2022); WaterNSW (2021); DFSI (2017); GA (2013)

Regional setting

Dungowan Dam and pipeline project
Figure 1.1

\\emmsvr1\EMM3\2020\200042 - Dungowan Dam\GIS\02 Maps\ EIS\ StandardTech\G001 RegionalSetting 20220606 03.mxd 6/06/2022

1.2.1 Project impact areas

In outlining the project, a project footprint has been defined to facilitate the assessment of direct impacts from the project:

- Project footprint: all areas where direct impacts may be experienced during construction and/or operation.

The project footprint has an area of 315 ha and is comprised of the construction and operational footprints, of which there is some overlap:

- Construction footprint: areas where vegetation clearing and/or ground disturbance is required for construction of the dam, pipeline and ancillary facilities, including the area needed to decommission and rehabilitate the existing dam.
- Operational footprint: areas where there will be permanent operational elements or easements, including infrastructure needed to operate the new Dungowan Dam and pipeline. The operation footprint includes the inundation area, being the area defined by the proposed full supply level (FSL) for the project.

The project construction and operational footprints are shown in Figure 1.2.

Additional areas outside the project footprint have also been considered where relevant to the assessment of project impacts and include:

- Upstream flood extent: An area above the FSL to the level of a probable maximum flood (PMF) event that would be inundated for relatively short periods during operation associated with extreme rainfall events.
- Project area: A 10 km buffer around the project footprint defined to allow for assessment of potential indirect impacts.
- Downstream impact area: the area where hydrological changes may occur due to the project. This area is discussed in detail in the Surface Water Assessment (EMM 2022) as well as other technical reports subject to changed flow regimes as a result of the new Dungowan Dam operation. The downstream impact area includes Dungowan Creek and also the Peel River downstream of Chaffey Dam.

1.2.2 Aquatic ecology study area

The aquatic ecology study area consists of the proposed inundation area for the new Dungowan Dam, Dungowan Creek itself and associated tributaries, and the Peel River between Chaffey Dam and Tamworth and associated tributaries.

i Inundation area

The proposed inundation area consists of Dungowan Creek upstream of the site of the new Dungowan Dam wall and a number of tributaries including:

- Paradise Creek.
- Terrible Billy Creek.
- Jones Oaky Creek.
- Two unnamed waterways.

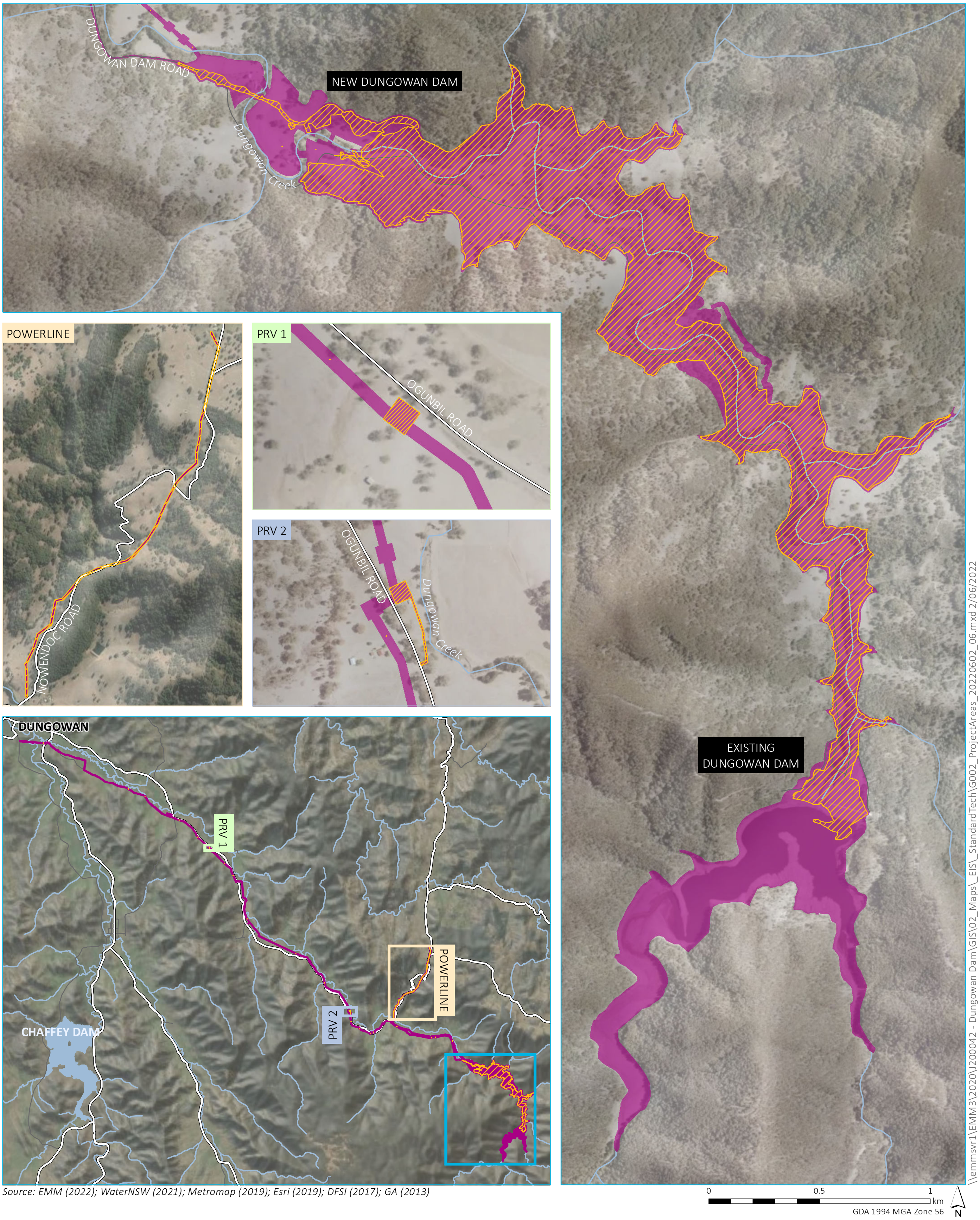
ii Downstream of the new Dungowan Dam

The aquatic ecology study area includes Dungowan Creek downstream of the new Dungowan Dam and associated tributaries. This section of the study area will be the location of the pipeline infrastructure, ancillary structures and to the north, the proposed powerline. Sampled tributaries intersecting Dungowan Creek include:

- Hell Hole Gully
- Johnstone Oaky Creek
- Big Oaky Creek
- Oaky Creek
- Nine unnamed waterways.

iii Peel River

The aquatic ecology study area includes the Peel River extending from the base of the Chaffey Dam wall to the centre of Tamworth and includes one unnamed tributary located in the vicinity of the confluence of the Peel River and Dungowan Creek.



Source: EMM (2022); WaterNSW (2021); Metromap (2019); Esri (2019); DFSI (2017); GA (2013)

KEY

- ■ Construction footprint
- ▨ Operational footprint

Existing environment

- ═ Major road
- — Minor road
- — Named watercourse
- ■ Named waterbody

Project footprint

Dungowan Dam and pipeline project
Figure 1.2

1.3 Purpose of this report

This aquatic ecology assessment supports the EIS for the project. It documents aquatic and subterranean ecology assessment methods and results (“aquatic ecology assessment”), the initiatives built into the project design to avoid and minimise associated impacts, and the mitigation and management measures, including offset requirements, proposed to address any unavoidable residual impacts.

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

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

The aquatic ecology assessment has been prepared jointly by EMM Consulting Pty Ltd and Austral Ecology and Research. The aim and objectives of the aquatic ecology assessment have been addressed to a standard suitable for assessment by relevant regulators, following best practice and in accordance with relevant legislation, policy and guidance material, summarised in Section 1.3.1. The aquatic ecology assessment has considered regulator input, based on the data and information available at the time of report submission.

1.3.1 Assessment guidelines and requirements

This aquatic ecology assessment has been prepared in accordance with the Secretary’s Environmental Assessment Requirements (SEARs) for the project as well as relevant government assessment requirements, guidelines and policies, and in consultation with the relevant government agencies.

The SEARs must be addressed in the EIS. Table 1.1 lists the matters outlined in the SEARs relevant to this aquatic ecology assessment and where they are addressed in this report.

Table 1.1 Aquatic and riparian biodiversity and ecology matters raised in SEARs

Requirement	Chapter/Section addressed
13. Assessment of aquatic, riverine and riparian biodiversity and ecology that addresses all direct, indirect, and prescribed impacts of the project on Key Fish Habitat and associated flora and fauna, threatened species, populations, and communities for the construction and operation of the asset. The assessment must comply with requirements outlined in the Policy and Guidelines for Fish Habitat Conservation and Management (2013), and must be prepared in consultation with, and have regard to the requirements of DPI Fisheries.	Aquatic Ecology Assessment Chapter 6, Chapters 8-10 EIS Appendix D, Community and Stakeholder Engagement Report
14. Assessment of impact of changes to inundation behaviour on aquatic ecosystems upstream and downstream from the project site.	Aquatic Ecology Assessment Chapter 8

Table 1.1 Aquatic and riparian biodiversity and ecology matters raised in SEARs

Requirement	Chapter/Section addressed
15. An assessment of likely significant impacts on listed threatened species, populations or ecological communities, in accordance with Part 7A of the Fisheries Management Act, 1994, including: a) assessment of the impacts according to the 'Seven-Part Test". b) consideration of NSW DPI threatened species indicative distribution maps for species, populations and ecological communities likely to be present.	Aquatic Ecology Assessment Annexure H
16. An Aquatic Biodiversity Offsets Strategy that is consistent with the Policy and Guidelines for Fish Habitat Conservation and Management (2013) and the NSW Biodiversity Offsets Policy for Major Projects that addresses direct, indirect, and prescribed impacts of the project during construction and operation, focusing on protecting and improving the biodiversity and conservation values of upstream and downstream waters , their biota, and associated riparian zones in the medium to long-term. The strategy must be prepared in consultation with, and have regard to the requirements of, DPI Fisheries.	Aquatic Ecology Assessment Section 11.1
17. Description of the type and extent of any dredging or reclamation activities within 'water land' as defined under the FM Act. This assessment must be prepared in consultation with, and have regard to the requirements of, DPI Fisheries.	Aquatic Ecology Assessment Chapter 8
18. An assessment performed in consultation with, and having regard to the requirements of NSW DPI Fisheries of the ecological impact of the project upon the safe upstream and downstream passage of fish over the full range of dam operating conditions, including: a) assessment of how the proposed operating rules of the existing and proposed dams may impact upon safe fish passage as a result of the rules. b) assessment of the risks of spillway design on the safe downstream passage of native fish, and mitigation measures that will be implemented to secure the safe downstream passage of native fish during dam spill events. c) assessment of how the spillway stilling basin design mitigates the risk of fish being left stranded within or beneath the spillway following the cessation of spillway operation.	Aquatic Ecology Assessment Chapters 8 and 9
19. Development of suitable fish passage mitigation strategies (including potential offsets) to the satisfaction of NSW DPI Fisheries that align with the NSW DPI Fisheries Fishway Design Guidelines (2015) and the Policy and Guidelines for Fish Habitat Conservation and Management (2013), including: a) justification that any proposed fish passage mitigation will be effective over the full operational range of the existing and proposed dams. b) details and identification of the costs of any monitoring program that is proposed to evaluate fish passage impacts and planned mitigation measures for the purpose of adaptive management of the existing and proposed dams.	Aquatic Ecology Assessment Section 11.1
20. A description and assessment of how the existing and proposed dams, pipeline, and associated water infrastructure will be managed over the full range of operating conditions, and how this relates to aquatic biodiversity mitigation and offsetting strategies.	Aquatic Ecology Assessment Chapter 9
21. An assessment of the ecological impacts of Cold-Water Pollution (CWP) from the operation of the existing and proposed dams.	Aquatic Ecology Assessment Section 9.1.1and 9.2.1, and (EMM, 2022c)

Table 1.1 Aquatic and riparian biodiversity and ecology matters raised in SEARs

Requirement	Chapter/Section addressed
22. Details of CWP impact mitigation strategies developed to minimise the impacts of CWP when releasing dam water into receiving waterways, including: a) justification that any proposed CWP mitigation will be effective during dam operation, including under operating constraints imposed by requirements to manage algae in the dams, and in accordance with water quality conditions outlined in Schedule 11 of the Murray Darling Basin Plan and within the NSW Cold Water Pollution Strategy Guidelines for Managing Cold Water Releases from High Priority Dams (2011). b) proposed operating protocols for any CWP mitigation measures, and details of how CWP mitigation operating protocols are affected by operating protocols put in place to manage algae in the dams. c) identification of the total cost of any monitoring program that is proposed to evaluate CWP impacts and mitigation measures for the purpose of adaptive management.	Aquatic Ecology Assessment Chapter 9and (EMM, 2022c)

Guidance material considered in this report includes:

- Policy and guidelines for fish habitat conservation and management (Department of Primary Industries, 2013a)
- Survey guidelines for Australia's threatened fish (Department of Sustainability, Environment, Water.Population and Communities, 2011)
- NSW Biodiversity Offsets Policy for Major Projects. Factsheet: Aquatic biodiversity (Department of Primary Industries, 2014)
- NSW Aquifer Interference Policy (Department of Primary Industries, 2012)
- The NSW State Groundwater Dependent Ecosystems Policy (Department of Land and Water Conservation, 2002)
- Risk assessment guidelines for groundwater dependent ecosystems: Volume 1 – The conceptual framework (Department of Primary Industries, 2012)
- Matters of National Environmental Significance Significant impact guidelines 1.1 (EPBC Act) (Department of the Environment, 2013).

1.3.2 Other relevant reports

This aquatic ecology assessment has been prepared with reference to other technical reports prepared for the project, listed below:

- Surface Water Assessment, Annexure A, Streamflow Analysis (EMM, 2022b) – ppended to the EIS.
- Surface Water Assessment, Annexure H, Temperature Model (EMM, 2022c) – appended to the EIS.
- Biodiversity Development Assessment Report (EMM, 2022d) – appended to the EIS.
- Groundwater Impact Assessment (EMM, 2022e) – appended to the EIS.
- Community and Stakeholder Engagement Report (Water Infrastructure NSW, 2022) – appended to the EIS.

2 Description of the project

This chapter provides a summary of the Dungowan Dam and pipeline project. It outlines the permanent infrastructure required to operate the project, as well as the key construction elements and activities required to construct the project. A comprehensive and detailed description of the project is provided as Appendix B1 of the EIS, which has been relied upon for the basis of this technical assessment.

2.1 Project overview

Water Infrastructure NSW proposes to build a new dam at Dungowan (new Dungowan Dam) about 3.5 km downstream of the existing Dungowan Dam and an enlarged delivery pipeline from the new Dungowan Dam outlet to the tie in point to the existing pipeline from Dungowan Showground to the Calala WTP. The existing pipeline from Dungowan Showground to the Calala WTP is not part of the Dungowan Dam and pipeline project. A summary of project elements is provided in Table 2.1. An overview of the project is provided in Figure 2.1.

Table 2.1 Overview of the project

Project element	Summary of the project
New Dungowan Dam infrastructure	Earth and rockfill embankment dam with height of ~58 m and a dam crest length of ~270 m.
	Storage capacity of 22.5 GL at full supply level (FSL) of RL 660.2 m AHD.
	The new Dungowan Dam on Dungowan Creek has a catchment size of 175 km^2 and is part of the Peel Valley and Namoi River catchment.
	Inundation extent (to FSL) of 130 ha (1.3 km^2)
	Spillway to the south of the dam wall including an approach channel, uncontrolled concrete ogee crest, chute and stilling basin. Free standing multiple-level intake tower connected with a bridge to the embankment, diversion tunnel with outlet conduit, valve house and associated pipework and valves.
	A permanent access road over the Dam crest to the valve house for operation and maintenance.
	Water diversion works including a diversion tunnel and temporary pipeline and upstream and downstream cofferdams to facilitate construction of the dam wall embankment.
Pipeline infrastructure	31.6 km of buried high density polyethylene (HDPE) pipe between 710 mm to 900 mm nominal diameter.
	Maximum 71 ML/day from the proposed dam to the junction with the pipeline from Chaffey Dam to the Calala Water Treatment Plant, to replace the existing 22 ML/day pipeline. The pipeline would connect to the valve house on the left abutment of the embankment. Valve infrastructure would include control valves installed in two above ground buildings along the pipeline.
	10 m wide easement for the 31.6 km length of the pipeline. The replacement pipeline extends from the new Dungowan Dam to a connection point with the existing pipeline between Dungowan Showground and Calala WTP.
Ancillary infrastructure and works	Road works to improve existing roads to provide construction access, temporary establishment and use of a construction compound, an accommodation camp, two upstream quarries and four borrow areas within the inundation area.
	A new 4.2 km long 11 kV overhead powerline (including a new easement and access track) connecting to an existing overhead line approximately 6 km north west of the dam. The existing overhead line that extends approximately 13.2 km to the Niangala area would also require minor upgrades, including re-stringing of new overhead wiring and replacement of some poles.
Decommissioning of existing Dungowan Dam	Dewatering of existing dam, removal of existing Dungowan Dam infrastructure and full height breach of the existing Dungowan Dam wall. Rehabilitation of inundation area of the existing Dungowan Dam.

Table 2.1 Overview of the project

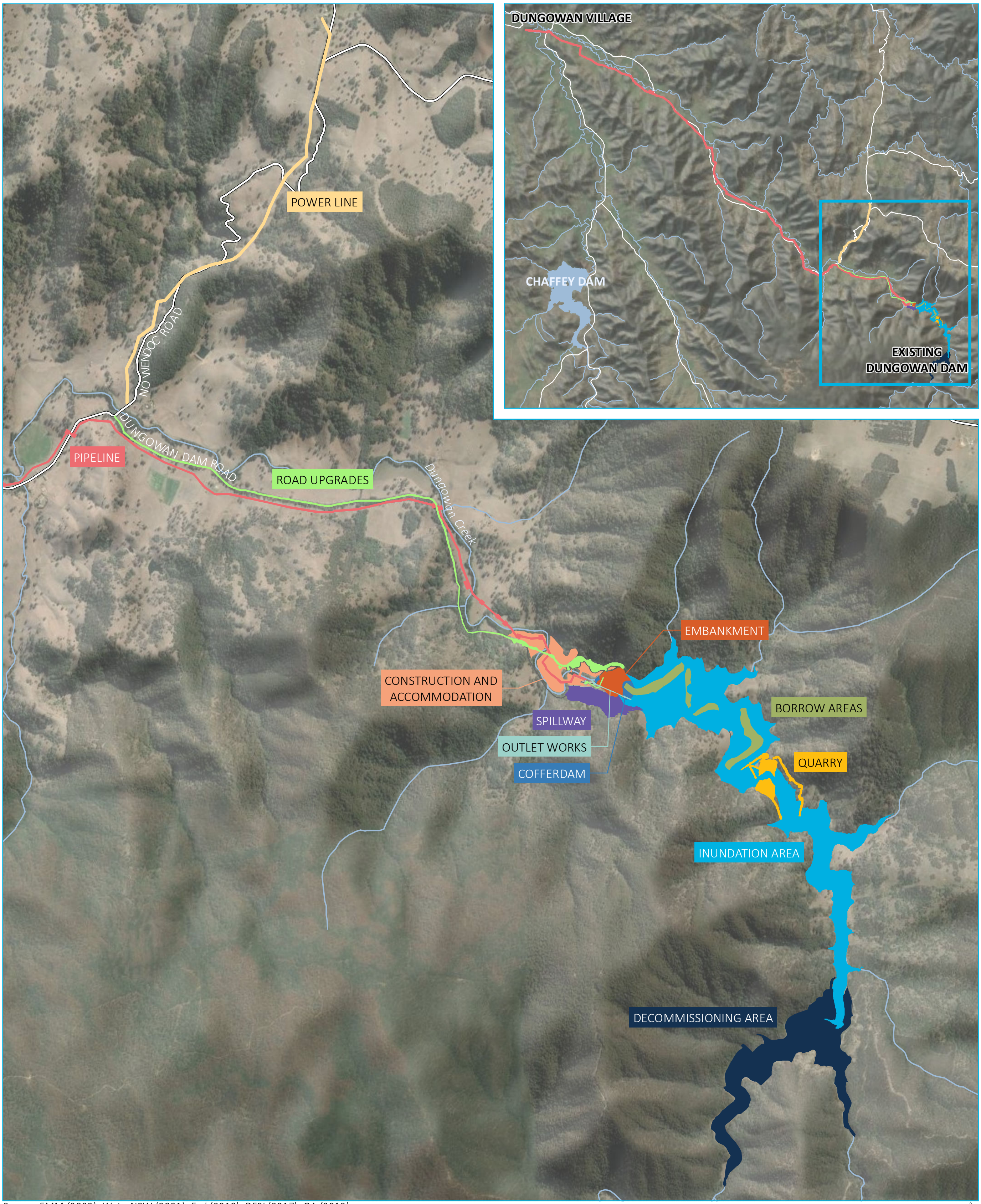
Project element	Summary of the project
Disturbance	Areas of disturbance have been identified based on the direct impacts of the project. There is some overlap in the areas disturbed during construction and operation, with a resulting total disturbance area proposed for the project of 315 ha (project footprint). Disturbance would occur in a staged manner, with construction requiring disturbance of approximately 315 ha (construction footprint). Following construction and once rehabilitation is completed, there would be a permanent disturbance of approximately 158 ha comprising the inundation area and permanent infrastructure (operational footprint).
Construction	Construction duration of approximately 6 years.
	Construction workforce of approximately 125 workers at construction peak.
Operation	WaterNSW will be responsible for management, operation and general maintenance of the new dam. Tamworth Regional Council will be responsible for the management, operation and general maintenance of the pipeline. Public use and access to the dam would not be permitted and there would be no public facilities available during operation.
	One to two new full time workers plus part time work for existing WaterNSW operations team. Due to the new Dungowan Dam being prioritised over Chaffey Dam for Tamworth's future water supply, the water reserved for town water in Chaffey Dam would increase from 14.3 GL to 30 GL to ensure that water is set aside to meet Tamworth's town water supply water demand in years when rainfall is low.
Design life	100 years for zoned earthen embankment, structural concrete elements of the dam and the pipeline. 15 to 50 years for other non-structural project elements and pavements.
Assessment period (operational)	The assessment end point is when the water system performance reaches a level when an additional water supply option or change to the Water Sharing Plan is required. This has been estimated to be when the mean average annual water demand from Tamworth increases to 11 GL/year.

2.2 Environmental flows

Environmental flows would be provided by a dedicated offtake from the outlet conduit and would be discharged into Dungowan Creek near the valve house. Two types of environmental flows would be provided:

- Translucent flows up to a maximum of 13 ML/day. This is an increase from the current 10 ML/day and is based on the larger catchment of the new Dungowan Dam.
- An Environmental Contingency Allowance (ECA) of a maximum of 200 ML/year. The ECA would be based on the General Security licence allocations for the Peel River each year.

The increased translucent flows and new ECA for the new Dungowan Dam have been provided to mitigate some of the impacts of the project, particularly in Dungowan Creek.



Source: *EMM (2022); WaterNSW (2021); Esri (2019); DFSI (2017); GA (2013)*

\\emmsvr1\EMM3\2020\J200042 - Dungowan Dam\GIS\02_Maps_EIS_StandardTech\G003_ProjectOverview_20220509_09.mxd 9/05/2022

KEY

■ Inundation area
■ Borrow areas
■ Construction and accommodation camp
■ Outlet works
■ Cofferdams
■ Embankment

■ Quarries
■ Spillway
■ Road upgrade
■ Decommissioning area
■ Power line footprint
■ Pipeline construction footprint

Existing environment
═ Major road
— Minor road
— Named watercourse
■ Named waterbody

Project overview

Dungowan Dam and pipeline project
Figure 2.1

EMM
creating opportunities

2.3 Cold water pollution

As the environmental flows are drawn from the water supply pipe, the water would be the same quality as drawn for town water supply. The selected level of draw off from the reservoir would be managed to reduce the potential for cold water pollution (CWP) downstream. To prevent stratification of the reservoir and algae blooms leading to poor water quality, a destratification system would be employed if necessary. Detailed design would investigate the need and, if necessary, the sizing of the two commonly accepted methods for mitigating stratification:

- the direct injection of air, or bubble plumes, through a network of pipes laid on the bottom of the reservoir; and
- the installation of floating or fixed large impellers.

2.4 Interaction with other water supply sources

The new Dungowan Dam and pipeline would operate in parallel with the existing Chaffey Dam to supply raw water to Tamworth. The sequence for supplying water from the two dams to Tamworth would be:

- When the new Dungowan Dam holds between 3 GL and 22.5 GL of water, water would be sourced from the Dungowan Dam and delivered via the Dungowan pipeline to Calala WTP. When the water level in Dungowan Dam reaches 3 GL, supply would switch to Chaffey Dam.
- Chaffey Dam would supply water to Calala WTP via run of the river discharges when the water level in Dungowan Dam is 3 GL or less. There is a pipeline from Chaffey Dam which connects to the replacement pipeline from Dungowan Showground to the Calala WTP, which is proposed for use during drought periods (ie when Chaffey Dam falls below 20 percent capacity). However, at the time of preparing the EIS, there is no approval to operate this pipeline. WaterNSW is currently in the process of preparing a separate EIS to obtain approval for operation of the Chaffey pipeline. Cumulative impacts, including from the operation of the Chaffey pipeline, are detailed in the EIS.
- If Chaffey Dam is supplying water to Tamworth and inflows to Dungowan Dam increase its level to above 3 GL, it has been assumed that both dams would supply water to Tamworth on a proportional basis until the water level in Dungowan Dam reaches 4 GL, at which point Dungowan Dam would supply 100 percent of Tamworth's daily demand. Further work would need to be undertaken to optimise the transition criteria between the two dams as proportional flows from each of the dams may not be operationally efficient for Calala WTP. However, any minor changes in these criteria would not change the outcomes of the environmental assessment in the EIS.
- Once the water supply in Chaffey Dam reaches 5 percent, water would be sourced from the remaining water in Dungowan Dam (ie the 3 GL or less depending on evaporation and inflows)

The sequence of water supply may change occasionally when:

- Water quality in one dam is poor and for operational reasons it is preferred that water be provided from the other dam.
- Maintenance, an incident, or other activities result in either a dam or pipeline being off-line while the issues are being rectified.

The only change in the operations at Chaffey Dam would be that the water reserved for town water would increase from 14.3 GL to 30 GL. This is to ensure that the extra water that would be held in Chaffey Dam due to the increased supply from the new Dungowan Dam is not allocated to other licence holders. This reserve level has also considered other licence allocations and these would be maintained at their existing average allocations.

3 Legislative context

While the project will be assessed as Critical State Significant Infrastructure (CSSI) under Part 5, Division 5.2 of the EP&A Act, requiring preparation of an EIS, legislation (and regulatory departments) that may be relevant, in part, to the aquatic ecology assessment include:

- *Fisheries Management Act 1994* (FM Act) (Department of Primary Industries: Fisheries division; DPI Fisheries)
- *Water Management Act 2000* (WM Act) (Department of Planning and Environment: Water division; DPE Water)
- *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Department of Climate Change, Energy, the Environmental and Water (DCCEEW)).

3.1.1 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 Division 6, Subdivision 1 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 Section 3.2.1 and Section 3.2.2 of the *Policy and guidelines for fish conservation and management* (Department of Primary Industries, 2013a), and is ranked based on a combination of habitat sensitivity (waterway type) and water classification (waterway class). These habitats include rivers, creeks, lakes, lagoons, billabongs, weir pools and impoundments up to the top of the bank, but do not include small ephemeral headwater creeks and gullies (ie 1st and 2nd order streams) (Strahler, 1952) or farm dams constructed on these systems (Department of Primary Industries, 2013a). Generally, 3rd order tributaries and above (Strahler, 1952) are considered key fish habitat that require conservation and management, although threatened species still have the potential to inhabit waterways of a 1st or 2nd order when inundated. In alignment with the FM Act's primary objective to 'conserve key fish habitats', permanent and semi-permanent freshwater habitats must be assessed if they intersect areas of impact related to a project.

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

As the project is being assessed under Part 5, Division 5.2 of the EP&A Act, permits under the following sections of the FM Act are not required; however, consideration has been given to these issues within this report:

- S 201 Circumstances in which a person (other than a public or local government authority) may carry out dredging or reclamation;
- S 205 Marine vegetation—regulation of harm; and

- S 219 Passage of fish not to be blocked.

i Section 7 Fisheries Management Act 1994 (Impact assessments)

Section 7 of the FM Act states that a species impact statement must include the following with respect to protected and threatened species:

- *a full description of the action proposed, including its nature, extent, location, timing and layout and, to the fullest extent reasonably practicable.*
- *a general description of the threatened species or populations known or likely to be present in the area that is the subject of the action and in any area that is likely to be affected by the action,*
- *an assessment of which threatened species or populations known or likely to be present in the area are likely to be affected by the action,*
- *for each species or population likely to be affected, details of its local, regional and State-wide conservation status, the key threatening processes generally affecting it, its habitat requirements and any recovery plan or threat abatement plan applying to it,*
- *an estimate of the local and regional abundance of those species or populations,*
- *a full description of the type, location, size and condition of the habitat (including critical habitat) of those species and populations and details of the distribution and condition of similar habitats in the region,*
- *a full assessment of the likely effect of the action on those species and populations, including, if possible, the quantitative effect of local populations in the cumulative effect in the region,*
- *a description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development,*
- *a full description and justification of the measures proposed to mitigate any adverse effect of the action on the species and populations, including a compilation (in a single section of the statement) of those measures,*
- *a list of any approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the species or population.*

Section 7 of the FM Act states that a species impact statement must include the following with respect to protected and threatened ecological communities:

- *a general description of the ecological community present in the area that is the subject of the action and in any area that is likely to be affected by the action,*
- *for each ecological community present, details of its local, regional and State-wide conservation status, the key threatening processes generally affecting it, its habitat requirements and any recovery plan or any threat abatement plan applying to it,*
- *a full description of the type, location, size and condition of the habitat of the ecological community and details of the distribution and condition of similar habitats in the region,*

- *a full assessment of the likely effect of the action on the ecological community, including, if possible, the quantitative effect of local communities in the cumulative effect in the region,*
- *a description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development,*
- *a full description and justification of the measures proposed to mitigate any adverse effect of the action on the ecological community, including a compilation (in a single section of the statement) of those measures,*
- *a list of any approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the ecological community.*

A species impact statement must include details of the qualifications and experience in threatened species conservation of the person preparing the statement and of any other person who has conducted research or investigations relied on in preparing the statement.

3.1.2 Water Management Act 2000

The WM Act, administered by the 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 will occur to "waterfront land". However, as the project is being assessed under Part 5, Division 5.2 of the EP&A Act, approval under the WM Act is not required (s 5.23 of the EP&A Act).

Division 6 of the WM Act requires consideration of aquifer interference activities. The *NSW Aquifer Interference Policy* (Department of Primary Industries, 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 & Water Conservation, 2002) and *Risk assessment guidelines for groundwater dependent ecosystems: Volume 1 – The conceptual framework* (Department of Primary Industries, 2012b).

3.1.3 Environmental Protection and Biodiversity Conservation Act 1999

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

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

The EPBC Act also facilitates a more streamlined national environmental assessment and approvals process between the Commonwealth, and the States and Territories. Under the EPBC Act, an action that may have a significant impact on a MNES is deemed to be a ‘controlled action’ and can only proceed with the approval of the Commonwealth Minister for the Environment and Water. An action that may potentially have a significant impact on a MNES is to be referred to DCCEEW for determination as to whether or not it is a controlled action. If deemed a controlled action the project is assessed under the EPBC Act and a decision made as to whether or not to grant approval.

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

- wetlands of international importance; and
- 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* (Commonwealth of Australia, 2013).

The project has been referred to the Commonwealth Minister for the Environment and Water and was determined to be a controlled action on 11 June 2020 (EPBC 2020/8654). The Minister for the Environment and Water has accredited the NSW planning process for the assessment of the project and therefore a single EIS has been prepared to address the requirements set out by the NSW DPE and the Commonwealth DCCEEW. The Secretary determined that the following controlling provisions apply:

- Listed threatened species and communities (s 18 and s 18A of the EPBC Act).

In addition to the above, the former Department of Agriculture, Water and the Environment (DAWE) (Wildlife and threatened species bushfire recovery research and resources, 2020) released a provisional list of animal species identified as requiring urgent management intervention following the 2019/2020 bushfire season in southern and eastern Australia (20 March 2020). Most of the species have potentially had at least 30% of their range burnt. The list includes a number of bird, mammal, reptile, frog, invertebrate, crayfish and fish species. The priority animals were identified based on the extent to which their range has potentially been burnt, their conservation status prior to the fires, and the physical, behavioural and ecological traits which influence their vulnerability to fire. While the list primarily comprises species already listed under the EPBC Act, it also includes species which are not currently listed as threatened under the FM Act or EPBC Act but have more than 30% of their range within burnt areas. The Platypus is listed as "*Species that are provisionally included as high priority whilst more information is gathered*" and has been included as a threatened species in this report.

Listed threatened species and communities listed under the EPBC Act that have been identified as having potential to be impacted by this project are as follows:

- Silver Perch (Bidyanus bidyanus);
- Murray Cod (Maccullochella peelii); and,
- Platypus (Ornithorhynchus anatinus).

4 Methodology

4.1 Desktop assessment

4.1.1 Database searches

Database searches were undertaken to compile background information and to assess the likelihood of occurrence of threatened aquatic habitat, communities, species or populations that may inhabit waterways with the potential to be impacted by the project. Databases providing information on aquatic GDEs were also accessed; however, there are no databases available for NSW, which specifically catalogue the presence of subterranean fauna. A complete list of database search results is provided in Annexure A.

State and Commonwealth database resources included:

- Freshwater threatened species distribution maps (DPI Fisheries);
- Threatened species lists (DPI Fisheries);
- Key Fish Habitat maps (DPI Fisheries);
- Fish stocking (DPI Fisheries);
- Fisheries NSW Spatial Data Portal (DPI Fisheries);
- BioNet Atlas (DPIE);
- Protected Matters Search Tool (PMST) (DCCEEW);
- Provisional list of animals requiring urgent management intervention (DCCEEW);
- Australian Ramsar Wetlands: Internationally Important Wetlands (DCCEEW);
- Directory of Important Wetlands: Nationally Important Wetlands (DCCEEW);
- Groundwater Dependent Ecosystems Atlas (BoM);
- NSW Fish Passage Database; and
- Climate data online (BoM).

4.1.2 Literature review

A review of publicly available literature relating to aquatic and subterranean environments in the region of the project was undertaken to investigate the occurrence of communities and taxa of conservation significance. Information was compiled from reports, books, journals, and relevant government, university or regulatory publications. A limited number of aquatic and subterranean fauna (to within 200 km of the project) assessments have been undertaken in the vicinity of the project.

A number of relevant reports were provided by WaterNSW, which detail the results of monitoring undertaken in the Peel River since 2020. These reports have been reviewed and utilised to inform this EIS. Details of these reports are summarised in Annexure B.

A limited number of subterranean fauna assessments have been undertaken in the vicinity of the project, with existing information gathered largely as part of environmental reviews associated with drought protection works, and an augmentation and safety upgrade of Chaffey Dam. Information was also taken from the documents below, where applicable:

- *Namoi Long-Term Water Plan Part A: Namoi catchment* (Department of Planning, Industry and Environment, 2020)
- *Namoi Long-Term Water Plan Part B: Namoi planning units* (Department of Planning, Industry and Environment, 2020)
- *Water Sharing Plan for the Peel Regulated River Water Source 2010.*
- *Water Sharing Plan for the Namoi and Peel Unregulated Rivers Water Sources 2012.*
- Water Sharing Plan *for the Namoi Alluvial Groundwater Source 2020*.

A summary of the results of the literature review are provided in Annexure B (excluding online databases, websites and reports listed in the reference section).

4.1.3 GDE identification and assessment

An assessment of aquatic GDEs was completed in accordance with *Risk assessment guidelines for groundwater dependent ecosystems: Volume 1 – The conceptual framework* (Department of Primary Industries, 2012), following the process detailed below where possible:

- identify potential GDEs;
- assess the degree of groundwater dependency of identified GDEs;
- assess ecological values of GDEs;
- assess potential impacts to GDEs;
- undertake risk assessment for GDEs; and
- identify mitigation measures, where required.

The identification of potential aquatic GDEs (ie surface waterways, subterranean fauna) was undertaken via desktop assessment. Only aquatic GDEs have been considered within the aquatic ecology baseline report; terrestrial GDEs (ie vegetation) have been considered within the Biodiversity Development Assessment Report - appended to the EIS (EMM, 2022d)

4.1.4 Likelihood of occurrence assessment

The criteria for assessing the likelihood of occurrence of threatened species listed in Section 5.9.1 and Annexure C is summarised in Table 4.1. While Commonwealth and State data sources indicate possible presence of species and habitats, local conditions should be considered when determining their actual likelihood of occurrence. Threatened habitats and/or communities that have the potential to be indirectly impacted by downstream effects are included in the assessment, as are threatened species and/or populations that have the potential to occur within the vicinity of the project and the Namoi River catchment. Due to the lack of knowledge of the occurrence and distribution of subterranean fauna in NSW, all communities within similar geologies were considered 'possible' to occur. The results of the likelihood of occurrence assessment are provided in Annexure C for all species identified during the desktop assessment.

Table 4.1 Likelihood of occurrence criteria

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

4.1.5 Risk assessment

A risk assessment matrix has been utilised to assess the degree of impact an event or action will have on a species, or species habitat. The consequence criteria (Table 4.2), likelihood descriptors (Table 4.3) and risk matrix (Table 4.4) adopted for the risk assessment are provided below.

Table 4.2 Consequence criteria adopted for the risk assessment

	Insignificant (IN)	Minor (MI)	Moderate (MO)	Major (MA)	Catastrophic (CA)
	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

Table 4.2 Consequence criteria adopted for the risk assessment

	Insignificant (IN)	**Minor (MI)**	**Moderate (MO)**	**Major (MA)**	**Catastrophic (CA)**
	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 Interactions-Aquatic Ecology	No measurable permanent impacts on aquatic ecology values	Minor short term impacts, life cycle may be disrupted but for less than a year. Annual recruitment should still occur. Short and long term viability of individual species not impacted	Medium term (1-2 year) impacts, life cycle disrupted and resulting in no recruitment for a year. Short term viability of individual species impacted recovery within 1 -5 years. Long term viability of species not impacted	Long term (2-5 year) impacts, life cycle significantly disrupted no recruitment for successive years. Short term and long term viability individual species impacted recovery time frame (5-10 years)	Loss of species and population. Minimal possibility of recovery
Surface Water - Water Quality	No measurable change to surface water quality or quality changes are not measurable	Changes to Surface Water quality during the activity, no further changes noted once activity is finished	Changes to Surface Water quality due to activity, recovery up to 1 year	Changes to Surface Water Quality due to activity, recovery 1-2 years	Changes to Surface water quality, where water becomes toxic, or permanent changes to quality, recovery is greater than 2 years

Table 4.3 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 4.4 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

4.2 Field survey design

To aid in determining the ecological values of waterways with the potential to be impacted by the project, field survey was undertaken from 24 to 28 August 2020, 21 January – 4 March 2022 and 15 March – 21 March 2022. A total of 52 sites across 19 waterways were assessed within, and downstream of, the inundation area as well as areas intersecting the proposed pipeline and along the Peel River to just downstream of the Chaffey Dam wall (Table 4.5, Figure 4.1). The assessment comprised a range of abiotic and biotic components (Table 4.5). Field sampling was undertaken in accordance with DPI Fisheries s 37 FM Act Scientific Collection Permit No P19/0025-1.0.

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

- habitat and substrate types;
- riparian vegetation condition and presence of weeds;
- vegetation cover and presence of native species;
- waterway morphology and presence/absence/flow of surface water;
- refuge availability (snags[1], aquatic vegetation, rocks, etc.);
- amount of erosion and bank incision; and
- livestock impact.

Photographs were taken of upstream and downstream condition, as well as the bed, banks and riparian zone where possible at all sites to provide a record of habitat conditions at the time of assessment (Annexure D).

The content of this aquatic ecology assessment report was limited to aquatic and riparian habitat and did not address terrestrial ecology or document plant species. Riparian vegetation is defined by the DPI Fisheries as "*The plants growing on the water's edge, the banks of rivers and creeks and along the edges of wetlands…*", and consist of trees, shrubs, grasses and/or vines across a number of structural components (ie groundcovers, understorey and canopy) (Department of Primary Industries, 2019a).

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[1] Submerged dead wood and trees.

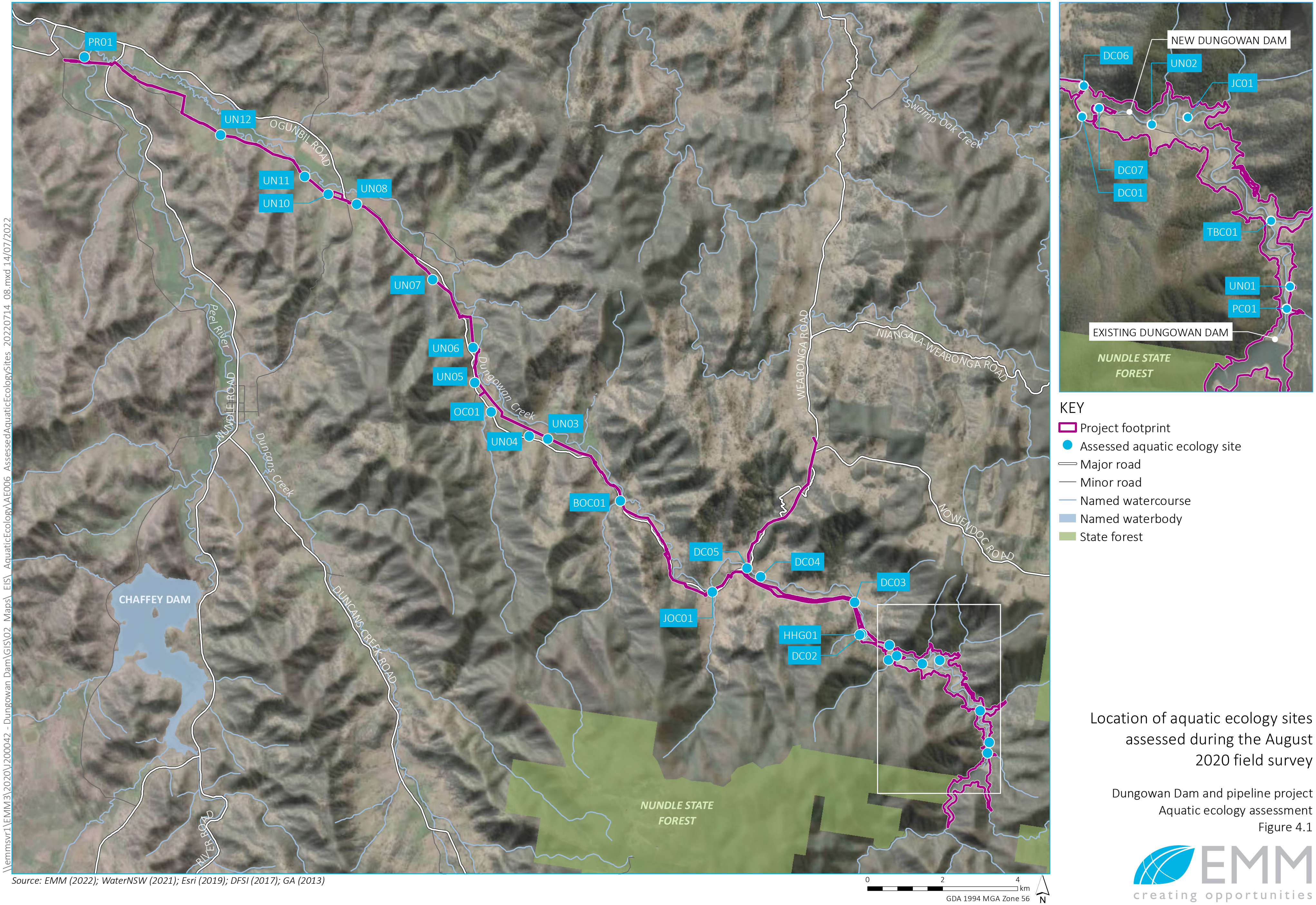
Each waterway assessed had previously been ranked by the DPI according to the Strahler (1952) method of waterway ordering, and only waterways ranked as 3rd order and above have been included in the aquatic ecology assessment report.

Table 4.5 Location of, and components sampled at, each aquatic ecology site during the field surveys

Project component	Waterway	Site	Strahler (1952) order	GPS coordinates	Sample date	Key fish habitat	Water quality	Sediment quality	Macrophytes	Algae	eDNA analysis	Aquatic invertebrates	Aquatic vertebrates
Proposed Dam	Jones Oaky Creek	JC01	4th	56J 342685 6528635	26-Aug-2020	✓	✓	✓	✓	✓	✓	✓	✓
Proposed Dam	Paradise Creek	PC01	4th	56J 343963 6526161	24-Aug-2020	✓	✓	✓	✓	✓		✓	✓
Proposed Dam	Terrible Billy Creek	TBC01	4th	56J 343762 6527294	25-Aug-2020	✓	✓	✓	✓	✓	✓	✓	✓
Proposed Dam	Unnamed waterway	UN01	3rd	56J 344007 6526445	25-Aug-2020	✓							
Proposed Dam	Unnamed waterway	UN02	3rd	56J 342217 6528545	25-Aug-2020	✓							
Proposed Dam	Dungowan Creek	DC01	6th	56J 341316 6528646	25-Aug-2020	✓	✓	✓	✓	✓	✓	✓	✓
Proposed Dam	Dungowan Creek	DC02	6th	56J 340602 6529343	26-Aug-2020	✓	✓	✓	✓	✓	✓	✓	✓
Proposed Dam	Dungowan Creek	DC03	6th	56J 340416 6530194	26-Aug-2020	✓	✓	✓	✓	✓	✓	✓	✓
Proposed Dam	Dungowan Creek	DC04	6th	56J 337906 6530873	27-Aug-2020	✓	✓	✓	✓	✓	✓	✓	✓
Proposed Dam	Dungowan Creek	DC05	6th	56J 337546 6531107	27-Aug-2020	✓							
Proposed Pipeline	Big Oaky Creek	BOC01	4th	56J 334163 6532902	27-Aug-2020	✓	✓	✓					
Proposed Pipeline	Dungowan Creek	DC06	6th	56J 341340 6529044	25-Aug-2020	✓	✓	✓	✓				
Proposed Pipeline	Dungowan Creek	DC07	6th	56J 341536 6528758	25-Aug-2020	✓	✓	✓	✓				
Proposed Pipeline	Dungowan Creek	DC08	6th	56J 341459 6528634	31-Jan-2022	✓	✓		✓		✓	✓	✓
Proposed Pipeline	Dungowan Creek	DC09	6th	56J 341001 6529143	3-March-2022	✓	✓		✓		✓	✓	✓
Proposed Pipeline	Dungowan Creek	DC10	6th	56J 340632 6529417	4-March-2022	✓	✓		✓		✓	✓	✓
Proposed Pipeline	Dungowan Creek	DC11	6th	56J 335360 6531713	30-January-2022	✓	✓		✓		✓	✓	✓
Proposed Pipeline	Dungowan Creek	DC12	6th	56J 335209 6531942	30-January-2022	✓	✓		✓		✓	✓	✓
Proposed Pipeline	Dungowan Creek	DC13	6th	56J 330245 6536634	3-March-2022	✓	✓		✓		✓	✓	✓
Proposed Pipeline	Dungowan Creek	DC14	6th	56J 330356 6536953	3-March-2022	✓	✓		✓		✓	✓	✓
Proposed Pipeline	Dungowan Creek	DC15	6th	56J 326789 6541139	2-March-2022	✓			✓				
Proposed Pipeline	Dungowan Creek	DC16	6th	56J 343441 6527667	21-Jan-2022	✓			✓		✓	✓	✓
Proposed Pipeline	Peel River	PR02	6th	56J 319737 6544695	4-March-2022	✓			✓				
Proposed Pipeline	Peel River	PR03	6th	56J 312954 6550948	4-March-2022	✓	✓		✓		✓	✓	✓
Proposed Pipeline	Hell Hole Gully	HHG01	3rd	56J 340543 6529323	25-Aug-2020	✓		✓					✓
Proposed Pipeline	Johnston Oaky Creek	JOC01	5th	56J 336614 6530467	27-Aug-2020	✓	✓	✓					
Proposed Pipeline	Oaky Creek	OC01	4th	56J 330718 6535275	28-Aug-2020	✓							
Proposed Pipeline	Oaky Creek	OC02	4th	56J 330715 6535289	28-Aug-2020	✓							
Proposed Pipeline	Unnamed waterway	UN03	3rd	56J 332223 6534551	27-Aug-2020	✓							
Proposed Pipeline	Unnamed waterway	UN04	3rd	56J 331732 6534626	27-Aug-2020	✓							

Table 4.5 Location of, and components sampled at, each aquatic ecology site during the field surveys

Project component	Waterway	Site	Strahler (1952) order	GPS coordinates	Sample date	Key fish habitat	Water quality	Sediment quality	Macrophytes	Algae	eDNA analysis	Aquatic invertebrates	Aquatic vertebrates
Proposed Pipeline	Unnamed waterway	UN05	3rd	56J 330280 6536059	28-Aug-2020	✓							
Proposed Pipeline	Unnamed waterway	UN06	3rd	56J 330230 6536987	28-Aug-2020	✓							
Proposed Pipeline	Unnamed waterway	UN07	3rd	56J 329149 6538805	28-Aug-2020	✓	✓	✓					
Proposed Pipeline	Unnamed waterway	UN08	3rd	56J 327122 6540825	28-Aug-2020	✓							
Proposed Pipeline	Unnamed waterway	UN10	3rd	56J 326372 6541084	28-Aug-2020	✓							
Proposed Pipeline	Unnamed waterway	UN11	3rd	56J 325746 6541558	28-Aug-2020	✓							
Proposed Pipeline	Unnamed waterway	UN12	3rd	56J 323491 6542676	28-Aug-2020	✓							
Proposed Dam	Peel River	PR01	6th	56J 319859 6544752	29-Aug-2020	✓	✓	✓		✓	✓	✓	✓
Chaffey Dam	Peel River	PHF01	6th	56J 323340 6530721	21-March-2022	✓	✓	✓	✓	✓	✓	✓	✓
Chaffey Dam	Peel River	PHF04	6th	56J 323263 6533872	21-March-2022	✓			✓		✓		✓
Chaffey Dam	Peel River	PHF06	6th	56J 323733 6535246	18-March-2022	✓	✓	✓	✓	✓	✓	✓	✓
Chaffey Dam	Peel River	PHF08	6th	56J 323122 6537773	18-March-2022	✓			✓		✓		✓
Chaffey Dam	Peel River	PHF09	6th	56J 321681 6540826	18-March-2022	✓			✓		✓		✓
Chaffey Dam	Peel River	PHF11	6th	56J 320163 6544447	19-March-2022	✓	✓	✓	✓	✓	✓	✓	✓
Chaffey Dam	Peel River	PHF12	6th	56J 319040 6545331	17-March-2022	✓			✓		✓		✓
Chaffey Dam	Peel River	PHF13	6th	56J 317552 6546417	17-March-2022	✓			✓		✓		✓
Chaffey Dam	Peel River	PHF14	6th	56J 315760 6548556	17-March-2022	✓	✓	✓	✓	✓	✓	✓	✓
Chaffey Dam	Peel River	PHF15	6th	56J 312873 6550884	17-March-2022	✓			✓		✓		✓
Chaffey Dam	Peel River	PHF17	6th	56J 311530 6551977	15-March-2022	✓			✓		✓		✓
Chaffey Dam	Peel River	PHF19	6th	56J 306093 6553805	21-March-2022	✓	✓	✓	✓	✓	✓	✓	✓
Chaffey Dam	Peel River	PHF22A	6th	56J 302205 6558510	15-March-2022	✓			✓		✓		✓
Chaffey Dam	Peel River	PHF22B	6th	56J 302205 6558510	15-March-2022	✓			✓		✓		✓



Location of aquatic ecology sites assessed during the August 2020 field survey

Dungowan Dam and pipeline project
Aquatic ecology assessment
Figure 4.1

Source: EMM (2022); WaterNSW (2021); Esri (2019); DFSI (2017); GA (2013)

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EMM
creating opportunities

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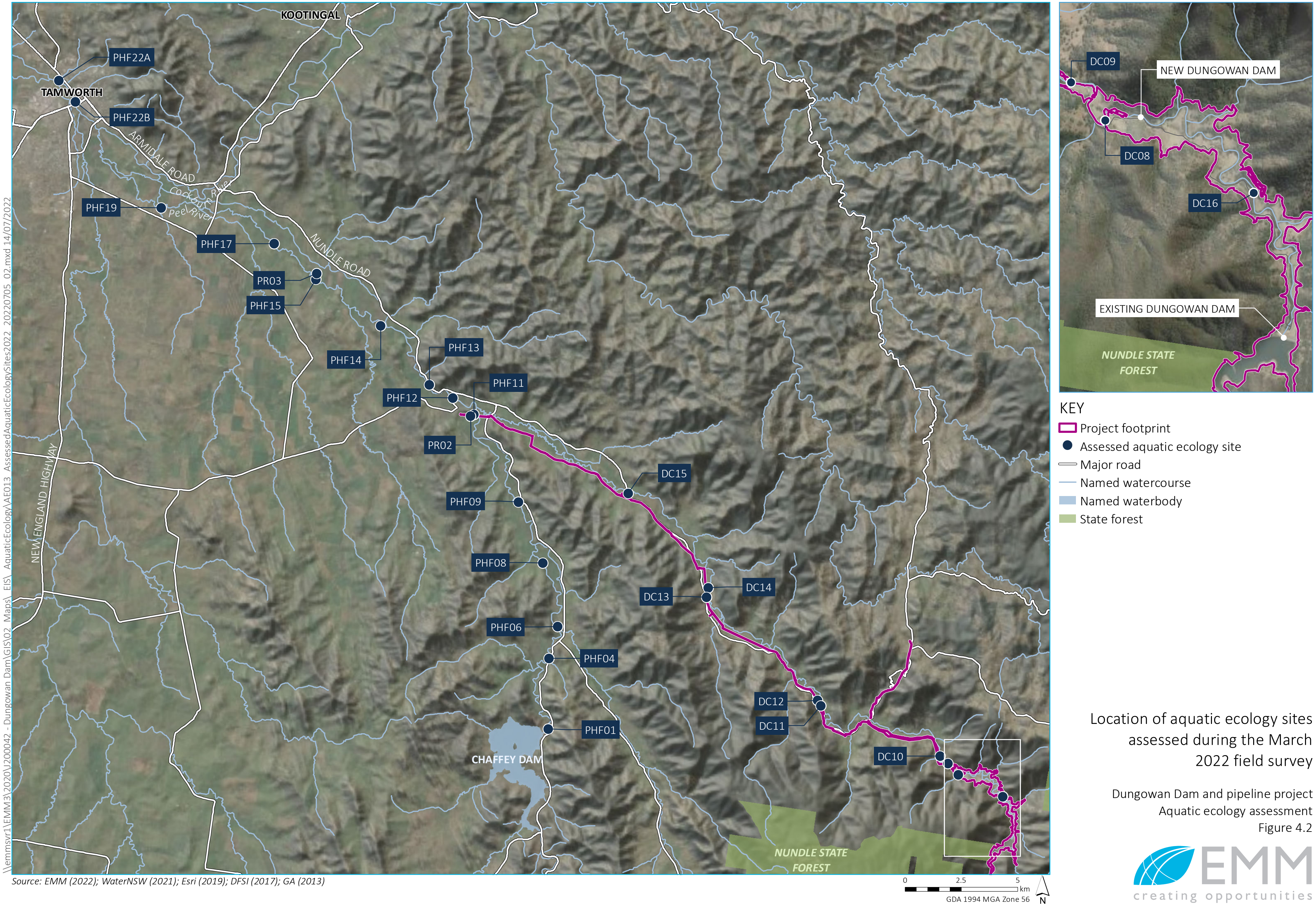

Source: EMM (2022); WaterNSW (2021); Esri (2019); DFSI (2017); GA (2013)

Location of aquatic ecology sites
assessed during the March
2022 field survey

Dungowan Dam and pipeline project
Aquatic ecology assessment
Figure 4.2

EMM
creating opportunities

4.2.1 Key fish habitat

In accordance with *Policy and guidelines for fish habitat conservation and management* (Department of Primary Industries, 2013a) habitat sensitivity was assessed at 52 sites (Figure 4.1 and Figure 4.2) by assigning a 'waterway type', while the functionality of the waterway as fish passage was assessed by assigning a 'waterway class'. 'Sensitivity' is defined by '*…the importance of the habitat to the survival of fish and its robustness (ability to withstand disturbance)*' (Department of Primary Industries, 2013a). Definitions, relevant to the aquatic ecology baseline report, of the waterway types and waterway classes are summarised in Table 4.6 and Table 4.7, respectively, and are provided in full in Annexure E. This policy (Department of Primary Industries, 2013a) only recognises native aquatic plants with regard to waterway type classification. Where it was not known as to whether an aquatic plant was native or exotic, a conservative approach was taken, potentially overestimating the native vegetation component of waterway type classification.

Table 4.6 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 4.7 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 (eg 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).

4.2.2 Water quality

During the initial survey period in August 2020 surface water samples were collected at 13 sites (Table 4.5, Figure 4.1) using sterilised bottles provided by the NATA -accredited Australian Laboratory Group (ALS), containing preservative where required. Bottles were completely filled with water and sealed, excluding air from the samples where possible. Samples were then couriered to ALS for analysis. Samples collected for the analysis of dissolved metals, metalloids and other trace elements ("metals") were filtered in the laboratory. Table 4.8 shows those parameters that were analysed in the laboratory. Holding times[2] were breached for the following parameters and therefore these results should be considered indicative only:

- pH at all sites;
- total dissolved solids and total suspended solids at PC01;
- turbidity at PC01, DC01, DC06, DC07, TBC01, JC01, DC03, DC02, DC04, JOC01, BOC01 and UN07;
- dissolved major cations at PC01; and
- nitrite, dissolved organic carbon and dissolved oxygen at all sites.

In situ water quality measurements were also recorded via the use of a handheld water quality meter (pH, salinity, electrical conductivity, dissolved oxygen, redox, turbidity, temperature (Annexure F)).

Surface water pH was compared to the classification system developed by Foged (Diatoms in Eastern Australia, 1978), comprising acidic water (4.5 to 6.5), circumneutral water (6.5 to 7.5), and alkaline water (>7.5). Salinity was compared to Hammer (Saline Lake Ecosystems of the World, 1986) classifying surface water into freshwater (<3,000 mg/L), hyposaline (3,000 mg/L to 20,000 mg/L), mesosaline (20,000 mg/L to 50,000 mg/L) and hypersaline (>50,000 mg/L) categories. Basic water quality parameters and nutrient concentrations were compared to ANZECC and ARMCANZ (Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Volume 1, The Guidelines (Chapters 1-7), 2000) guideline trigger values ("trigger values"), where available, representative of slightly disturbed[3] freshwater upland river ecosystems in south-east Australia. Metal concentrations were compared to the Australian & New Zealand Guidelines for Fresh & Marine Water Quality (ANZG) (Water Quality Australia, 2018) toxicant default guideline values (DGV) for the protection of 80% of species in freshwater, representative of highly disturbed ecosystem (where available).

Table 4.8 Water quality parameters analysed from surface water during the August 2020 field survey

Basic	Major Ions	Nutrients	Dissolved Metals	
pH	Calcium	Nitrogen (total)	Arsenic	Manganese
Total dissolved solids	Sodium	Kjeldahl Nitrogen (total)	Barium	Mercury
Electrical conductivity	Magnesium	Nitrate	Beryllium	Nickel
Suspended solids	Potassium	Nitrite	Boron	Selenium
Turbidity	Bicarbonate	Nitrite + Nitrate	Cadmium	Vanadium

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[2] 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.

[3] While the Nandewar-Northern Complex and Tenterfield Plateau sub-catchments are considered to be disturbed, there are only guideline values available for slightly disturbed ecosystems.

Table 4.8 Water quality parameters analysed from surface water during the August 2020 field survey

Basic	Major Ions	Nutrients	Dissolved Metals	
Dissolved oxygen	Sulphate	Ammonia	Chromium	Zinc
	Chloride	Phosphorus (total)	Cobalt	
	Carbonate	Organic carbon (total)	Copper	
	Hydroxide		Iron	
	Alkalinity (total)		Lead	

During the February-March 2022 survey period surface water samples were collected from a total of 11 sites (Table 4.5, Figure 4.2). All samples were collected and analysed as per the August 2020 survey period protocol. Table 4.9 shows the water quality parameters that were analysed for in the laboratory for the February-March 2022 survey period.

All *In situ* water quality measurements were also recorded via the use of a handheld water quality meter (pH, electrical conductivity, specific conductivity, dissolved oxygen, turbidity and temperature, with results presented in Table 6.4 and Annexure F.

As per the August 2020 survey period, all water quality parameters, nutrients and metal concentrations were compared to the relevant guidelines and trigger values (where available).

Table 4.9 Water quality parameters analysed from surface water during the February-March 2022 field survey

Basic	Major Ions	Nutrients	Dissolved Metals	
pH	Calcium	Nitrogen (total)	Arsenic	Lead
Electrical conductivity	Sodium	Kjeldahl Nitrogen (total)	Barium	Manganese
Turbidity	Magnesium	Nitrate	Beryllium	Mercury
Dissolved oxygen	Potassium	Nitrite	Cadmium	Nickel
Total dissolved solids		Nitrite + Nitrate	Chromium	Selenium
Biological Oxygen Demand		Ammonia	Cobalt	Vanadium
		Phosphorus (total)	Copper	Zinc
		Nitrite + Nitrate	Iron	

4.2.3 Sediment quality

Surface sediment samples were collected at 14 sites during the initial survey period in August 2020 and at five sites during the February-March 2022 survey period (Table 4.5, Figure 4.2) using sterilised glass jars provided by ALS. The top two to three centimetres of sediment was scraped into a sterilised glass container and couriered to ALS for analysis. Samples were collected for the analysis of total metals, metalloids and other trace elements ("metals"). Holding times were breached for pH at sites LG01, MR03 and YC01 and therefore these results should be considered indicative only. Table 4.10 shows those parameters that were analysed in the laboratory.

Sediment pH was compared to Hazelton and Murphy (Interpreting Soil Test Results. What do all the numbers mean., 2007) which ranges from very strongly acidic (<5.0) to very strongly alkaline (>9.0). Metal concentrations were compared to the DGV and GV-High (Water Quality Australia, 2018) (where available).

Table 4.10 Sediment quality parameters analysed during the field surveys

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

4.2.4 Algae and macrophytes

Samples of phytoplankton, periphyton and macrophytes were collected from surface water at eight sites (Table 4.5, Figure 4.1) during the August 2020 field survey. Additional samples for phytoplankton and periphyton were collected at five sites during the February-March 2022 field surveys (Table 4.5). 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 species; within waterways with the potential to be impacted by the project. A 45 micrometre (µm) mesh net was towed through the water or suspended in the current for up to 5 min to collect a sample. Each sample was transferred into a 70 millilitre (mL) vial and kept cool to preserve the algae. Samples were couriered on ice to the laboratory the next day. In the laboratory, three representative slides were prepared and observed under a compound microscope at 40X magnification. Algae were identified to at least genus level, using appropriate taxonomic literature. The relative abundance was recorded for each taxon, calculated per cell, colony or filament, dependent on the morphological form.

ii Periphyton

Periphyton growing on submerged vegetation, sediment, rocks or woody debris in shallow surface water was collected for the analysis of diatoms (microalgae). Rocks and surfaces were scrubbed and the periphyton was dislodged and concentrated in a bucket. Approximately 4-6 rocks were sampled and the sample was homogenised in a bucket and subsample was placed in 70 mL vials and kept cool to preserve the samples.

For samples collected during the August 2020 field survey, in the laboratory, diatoms were treated in 70% nitric acid to remove organic material, and permanent slides were prepared according to (John J. , 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.

For samples collected during the February-March 2022 field surveys samples were prepared and analysed in the laboratory in accordance with Hotzel and Croome (A phytoplankton methods manual for Australian rivers. LWRRDC Occasional Paper 22/99, 1999) *A phytoplankton methods manual for Australian rivers*.

iii Macrophytes

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

4.2.5 Aquatic invertebrates (macroinvertebrates)

Macroinvertebrates were collected at each site 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 250µm mesh dip net to sample ten metres of representative habitat at each site and a longer net was used in the riffle areas where present. The contents of the net are 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, Waddell, & Johnstone, 2004). Macroinvertebrates were identified in the laboratory in accordance with the guidelines; to class for Oligochaeta, Mites and Ostracoda, chironomids to sub-family and all other taxa to family.

NSW Sampling and Processing Manual (Turak, Waddell, & Johnstone, 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 (ºC), 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 August 2020 field survey, aquatic vertebrates were assessed at eight sites[4] and during the February-March 2022 survey period aquatic vertebrates were surveyed at 23 sites (Table 4.5, Figure 4.1), using a number of methods to sample fish and the Platypus, including an electrofisher, bait traps and eDNA sampling. For the purposes of reporting, aquatic vertebrate data has been combined, irrespective of collection method. Turtles have not been considered further in this report as they have been considered within the Biodiversity Development Assessment Report (EMM, 2022d).

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[4] eDNA samples were not collected at Paradise Creek.

i Electrofisher

Electrofishing was undertaken at 23 sites to assess the presence of small-bodied fish and large-bodied fish. Electrofishing involves passing an electrical current through water, stunning aquatic fauna so that they can be netted and identified. Water temperature was monitored closely to ensure that an appropriate electrical current was maintained. The electrofisher maintained an upstream path to avoid recapture of previously stunned individuals. The voltage output was also monitored continuously, to ensure only the minimum current necessary was used to attract and capture fish effectively. The electrofisher was active for an average of 20 minutes per site and averaged 500 volts and 30 Hz at a duty cycle of 15%. Electrofisher settings per site are provided in Annexure G. Once aquatic fauna entered the electric field, the operator ceased administering current into the water and the second field team member netted the individuals and placed them into a holding container fitted with an aeration system. Taxonomic verification was undertaken *in situ* at all sites using appropriate taxonomic literature. Specimens were measured using a ruler and, once recovered, gently placed back into the same waterway in an area of slow flow near the bank. The electrofisher was cleaned before leaving each site to prevent transfer of specimens and pathogens.

ii Bait trap

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

iii eDNA sampling

During the August 2020 field surveys water samples for eDNA analysis were collected from eight sites to assess the presence of the Murray Cod, the Eel-tailed Catfish, the Western Sawshelled Turtle (*Myuchelys bellii*[5]) and the Platypus. During the February-March 2022 field survey water samples for eDNA analysis were collected from 11 sites. Samples were analysed for the presence of Platypus DNA, an additional fish biodiversity assessment was performed on all water samples to determine the presence of fish species. The following sampling protocol was followed during both surveys. Three eDNA filters were collected from each of the 19 sites (total of 57 filters) to ensure the rate of positive detection was 95%. At each site, a new pair of latex gloves were worn, three eDNA filters were removed from sterile packaging, and the packaging was labelled with the site name and filter number. A 50 mL syringe was used to draw water from each site and a 1.2µm filter was attached without touching either end. The syringe was then used to push water through the filter and the filter was removed. This process was repeated until water could no longer be pushed through the filter, or up to a volume of 500 mL had been collected. The total volume of water pushed through each filter was noted on the packet next to the site name and filter number, and the filter was placed inside. A preservative (approximately 0.5 ml 10xTris-EDTA) was added to the filters post filtering. 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.

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[5] Listed as *Wollumbinia belli* under the EPBC Act

The eDNA results are presented as ‘positive’, ‘negative’ or ‘equivocal’, where equivocal indicates that only one or two of the three assays returned a positive result, indicating very low levels of target DNA were present. This may happen as a result of sample contamination through the sampling or laboratory screening process, facilitated movement of DNA between waterbodies, or dispersal from further upstream. In addition, fauna DNA usually degrades after approximately one to seven days, independent of the animal, in the environment (J. Griffiths, pers. comm, March 2020); therefore, the results should be considered indicative only.

4.3 Limitations

Austral Ecology and Research and EMM have relied on some information provided by third parties to undertake this assessment. Errors or omissions in the provided data could affect the validity of the assessment. Water quality data presented in Section 6.1.1 and referred to in Section 6.1.1 was provided by WaterNSW as a water quality range dataset (minima, maxima, mean values), and not as original raw *in situ* or analytical datasets, therefore data presented should be considered indicative only.

The limitations of the eDNA methodology have been outlined above and the following species-specific limitations need to be documented. It should be noted that the assay for the Murray Cod does not distinguish between the Murray Cod, the Eastern Freshwater Cod (*Maccullochella ikei*) or the Mary River Cod (*Maccullochella peelii mariensis*); however, the Eastern Freshwater Cod is currently restricted to the Clarence River catchment of northern NSW (Department of Primary Industries, 2017), while the Mary River Cod occurs only with the coastal drainages of southeast Queensland (Simpson & Jackson, 1996).

Similarly, the assay for the Western Sawshelled Turtle does not distinguish between this species and the Bellinger River Snapping Turtle (*Myuchelys georgesi*), the Manning River Helmeted Turtle (*Myuchelys purvisi*) or the Common Sawshelled Turtle (*Myuchelys latisternum*). However, while there is some overlap in predicated distributions of the Western Sawshelled Turtle and Manning River Helmeted Turtle (NSW Office of Environment and Heritage, 2019; NSW Office of Environment and Heritage, 2018), in terms of the specific project area, it is considered unlikely that the Manning River Helmeted Turtle would occur within Dungowan Creek or the Peel River. The Bellinger River Snapping Turtle is restricted to the coastal Clarence River catchment and Bellinger and Coffs Harbour catchment.

The following limitations apply to the aquatic ecology assessment as a whole:

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

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

5 Desktop assessment results

5.1 Bioregional overview

5.2 Biogeographical context and land use

The project is located in northern NSW within the Nandewar bioregion and the Peel subregion (NAN04) as described by the Interim Biogeographic Regionalisation for Australia (IBRA) (Thackway & Cresswell, 1995) (Figure 5.1). The Nandewar bioregion is located across two states, NSW and Queensland, and is bounded by the North Coast, New England Tablelands and Brigalow Belt South bioregions in the south, east and west respectively (Thackway & Cresswell, 1995). The bioregion covers approximately 2,700,313 ha, of which 77% lies within New South Wales. Major urban centres within the bioregion include Inverell and Tamworth, and smaller centres include Quirindi, Bingara, Barraba, Manilla and Bendemeer (NSW National Parks and Wildlife Service, 2003). The Macintyre, Gwydir and Namoi catchments are located, in part, within the Nandewar bioregion, and the Peel, Macdonald, McIntyre, Namoi, Severn and Gwydir rivers pass through the bioregion. Dungowan Creek is located predominantly within the Peel subregion, with a short section upstream of the dam wall crossing into the Walcha Plateau subregion (NET03) within the New England Tablelands bioregion. The Peel River is wholly located within the Peel subregion (Thackway & Cresswell, 1995) (Figure 5.1).

The broader catchment is predominantly subject to agricultural practices including irrigated lucerne, cotton, wheat, vegetables, fruit trees, oil seeds, fodder and pasture for sheep and cattle (Natural Resources Commission, 2010), as well as irrigated pasture, which comprises approximately 80% of irrigated land use (NSW Office of Water, 2010). Dungowan Creek is located entirely within agricultural land, while the peel river is also located within agricultural land, it transitions to urbanisation in the northwest towards Tamworth.

5.3 Geology and topography

The region comprises Palaeozoic sedimentary rocks on the western edge of the New England Tablelands and incorporates the Tertiary basalts of Inverell and Kaputar. The New England Fold Belt is the youngest structural feature in NSW and is separated from the Lachlan Fold Belt by the Sydney-Bowen Basin, with the oldest rocks comprising Devonian sedimentary and volcanic rocks, and the youngest comprising Triassic sandstones and shales deposited by rivers on the edge of the Gunnedah Basin (Department of Planning, Industry and Environment, 2016). The western slopes (including the project area) represent a dissected ramp that links the uplifted highlands with the western plains. The western rivers pass across the ramp without depositing large volumes of sediment and the Darling Riverine Plains alluvial fans begin at the base of the ramp.

The geology of the Peel subregion is characterised by Silurian to Devonian sedimentary rocks, areas of sub-horizontal Carboniferous shales and sandstones in the north, and limited areas of basalt cap occur within the Nandewar and Liverpool Ranges. Linear outcrops of serpentinite and scattered bodies of limestone also occur. The soil landscape is characterised by clay or loam soils, but siliceous soils derived from acid volcanic rocks are also found. Alluvial loams and clays with moderate to high fertility are found in the valleys (Department of Planning, Industry and Environment, 2016).

5.4 Catchment and hydrology

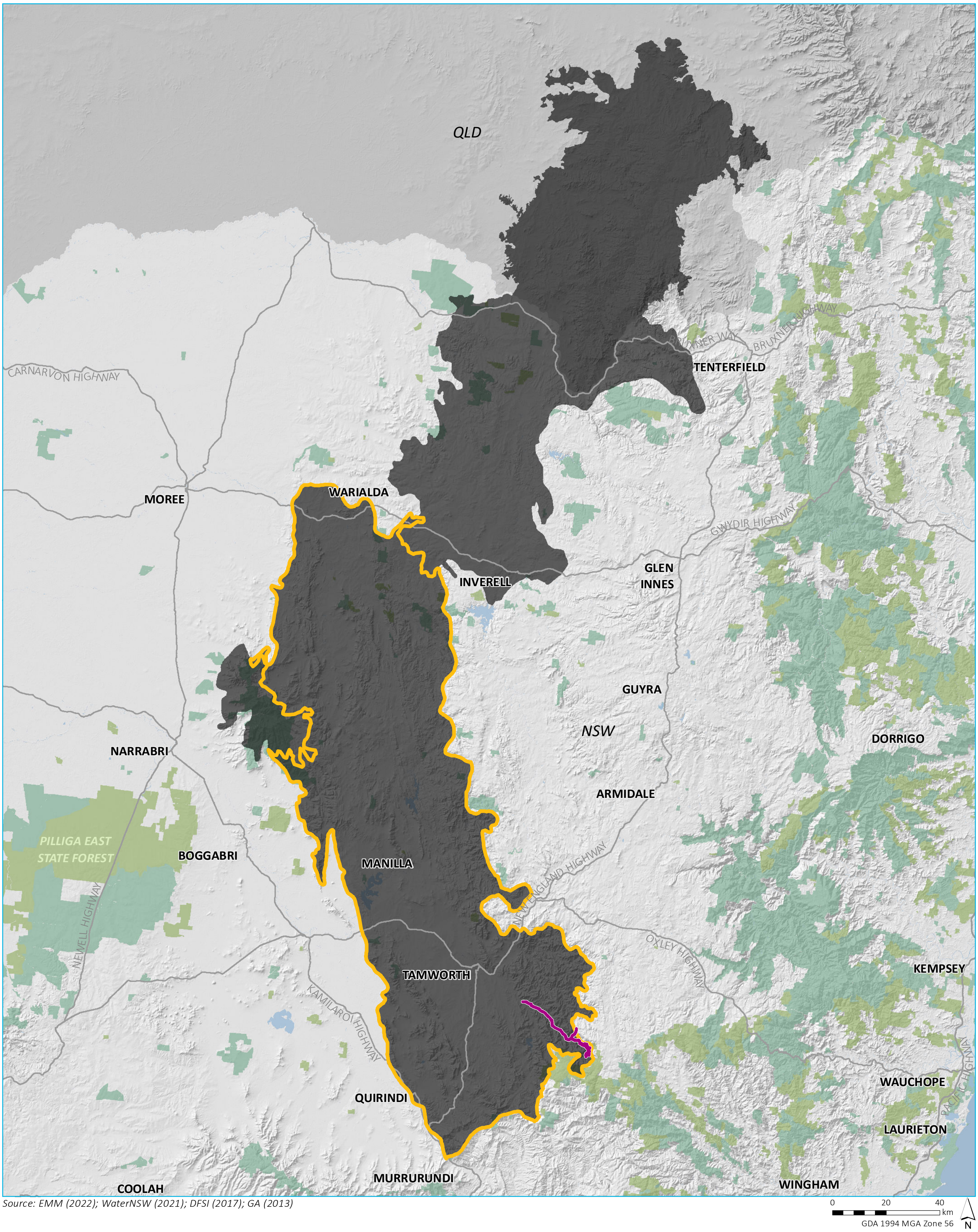
The project is located within the Peel River subcatchment, part of the Namoi catchment (Figure 5.2), which extends from the cool, high rainfall areas within the Great Dividing Range in the east, to the semi-arid, low rainfall areas on extensive riverine plains of northern New South Wales in the west (Murray–Darling Basin Authority, 2010). The catchment covers approximately 42,440 km^2 (Murray–Darling Basin Authority, 2010) and comprises a number of major tributaries and distributaries. Major tributaries within the catchment include the Macdonald, Manilla, Peel, Mooki and Cockburn rivers, and Coxs, Baradine and Bohena creeks, as well as the major distributaries of the Narrabri, Pian and Gunidgera creeks (Murray-Darling Basin Authority, 2019). The McDonald River becomes the Namoi River northeast of Manilla and its headwater originates in the Great Dividing Range at approximately 1,500 m ASL where average annual rainfall ranges from 800 mm to 1,000 mm. The Peel River, a regulated tributary running through the city of Tamworth, meets the Namoi River in the foothills of the ranges and accounts for 11% of the Namoi catchment (Murray-Darling Basin Authority, 2019).

Surface water within the catchment is primarily used for town water supply, irrigation, mining, stock and domestic use. Major water storages within the catchment include Keepit Dam (426 GL) on the Namoi River, Split Rock Dam (397 GL) on the Manilla River, Chaffey Dam (101 GL) on the Peel River, and Dungowan Dam (6 GL) on Dungowan Creek. A number of other smaller weirs have been constructed on the Namoi River, Peel River and Dungowan Creek to regulate flow and deliver water to downstream users with more precision (Murray-Darling Basin Authority, 2019). The Namoi catchment is an important water supply for the Barwon and Darling rivers, as there are few wetlands present to capture flow (Murray-Darling Basin Authority, 2019); however, current issues within the catchment include:

- unsuitability of the water for aquatic ecosystems or safe recreation;
- riverbank instability with resulting erosion, turbidity and sedimentation;
- occurrence of blue-green algal blooms (due to high nutrient concentration and low surface water flow); and
- low temperature of water released from dams.

In terms of surface water management, water allocation within the catchment is subject to the provisions of the *Basin Plan 2012* for the Murray-Darling Basin ("Murray-Darling Basin Plan"; MDBP), including the Sustainable Diversion Limits (SDLs). However, water allocation within the Peel River subcatchment is controlled in accordance with the requirements of the:

- *Water Sharing Plan for the Peel Regulated River Water Source 2022; and*
- *Water Sharing Plan for the Namoi and Peel Unregulated Rivers Water Sources 2012.*



Source: EMM (2022); WaterNSW (2021); DFSI (2017); GA (2013)

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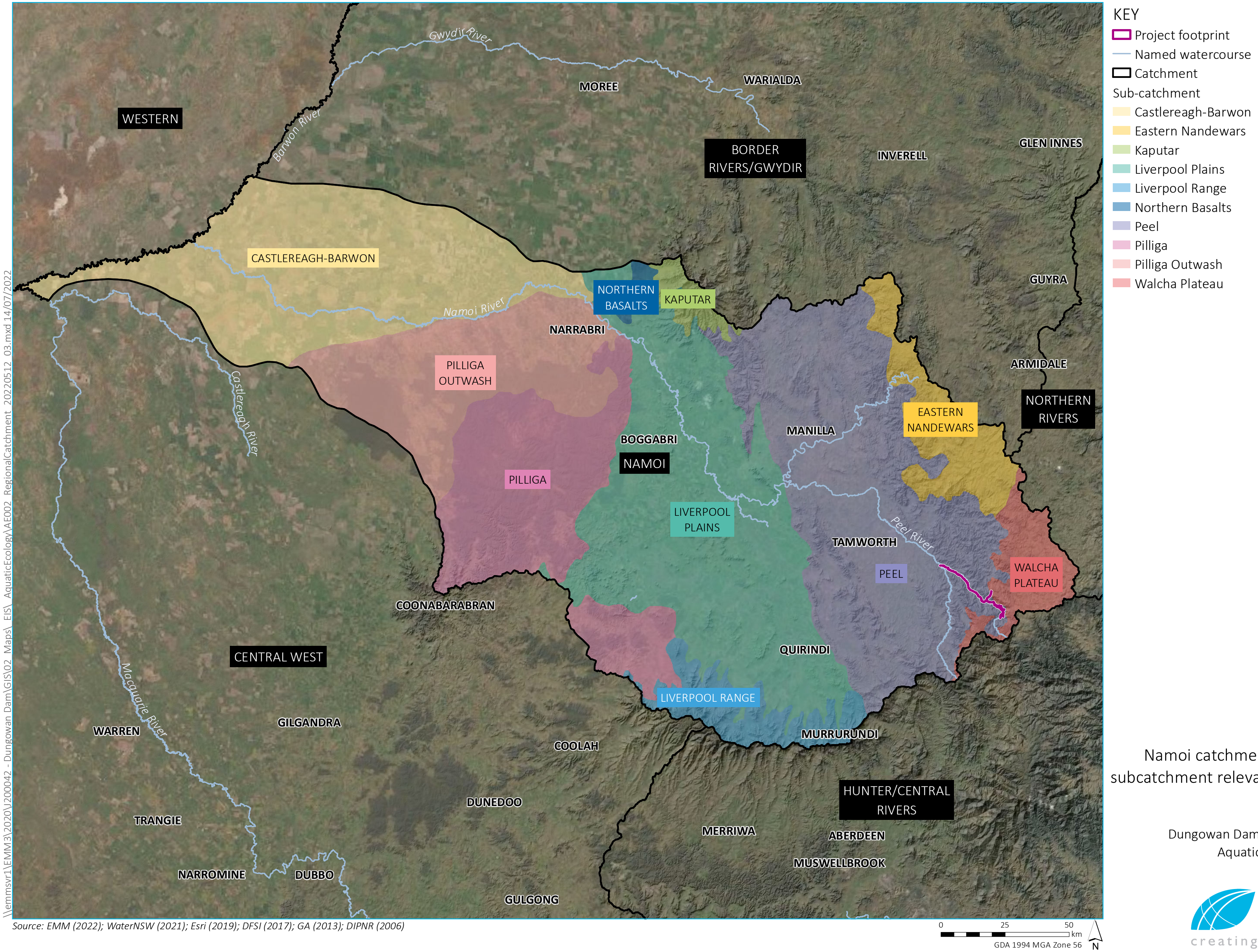
KEY

▭ Project footprint	— Main road
▭ Peel subregion	■ Named waterbody
■ Nandewar bioregion	■ NPWS reserve
	■ State forest

Nandewar bioregion and Peel subregion relative to the Dungowan Dam Project

Dungowan Dam and pipeline project
Aquatic ecology assessment
Figure 5.1

EMM
creating opportunities



Source: EMM (2022); WaterNSW (2021); Esri (2019); DFSI (2017); GA (2013); DIPNR (2006)

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Namoi catchment and Peel River subcatchment relevant to the project

Dungowan Dam and pipeline project
Aquatic ecology assessment
Figure 5.2

EMM
creating opportunities

5.5 Hydrogeology

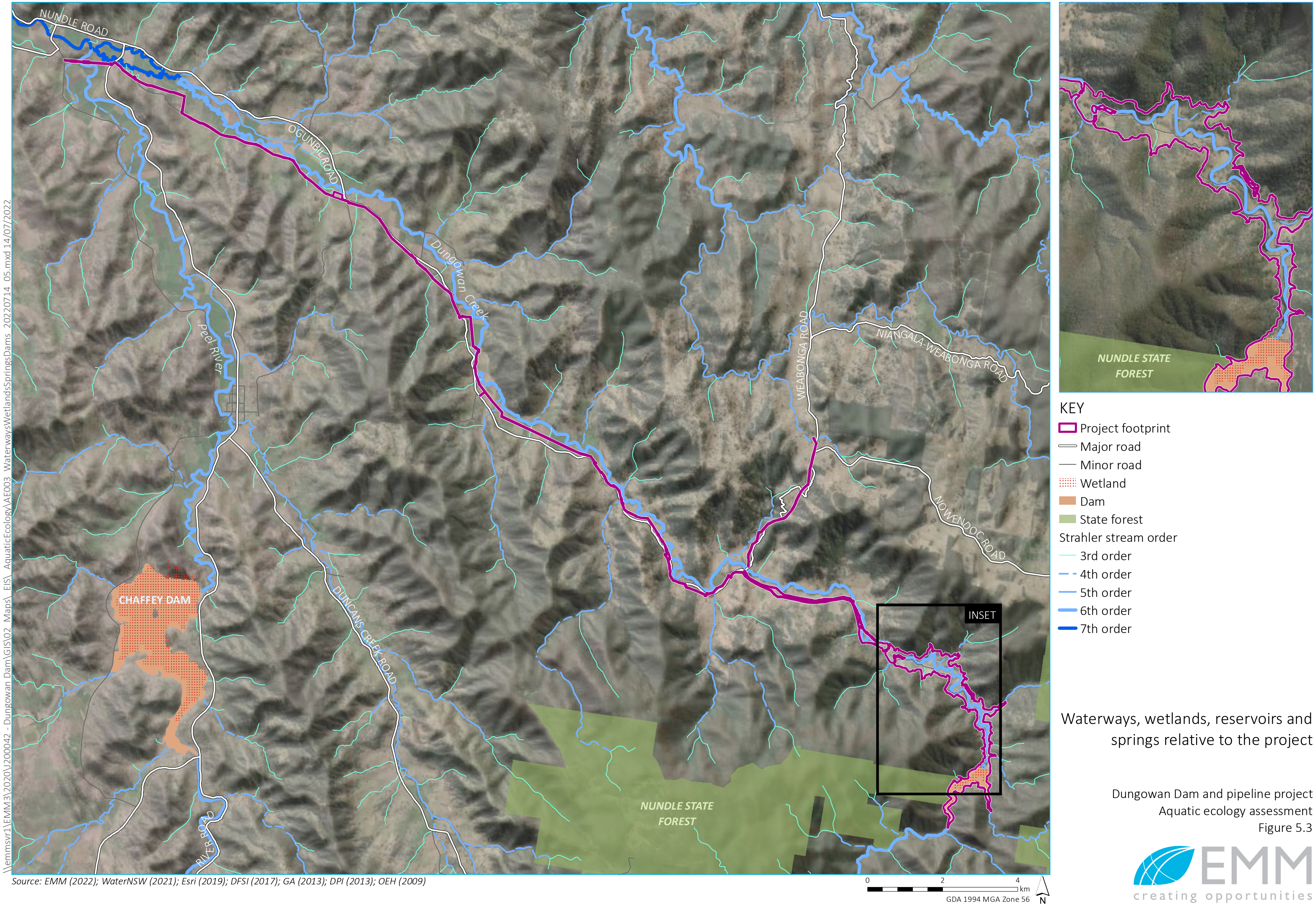
There are two groundwater systems in the vicinity of the project, one associated with the Quaternary alluvium and the other associated with the Ordovician fractured rock (EMM, 2022b). The local alluvial system overlies the fractured rock and is limited to unconsolidated deposits associated with the rivers and floodplains. The regional fractured rock systems form the valley slopes, the hills and ranges and cover most of the catchment. There is the potential for perched groundwater to occur in the weathered rock, where present.

The Peel Alluvium comprises the alluvial groundwater adjacent to the regulated and unregulated rivers in the Peel Valley, including Dungowan Creek (EMM, 2022b). The alluvial groundwater system is a shallow unconfined system comprising unconsolidated cobble, gravel, sand, silt and clayey sediment, transitioning to coarser sediment in thick deposits (ie greater than 15 m), which form productive aquifers upgradient in the Peel Valley, and are used for water extraction purposes. However, the extent of the mapped alluvium within the project area is relatively thin compared to the lower Peel River subcatchment. Alluvial groundwater is assumed to be hydraulically connected to surface water within Dungowan Creek (EMM, 2022b). The fractured rock is likely to have very low primary porosity, with groundwater flow occurring within secondary porosity features such as fractures or along contact boundaries between different rock lithologies. The hydraulic conductivity and groundwater storage within these secondary porosity features is typically very low.

Recharge to the upgradient alluvial aquifer and the fractured rock aquifer is generally considered to be via rainfall on the upper slopes, ridgelines and hilltops of the landscapes where the rock sub-crops or outcrops. Infiltration at rock outcropping is reported to be 4% of annual rainfall (EMM, 2022b). Groundwater discharge is likely to occur at springs, spring-fed dams, lower slopes and relatively lower lying areas. It is understood that Dungowan Creek typically loses surface water to groundwater aquifers along most of its length. However, this is not expected to occur within the project area, due to the relative thin alluvium deposit thickness, and the steep terrain (EMM, 2022b). The fractured rock groundwater source is considered to be ‘not highly connected’ to surface water (EMM, 2022b).

The following documents guide management of groundwater with the local area:

- Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Source 2020 (New England Fold Belt Murray Darling Basin Groundwater Source)
- Water Sharing Plan for the Namoi and Peel Unregulated Rivers Water Sources 2012 (Upper Peel River Tributaries Water Source, Lower Peel River Tributaries Water Source, Dungowan Creek Management Zone).



Source: EMM (2022); WaterNSW (2021); Esri (2019); DFSI (2017); GA (2013); DPI (2013); OEH (2009)

Waterways, wetlands, reservoirs and springs relative to the project

Dungowan Dam and pipeline project
Aquatic ecology assessment
Figure 5.3

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5.6 Climate

The climate of the Nandewar bioregion varies with elevation, though is considered to be predominantly dry and warm (NSW National Parks and Wildlife Service, 2003). Mean temperatures range from 10ºC-18ºC (NSW Department of Planning, Industry and Environment, 2021). Rainfall varies considerably, attributed to the varying topography of the region, with higher elevations experiencing substantially more rainfall than lower lying areas in the west. In general, frequent, high-intensity rainfall and high run-off is characteristic of the bioregion, with summer months receiving slightly higher rainfall. Annual average rainfall varies across the Namoi catchment, from a maximum of 1,300 mm over the eastern ranges, to approximately 400 mm near Walgett (Green, et al., 2011).

The nearest Bureau of Meteorology weather station to the project area is at Ogunbil (Amaroo – station number 556262) for rainfall data, and Tamworth Airport weather station (station number - 55325) for temperature data. Annual rainfall in the 12 months prior to the February-March 2022 survey totalled 781.2mm, 20.1 mm above the long-term (30 year period) annual mean of 761.1 mm (Figure 5.4) (Bureau of Meteorology, 2022a). The months of March, June, July, August, and November 2021 recorded above average rainfall, ranging from 1.8 mm (November 2021) to more than 71.6 mm (June 2021) above the long-term monthly mean (Figure 5.5). The remaining months recorded below average rainfall, with January 2022 more than 49 mm below the long-term monthly mean (Figure 5.5).

Over the last 10 years, six years have recorded rainfall higher than the long term annual average (Figure 5.4) (Bureau of Meteorology, 2022a). While rainfall totals for 2022 were only marginally higher than the long term annual average at the time of the August 2020 field survey, rainfall during the 2022 survey period was lower than the mean rainfall for that time of year.

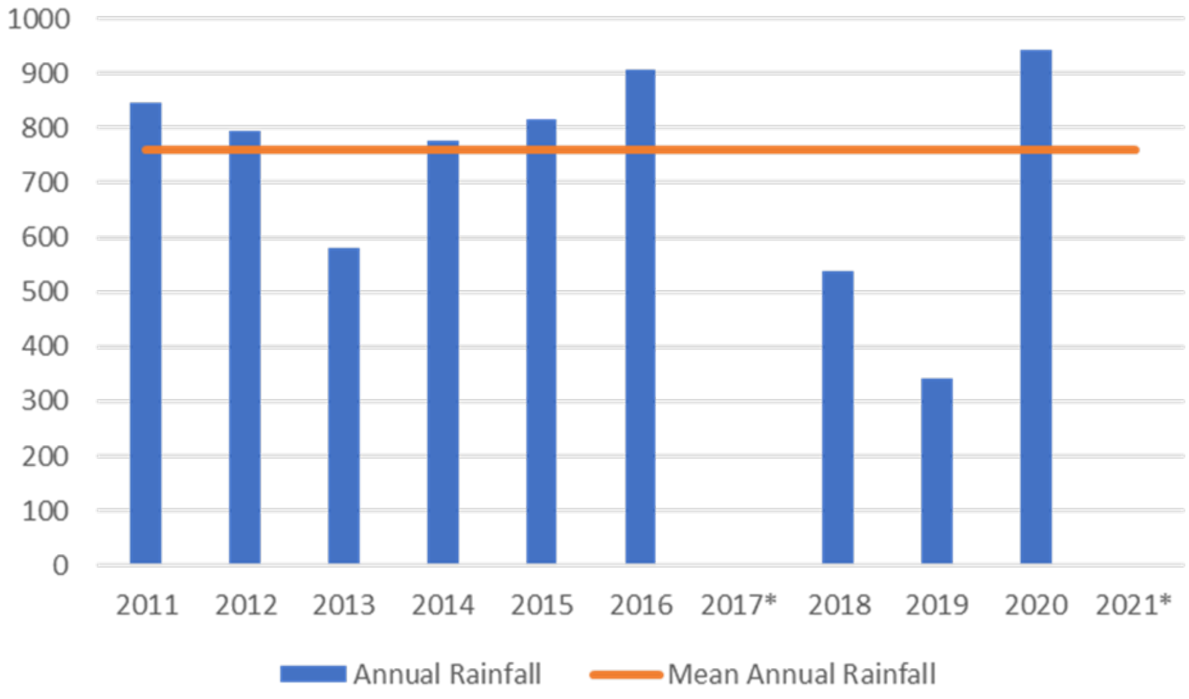

Figure 5.4 **Annual rainfall compared to long-term (30 year period) mean annual rainfall, 2011-2021 (* indicates that rainfall data was incomplete for that year)**

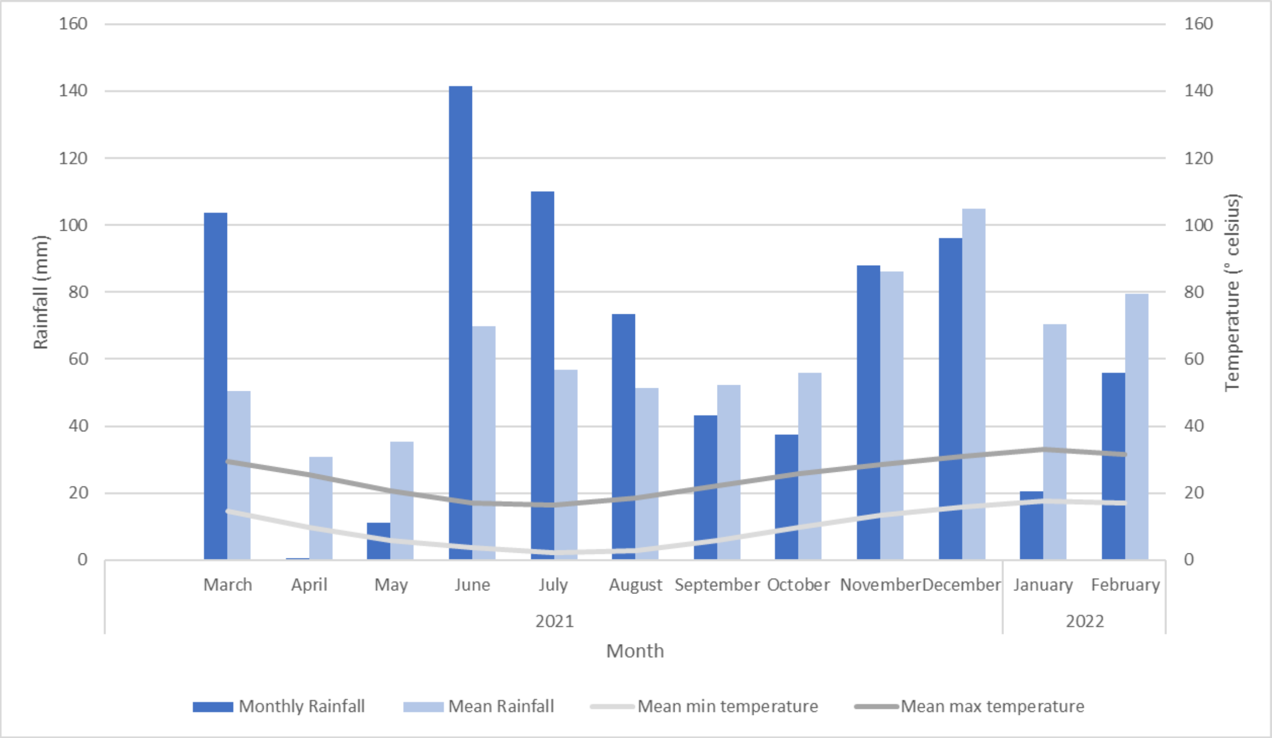

Figure 5.5 Monthly rainfall compared to long-term (30 year period) mean monthly rainfall, and mean minimum and mean maximum temperature, March 2021-February 2022

5.7 Aquatic habitats

Overall, the Namoi catchment is considered to be in “good” hydrological condition and “moderate” physical form condition (Murray–Darling Basin Authority, 2010). Dungowan Creek is characterised by a series of pool and riffle habitats within a defined channel, with muddy clay to clayey sediment and banks. At its confluence with the Peel River, aquatic habitat is relatively undisturbed and remains in reasonable condition downstream until it reaches Tamworth where it has undergone channel modification and straightening (GHD, 2019). The Peel River from the Chaffey Dam wall to the confluence with Dungowan Creek is characterised by a series of pool and run habitats within a defined channel, with muddy clay to clayey sediment and banks. Although unlikely to support the same diversity of species as the upstream areas of the Peel River, deep pools near Jewry Street Weir (in Tamworth) may provide habitat for Murray Cod and other large fish species. According to GHD (2019), the section of the Peel River between the Chaffey Dam wall and its confluence with Dungowan Creek has been observed to be the least disturbed, containing important features such as in-stream woody habitat, remnant riparian vegetation, sequences of riffle, pools, boulders, cobblestones and gravel beds. These habitats may be capable of supporting a range of species with different habitat preferences, as well as threatened species including the Murray -Darling Basin population of Eel-tailed Catfish (*Tandanus tandanus*), Murray Cod and the Southern Purple-spotted Gudgeon (*Mogurnda adspersa*).

The Sustainable Rivers Audit 2 classified riparian vegetation as ‘poor’ throughout the Namoi Valley system, with a riverine vegetation index (SR-VI) score of 50 (Murray–Darling Basin Authority, 2010); however, some native species persist along the Peel River including River Oak (*Casuarina cunninghamiana*), Rough-barked Apple (*Angophora floribunda*), *Callitris* sp. (native conifers), River Red Gum (*Eucalyptus camaldulensis*) and *Lomandra* sp. (a mat rush) (NGH Environmental, 2012).

Agricultural practices on both the lower and upper slopes and floodplains are the dominant land uses of the Namoi catchment with extensive clearing for grazing and cropping (Green, Petrovic, Moss, & Burrell, 2011). As a result, one of the more considerable impacts that have occurred within the catchment is river regulation to meet the needs of licensed water users for irrigation and stock supplies as well as the town water supply of Tamworth (GHD, 2019; Davies, Harris, Hillman, & Walker, 2008). This is highlighted by the number of major dams, summarised in Section 5.4, as well as several regulators and offtakes situated throughout the catchment (eg Jewry Street Weir, Calala Water Treatment Plant (WTP)). The Chaffey Dam maintains water levels within the Peel River, which provides an almost constant flow between Chaffey Dam and Tamworth, despite drought conditions. However, flow further downstream from the Peel River offtake become reduced where periods of zero or near zero flow can occur (GHD, 2019). As a result of waterway modification and agricultural practises, the removal of large woody debris from waterways has occurred (listed as a key threatening process under the FM Act). This 'de-snagging' results in loss of in-stream habitat complexity and available feeding, breeding and refugia habitat, as well as increasing erosion and decreasing the amount of decomposing organic matter, which contributes nutrients to the local aquatic food web (Department of Primary Industries, 2005).

The broader catchment has over 2,700 mapped wetlands, with several considerable wetlands occurring, independent of the river system. In particular, Lake Goran is listed as a wetland of national significance (Figure 5.3) (Department of Agriculture, Water and the Environment, 2001) and is a drainage basin expanding approximately 60 km^2 south of Gunnedah, providing important habitat for migratory birds when flooded (Green, Petrovic, Moss, & Burrell, 2011). The Namoi catchment supports a wide range of aquatic habitats including large areas of anabranch and billabong wetlands downstream of Narrabri; however, there are few lakes or wetlands within the subcatchment. The lower Namoi River is characterised by a primary channel with a network of anabranches, small tributaries, lagoons and wetlands across the floodplain. Waterways and wetlands, and biodiversity in general, across the catchment are currently under ecological pressure from exotic weeds, feral animals, grazing, sedimentation and altered water regimes, as well as recreational impacts (Thoms, Norris, Harris, Williams, & Cottingham, 1999). In terms of aquatic habitat, the Lowland Darling River aquatic ecological community, listed as endangered under the FM Act ("Lowland Darling River Endangered Ecological Community (EEC)"), is located downstream of the Chaffey Dam wall along the Peel River (Figure 5.6). The Lowland Darling River EEC is a lowland riverine environment supporting an abundance of native fish and invertebrates throughout a number of varied habitats. In terms of habitat for subterranean fauna (stygofauna), communities are known to occur within alluvial and fracture rock aquifers, which are potentially present relative to the project, therefore it is possible that communities may occur within the aquifers associated with the project.

The local area surrounding Dungowan Creek and the Peel River is highly fragmented, with native vegetation occurring only in isolated patches and surrounded by urban and agricultural land. In addition, aquatic and riparian habitat is generally of poor condition, with invasive exotic species dominant and habitat modification prevalent (eg land clearing, agriculture, river regulation, erosion/sedimentation). A narrow corridor of riparian vegetation immediately adjacent to Dungowan Creek is generally intact; however, this dissipates with distance downstream due to encroaching agricultural use. Habitats surrounding the existing Dungowan Dam, upstream of the dam wall, comprise largely intact vegetation, attributed to its location within a water catchment area.

The Biodiversity Development Assessment Report (BDAR) (EMM, 2022d) details that the remaining remnant riparian forest (PCT 84) located on the banks of Dungowan Creek as being dominated by River Oak with eucalypts typically sparse and only rarely sub-dominant. Through most of the study area, surrounding floodplain vegetation has been cleared and utilised for agriculture leaving the riparian forest isolated from other treed habitat and impacted by livestock grazing, increased nutrients from agricultural activity and weed invasion. The dominance of a single tree species in this forest results in reduced habitat complexity and limits its value for some threatened animal species.

5.7.1 Threatened communities and habitats

The database searches identified several internationally important ecosystems located within NSW more broadly; however, these were typically more than 900 km from the project (Annexure A). A number of threatened ecological communities (TECs) listed under the EPBC Act were identified from the vicinity of the project, with one having the potential to contain aquatic habitat; “Upland wetlands of the New England Tablelands and the Monaro Plateau” (EPBC Act, Endangered) (Annexure A). The nearest documented “Upland wetlands of the New England Tablelands and the Monaro Plateau” is located north-northeast of the existing Dungowan Dam within the New England Tablelands bioregion, therefore it is unlikely that this community will be impacted by the proposed project.

One TEC listed under the FM Act was recorded; the Lowland Darling River aquatic ecological community (FM Act, Endangered; “Lowland Darling River EEC”) (Department of Primary Industries, 2007a). The Lowland Darling River EEC is a lowland riverine environment and is characterised by a variety of habitats of deep channels, pools, wetlands, gravel beds and floodplains, it includes all natural creeks, streams, rivers, lagoons, billabongs, lakes, anabranches, flow diversions to anabranches and floodplains of the Darling River (Department of Primary Industries, 2007b). The Lowland Darling River EEC is critical for supporting the life cycles of the species comprising its community of which many have not been comprehensively studied, including 21 native fish species and hundreds of species of native invertebrates. These habitats support an abundance of native fish and invertebrate species, of which many have not been comprehensively studied (Department of Primary Industries, 2007a).

The Lowland Darling River EEC includes all native fish and aquatic invertebrates within all waterways associated with the Darling River, including the Peel River downstream of Chaffey Dam (Fisheries Scientific Committee, 2007). The Lowland Darling River EEC occurs within the area of direct impact and has the potential to be directly impacted by changes to flow within the Peel River, or indirectly impacted by construction and changes to flow occurring on Dungowan Creek. A significant cause of degradation to the Lowland Darling River EEC within the Namoi catchment is the modification of natural flow attributed to river regulation (Department of Primary Industries, 2007b). Other factors contributing to habitat degradation include agricultural practices, removal of in-stream woody debris and cold water release from dams.

5.7.2 Key fish habitat

A total of 58.8 km of waterways intersect the project ranging from 1st order to 6th order (Strahler, 1952) (Figure 5.7), including permanent, semi-permanent and ephemeral waterways. A total of 40.9 km of waterways intersect the pipeline alignment, while 17.9 km of waterways intersect operational areas including the FSL. The key fish habitat map for the Tamworth local government area (LGA) indicates that, of these waterways, the majority of them are considered to contain key fish habitat, in particular Dungowan Creek and the Peel River (Figure 5.7) (Department of Primary Industries, 2022a).

Dungowan Creek is considered to be a gaining waterway as it increases from 6th order below the existing Dungowan Dam wall, to 7th order below the confluence with Hodkiss Creek (Figure 5.7). The Peel River is considered gaining to a certain degree as it increased from 6th order below the Chaffey Dam wall to 7th order below the confluence with Dungowan Creek; however, downstream of the Cockburn River, it decreases to 3rd order.

KEY

▭ Project footprint

— Major road

— Named watercourse

🟦 Named waterbody

🟩 NPWS reserve

🟩 State forest

⬛ Darling River endangered ecological community

Source: *EMM (2022); WaterNSW (2021); Esri (2019); DFSI (2017); GA (2013)*

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Location of the project relative to the Darling River EEC

Dungowan Dam and pipeline project
Aquatic ecology assessment
Figure 5.6

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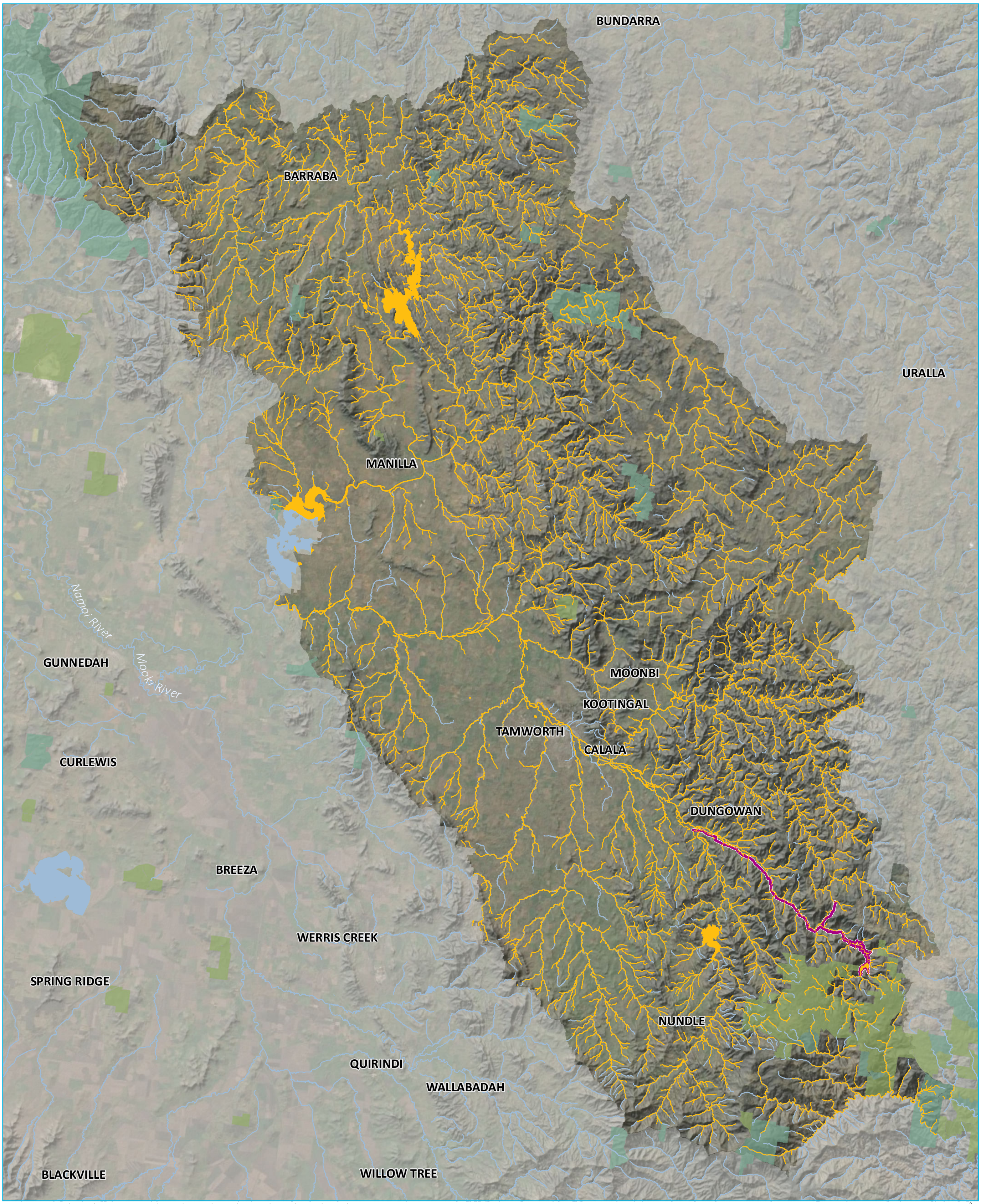

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Source: EMM (2022); WaterNSW (2021); Esri (2019); DFSI (2017); GA (2013)

KEY

- ▭ Project footprint
- — Named watercourse
- ▬ Named waterbody
- ▬ NPWS reserve
- ▬ State forest
- ▬ Key fish habitat

Tamworth Local Government Area key fish habitat distribution

Dungowan Dam and pipeline project
Aquatic ecology assessment
Figure 5.7

EMM
creating opportunities

5.7.3 Water and sediment quality

A range of *in situ* and analytical water quality parameters have been recorded between 1969 and 2020 from various monitoring stations within Dungowan Creek, the Peel River and the Chaffey Dam (WaterNSW, unpublished data); however, sediment quality data was not available. Surface water pH results ranged from neutral (pH 7.2) to alkaline (pH 9.6), and salinity was considered to be fresh (ranging from 98 mg/L to 650 mg/L). Dissolved oxygen ranged from 3.7 mg/L to 13.3 mg/L, temperature ranged from 6^{o}C to 33^{o}C, and turbidity was highly variable ranging from -3 NTU to 3,700 NTU (WaterNSW, unpublished data). With regard to nutrient concentrations, nitrogen (total) ranged from 0.05 mg/L to 14.4 mg/L and phosphorus (total) ranged from below detection to 9 mg/L (WaterNSW, unpublished data). Concentrations of more than 15 metals have been detected within the catchment including aluminium, arsenic, copper, lead, mercury and zinc. More than 40 different herbicides, insecticides and other chemicals have also been recorded at various monitoring stations, including demeton-s-methyl, fluazifop-p-butyl, haloxyfop, malathion, omethoate, thidiazuron and chlorfluazuron (WaterNSW, unpublished data).

Monitoring data has been recorded from the offtake location at several depths (4 m, 10 m, 18 m) within the existing Dungowan Dam, and includes pH, electrical conductivity, alkalinity, turbidity, iron, manganese and colour (Annexure B of the Surface Water Assessment). On average, all reported parameters increased as depth increased, excluding true colour which decreased. For those parameters with an available ANZECC and ARMCANZ (2000) trigger value[6]:

- pH exceeded the upper range limit of pH 8 at 18 m in depth;
- electrical conductivity exceeded the upper range limit of 0.03 µS/cm at 4 m, 10 m and 18 m in depth; and
- turbidity exceeded the upper range limit of 20 NTU at 10 m and 18 m in depth.

Similar results were also recorded for the existing Dungowan Dam tunnel with pH, electrical conductivity, turbidity and manganese exceeding relevant ANZECC and ARMCANZ (2000) trigger values and ANZG (Water Quality Australia, 2018) DGVs[7].

5.8 Aquatic flora

No aquatic flora or riparian vegetation communities listed under the FM Act or the EBPC Act were identified during the desktop assessment. A total of 32 cyanophyte ("blue-green" algae from the phylum Cyanophyta) genera have been recorded from various monitoring stations within Dungowan Creek, the Peel River and the Chaffey Dam (WaterNSW, unpublished data). The genus *Anabaena* was the most abundant, followed by *Microcystis* and *Aphanocapsa*. Representatives of *Anabaena* and *Microcystis* genera have the potential to form blooms and to produce either the microcystin toxin or anatoxins. However, while *Aphanocapsa* species also have the capacity to form blooms and produce either the microcystin or nodularin toxins, they are not considered by WaterNSW to be a risk in terms of toxicity in Australian environments (Sydney Catchment Authority, 2010). In specific relation to the existing Dungowan Dam water column, offtake and tunnel, seven algal phyla have been recorded, including Bacillariophyceae, Chlorophyceae, Chrysophyta, Cryptophyceae, Cyanophyta, Dinophyceae and Euglenophyceae (WaterNSW, unpublished data). Of the cyanophytes, 18 genera were recorded, of which two have the potential to be toxic in Australia (Sydney Catchment Authority, 2010).

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[6] Representative of slightly disturbed freshwater lakes and reservoirs in southeast Australia.

[7] For the protection of 80% of species in freshwater, representative of highly disturbed ecosystem.

The aquatic plants, *Potamogeton crispus* and *Myriophyllum* sp., have been observed in the Peel River, immediately downstream of Chaffey Dam (NGH Environmental, 2012), which may provide important habitat for a range of aquatic fauna. These species occurred in riffle zones and were reported as being covered in fine sediment. Emergent aquatic plants including *Typha orientalis*, *Juncus* sp. and *Eleocharis sphacelota*, and *Typha* sp. were also observed further downstream in more disturbed parts of the Peel River adjacent to Tamworth. *Azolla* spp., *Juncus* spp., *Bolboschoenus* spp., Common Reed *Phragmites australis* and Watercress *Nasturtium officinale* are all reported as occurring within the Peel River between Chaffey Dam and Tamworth (Department of Primary Industries, 2020a). No information on aquatic flora within Dungowan Creek was available. A number of exotic species are known from the local catchment, including Alligator Weed (*Alternanthera philoxeroides*; WoNS[8]) and Salvinia (*Salvinia molesta*; WoNS) (Department of Primary Industries, 2019), with a number of willow species also likely to occur within the riparian zone.

5.9 Aquatic fauna

The Sustainable Rivers Audit 2 classified the ecology of the Namoi Valley system, of which Dungowan Creek and the Peel River form part of, as ‘poor’ in terms of ecosystem health, ‘very poor’ in terms of fish community health, and ‘moderate’ in terms of the macroinvertebrate community (Murray–Darling Basin Authority, 2010). Between 15 and 30 native fish species were recorded per sample site; however, average fish numbers per site were approximately 50% native and 50% exotic, and average total fish biomass (kg) per site was substantially higher for exotic fish compared to native fish biomass. A total of 67 families of macroinvertebrates were recorded (Murray–Darling Basin Authority, 2010). Between 2004 and 2010 there has been a significant decrease in fish expectedness, nativeness, and recruitment, whereas macroinvertebrate communities have remained relatively stable.

DPI Fisheries also provides data on the condition of freshwater fish communities in terms of distribution, diversity and abundance of native and exotic species. The status of Dungowan Creek immediately downstream of the dam wall is “very poor”, changing to “poor” along its length until its confluence with the Peel River. Terrible Billy Creek is also classified as “poor”. The Peel River is classified as “poor” immediately downstream of the Chaffey Dam wall, becoming “fair” until its confluence with the Namoi River. Reedy Creek, a tributary of the Peel River is classified as “very poor” along its entire length (Department of Primary Industries, 2022a). These classifications are likely attributed to the proliferation of exotic fish species and the stocking of exotic species for recreational purposes, with the fish fauna of the Namoi valley declining in condition over time. It is likely that habitat modification, degradation and fragmentation of aquatic and riparian habitat along waterways and within the greater catchment has contributed to this decline (Murray–Darling Basin Authority, 2010). Macroinvertebrate communities were also comparably low in diversity compared to reference conditions, with a notable absence of disturbance-sensitive families (Murray–Darling Basin Authority, 2010).

A number of non-threatened native aquatic vertebrate fauna species inhabit Dungowan Creek and the Peel River based on the assemblage of the Lowland Darling River EEC (Department of Primary Industries, 2007a) and information provided by WaterNSW (EnviroDNA, 2021a; EnviroDNA, 2021b) and the NSW Department of Primary Industries (Department of Primary Industries, 2020a) including the Australian smelt (*Retropinna semoni*), Golden Perch (*Macquaria ambigua*), Mountain Galaxias (*Galaxias olidus*), Obscure galaxias (*Galaxias oliros*), River Blackfish (*Gadopsis marmoratus*), a species of carp gudgeon (*Hypseleotris* sp.), Bony Herring (*Nematalosa erebi*), Darling River Hardyhead (*Craterocephalus amniculus*), Murray River Rainbowfish (*Melanotaenia fluviatilis*), Spangled Perch (*Leiopotherapon unicolor*) and Unspecked Hardyhead (*Craterocephalus stercusmuscarum fulvus*). Several species are, or have been, actively stocked within Dungowan Creek (Rainbow Trout *Oncorhynchus mykiss*), Chaffey Dam (Golden Perch, Murray Cod, Silver Perch, and the Peel River (Golden Perch, Murray Cod, Rainbow Trout) (Department of Primary Industries, 2022b; Department of Planning, Industry and Environment, 2020). A number of macroinvertebrates are also known from the waterways including the Common Yabby (*Cherax*

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[8] Weed of national significance

destructor), the Common Australian River Prawn (*Macrobrachium australiense*) and a species of spiny crayfish (*Euastacus* sp.) (NSW Department of Planning and Environment, 2022).

With regard to exotic aquatic fauna species, the Common Carp (*Cyprinus carpio*), Eastern Mosquitofish (*Gambusia holbrooki*) and Rainbow Trout, at a minimum, are known from the Namoi catchment as well as waterways within the vicinity of the project (NSW Department of Planning and Environment, 2022). The Common Carp is listed as a Class 3 noxious fish under the FM Act, while the Eastern Mosquitofish is listed as a pest within NSW.

5.9.1 Threatened aquatic fauna

The results of the desktop assessment indicate that a total of four threatened aquatic species or species comprising a threatened population, listed under the FM Act and/or the EPBC Act, and the Platypus have the potential to occur in waterways associated with the Namoi catchment (Annexure A):

- Southern Purple-spotted Gudgeon.
- Silver Perch.
- Murray Cod.
- Murray-Darling Basin population of Eel-tailed Catfish.
- Platypus.

An assessment was undertaken to evaluate the likelihood of each of these threatened aquatic species occurring within waterways intersecting the project, or downstream of the project, based on the aquatic habitats likely to be present as well as existing literature and DPI Fisheries datasets (Department of Primary Industries, 2022b) (Table 5.1). Of the five species listed above, all are possible or known to occur within waterways intersecting the project, or downstream of the project, and have the potential to be impacted by construction and operation of the project. A summary of the ecology of the five species are provided in subsequent sections.

Table 5.1 Threatened species with the potential to occur within, or adjacent to, the project

Family	Common name	Scientific name	Data source						LoO
			DPI	BioNet	PMST	WaterNSW	FM Act	EPBC Act	
Fish									
Eleotridae	Southern Purple-spotted Gudgeon	*Mogurnda adspersa*	✓				E		Possible
Percichthyidae	Murray Cod	*Maccullochella peelii*	✓^		✓	✓		V	Known
Plotosidae	Murray-Darling Basin population of Eel-tailed Catfish	*Tandanus tandanus*	✓			✓	E		Known
Ornithorhynchidae	Platypus	*Ornithorhynchus anatinus*	✓	✓		✓		PL	Known
Terapontidae	Silver Perch	*Bidyanus bidyanus*	✓		✓	✓	V	CE	Known

Note LoO = Likelihood of occurrence; CE = Critically Endangered, E = Endangered, EP = Endangered population, V = Vulnerable, PL = DAWE (2000) provisional management list; ^ indicates data source is stocking data.

The Southern Purple-spotted Gudgeon is listed as endangered under the FM Act, while the Murray-Darling Basin population of Eel-tailed Catfish is listed as an endangered population under the FM Act. Murray Cod is not listed under the FM Act, but is listed as vulnerable under the EPBC Act. These species and communities are considered 'known to occur' or 'may possibly occur' within Dungowan Creek and/or the Peel River (Annexure A).

While the Platypus is not currently listed under the FM Act or the EPBC Act, there is currently a lack of knowledge regarding species abundance at a local catchment level (Australian Museum, 2019) and the species is subject to similar impacts as threatened fish, including waterway bank erosion, channel sedimentation, regulated waterways, barriers to water flow (eg dams and weirs), riparian zone degradation and loss of riparian vegetation (Bino, et al., 2019; Temple-Smith & Grant, 2003). The Platypus was included on the DAWE (2020) provisional list of animal species identified as requiring immediate urgent management intervention in February 2020, following the 2019/2020 bushfire season in southern and eastern Australia (20 March 2020). The Platypus has been observed within the Peel River and Dungowan Creek (NSW Department of Planning and Environment, 2022), and has been recorded as using waterways in the vicinity of the project, between Tamworth and Chaffey Dam (EnviroDNA, 2021b; GHD, 2019; EnviroDNA, 2021a).

i Southern Purple-spotted Gudgeon

Southern Purple-spotted Gudgeon prefer slow-flowing or still water with a substantial amount of macrophyte coverage or a rocky benthos (Fish Base, 2022b), and is a benthopelagic feeder on larvae and small fish. This species is known to occur in quite shallow water; however, fluctuations in water volume/flow (affecting water level) as a result of river regulation have the potential to impact on important wetland habitat used for reproduction and recruitment. The Southern Purple-spotted Gudgeon requires a specific temperature range (19--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. Recent population decline is attributed to competition for resources with exotic species, habitat degradation, cold water pollution and fishing pressure, with the Southern Purple-spotted Gudgeon subject to competition from the Eastern Gambusia and predation by Redfin Perch (*Perca fluviatilis*) (Department of Primary Industries, 2018b), although the Redfin Perch appears to be largely absent from the Namoi catchment (Lintermans, 2017). The Department of Primary Industries (2022e) have issued a “Priorities Action Statement”, which lists a range of actions with regard to the recovery of the species. Key high priority actions include:

- Provide information on the distribution of Southern Purple-spotted Gudgeon to local councils and determining authorities to ensure appropriate consideration during development assessment processes.
- Maximise compliance with the ban on collecting Southern Purple-spotted Gudgeon by communicating with aquarium enthusiasts using a number of communication mediums (eg aquarium industry journals, newsletters, conferences).
- Incorporate new research information into catchment management, river health and wetlands programs where appropriate.
- Negotiate with relevant authorities to encourage the identification, assessment, and modification of natural resource management plans and policies to minimise impacts on Southern Purple-spotted Gudgeon habitats and water quality.
- Undertake work to identify, restore and protect known and potential Southern Purple-spotted Gudgeon habitats and address key threats such as habitat degradation and water quality decline from expanding development.
- 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.

- Actively seek funds through grant schemes or other sources to implement riparian vegetation and water quality improvement projects in priority areas.

- Undertake priority rehabilitation, restoration and enhancement work (eg rehabilitating riparian vegetation, cold water pollution reduction measures, reinstating large woody debris, removal of barriers to fish passage, removal of willows from riverbanks, sediment and erosion control measures) at key sites known to support Southern Purple-spotted Gudgeon populations.

- Conduct research on the biology and ecology of Southern Purple-spotted Gudgeon, particularly the species' ecological role, environmental tolerances, factors influencing population dynamics, age and growth, life cycle and diet.

- Undertake research to identify, prioritise and improve understanding of the threatening processes and causes of decline of Southern Purple-spotted Gudgeon.

- Obtain and analyse genetic material from remnant populations of Southern Purple-spotted Gudgeon to identify genetic units to inform conservation breeding or translocation.

- Conduct targeted surveys to determine the current distribution and abundance of Southern Purple-spotted Gudgeon.

- Collect data on the presence/absence of Southern Purple-spotted Gudgeon during incidental surveys.

The Southern Purple-spotted Gudgeon is currently considered to be extremely rare in inland NSW, and has only been recorded once since 1983 (Department of Primary Industries, 2018b); however, publicly -available spatial datasets indicate it is possible that it is present within the Peel River and Dungowan Creek (Figure 5.8) (Department of Primary Industries, 2022c). Suitable habitat has the potential to exist within the Peel River and Dungowan Creek, although both waterways are subject to river regulation and periodic water release.

ii Murray Cod

Murray Cod tolerate a range of warm water habitats from clear rocky streams to turbid slow flowing rivers, often occupying main channels of rivers and larger tributaries where it is known to actively hunt throughout the water column (Department of Agriculture, Water and the Environment, 2022a). It has been observed to have a strong association with substantial structural woody habitat close to the riverbank and in parts of the river with deeper slow-flowing water. Spawning activity of the Murray Cod is short and varies latitudinally, between regions and with seasonal climatic conditions. The typical spawning season occurs in spring-summer in response to rising water temperatures of 16.5 – 23.5°C. Upstream spawning migrations as far as 120 km have been observed before the fish return downstream to the same area they occupied before migration. Hard surfaces such as sunken trees or submerged rocks are required to lay their eggs. Predation on juveniles from introduced species such as the Redfin Perch has contributed partly to the Murray Cod’s decline, as well as competition for food and habitat resources, habitat alteration, overfishing, and sedimentation from altered water regimes (Department of Agriculture, Water and the Environment, 2022a). A national recovery plan for the Murray Cod has been prepared (National Murray Cod Recovery Team, 2010) and lists the following key actions as part of the plan:

- Determine the distribution, structure and dynamics of Murray Cod populations across the Murray-Darling Basin and devise appropriate Spatial Management Units and monitoring program.

- Identify and quantify the environmental parameters (eg flows and available food) that drive recruitment and population growth.

- Identify, protect and repair key aquatic and riparian habitats for Murray Cod in each Spatial Management Unit.

- Manage the recreational fishery for Murray Cod in a sustainable manner while recognising the social, economic and recreational value of the fishery.

- Encourage community awareness and support for Murray Cod management (including angling and conservation groups)

- Establish a long-term structure for the implementation of the national Murray Cod Recovery Plan.

Murray Cod have been identified in the upstream area of the Namoi Catchment (EnviroDNA, 2021a; EnviroDNA, 2021b; GHD, 2019) and an important population is located within the Namoi River (National Murray Cod Recovery Team, 2010). Stocking of the species has occurred within the Peel River and Chaffey Dam, with the most recent stocking program occurring in 2013 (Department of Primary Industries, 2022b; GHD, 2019). The Department of the Environment (Department of the Environment, 2016) published a figure of the natural distribution of the Murray Cod, indicating possible occurrence within the Namoi catchment due to records post-1980 (National Murray Cod Recovery Team, 2010). There is suitable habitat in the Peel River to support Murray Cod and they are likely to be present. Dungowan Creek is a smaller waterway and has less typical habitat but may still support Murray Cod.

iii Eel-tailed Catfish

The Eel-tailed Catfish is a benthic feeder, allowing it to forage in shallower water on aquatic insect larvae, small fish and molluscs (Fish Base, 2022a). Breeding in the Eel-tailed Catfish occurs irrespective of water temperature; however, between 20 and 24°C is preferable and the typical season for breeding is spring-summer. The species builds a nest within macrophytes for egg laying, hence its preference for slower moving waterways including lakes and ponds with fringing vegetation. As a result of these preferences, fluctuations in water volume/flow (affecting water level) as a result of river regulation may result in a retraction of permanent pools and effectively increase the distance between the waterbody and the overhanging vegetation. A decrease in water level may also lead to exposure of nests, causing that nest to be abandoned. Although breeding can occur at a range of temperatures, water release may still impact the species if release occurs during spring or early summer; however, water is need just prior to breeding to ensure sufficient depth for nest building. The Department of Primary Industries (2022d) have issued a “Priorities Action Statement” which lists a range of actions with regard to the recovery of the species. Key high priority actions include:

- Work with community groups, relevant natural resource management agencies, local councils, landholders etc. to identify, restore and protect known and potential Eel-Tailed Catfish habitats and address key threats such as habitat degradation and water quality decline from expanding development Recent population decline is attributed to competition for resources with exotic species, habitat degradation, cold water pollution and fishing pressure.

- 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.

- Actively seek funds through grant schemes or other sources to implement riparian vegetation and water quality improvement projects in priority areas.

- Undertake priority rehabilitation, restoration and enhancement work (eg rehabilitating riparian vegetation, cold water pollution reduction measures, reinstating large woody debris, removal of barriers to fish passage, removal of willows from riverbanks, sediment and erosion control measures) at key sites known to support Eel-Tailed Catfish populations.

- Undertake research to identify, prioritise and improve understanding of the threatening processes and causes of decline of Eel-Tailed Catfish.
- Conduct research on the biology and ecology of Eel-Tailed Catfish, particularly the species' ecological role, environmental tolerances, factors influencing population dynamics, age and growth, life cycle and diet.
- Implement the NSW Freshwater Fish Stocking Fishery Management Strategy to prevent significant impacts from stocking on Eel-Tailed Catfish populations.
- Conduct targeted surveys to determine the current distribution and abundance of Eel-Tailed Catfish.
- Collect data on the presence/absence of Eel-Tailed Catfish during incidental surveys.

It is considered that the species is now largely absent from the Murray River, Murrumbidgee River and Lachlan River, and associated catchments (Department of Primary Industries, 2015). However, publicly available literature indicate that the species is present within the Peel River, upstream and downstream of the confluence with Dungowan Creek (Figure 5.8) (NGH Environmental, 2012; EnviroDNA, 2021a). Therefore, it is known that the Eel-tailed Catfish occurs within the project area, likely within slower moving areas of water and fringing vegetation.

iv Silver Perch

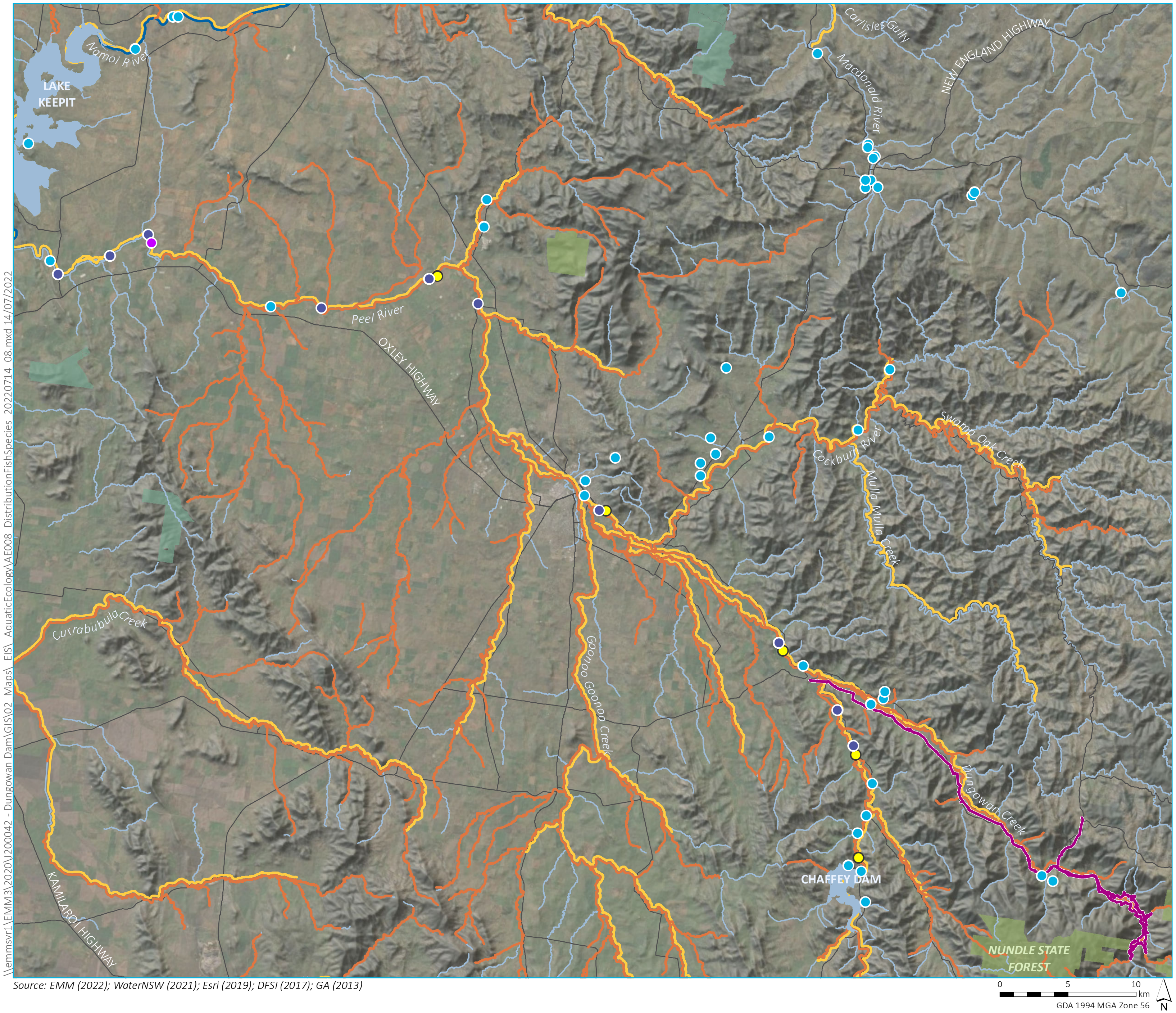
Within its natural range, Silver Perch are known to occupy cool clear water of the upper reaches and highlands, to the lower turbid slow flowing rivers of the west (Department of Primary Industries, 2006). It is thought that they prefer fast flowing conditions around rapids (Merrick & Schmida, 1984) as they have been observed congregating below rapids and weirs (Allen, Midgley, & Allen, 2002). However, this may be coincidental and may coincide with fish encountering a barrier as they attempt to migrate upstream, rather than a preference for flowing water. It is also suggested that they prefer open water rather than areas of snags and debris (Cadwallader & Backhouse, 1983) demonstrated by visual observation within impoundments; however, DPI Fisheries data indicates that most individuals are caught near snagged habitat. There is limited information available on their habitat requirements and preferences for particular habitat components. Hatchery-bred Silver Perch are stocked out of their range in several dams on east coast river systems; however, reproduction does not appear to occur. One self-sustaining population of Silver Perch occurs in Cataract Dam in the Hawkesbury Nepean catchment. Silver Perch are an omnivorous species, with a diet including insects, small crustaceans and vegetation. Changes in conditions, usually a rise in water levels from rainfall and water temperatures above 23°C, cause Silver Perch to spawn. The typical season for spawning is spring or summer with spawning occurring late afternoon, dusk or shortly after nightfall (Department of Agriculture, Water and the Environment, 2022c). Interaction with exotic fish is likely to be a threat to the species, as well as river regulation and thermal pollution (Lintermans, 2017). A New South Wales Recovery Plan for Silver Perch has been prepared (Department of Primary Industries, 2006). The recovery plan lists the following key actions towards recovery for Silver Perch in New South Wales:

- Habitat protection and restoration.
- Active management by Fisheries officers.
- Formal surveys will be implemented to monitor the species across the Murray-Darling Basin.
- Community education.

Silver Perch have been recorded in the Peel River (EnviroDNA, 2021a), and was last stocked in Chaffey Dam in 2010 (Department of Primary Industries, 2022b), although the individuals are unlikely to represent a self-sustaining population.

v Platypus

Platypus inhabit a variety of freshwater streams throughout eastern Australia (Grant T. R., Historical and current distribution of the platypus, Ornithorhynchus anatinus, In Australia, 1992; Australian Museum, 2022). Platypus were recently listed as Near Threatened by the International Union for the Conservation of Nature (IUCN) (Woinarski & Burbidge, 2016; Woinarski, Burbidge, & Harrison, 2014) and Vulnerable in Victoria. As an apex predator in Australian aquatic ecosystems, platypuses are vulnerable to a number of threatening processes, which 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, Conservation of the Platypus, Ornithorhynchus anatinus: Threats and challenges, 2003; Grant & Temple-Smith, Field biology of the platypus (Ornithorynchus anatinus): Historical and current perspectives, 1998). Platypuses are highly mobile with individual home ranges and daily movements encompassing several kilometres (Gust & Handasyde, 1995; Griffiths, Kelly, & Weeks, 2014; Kelly, Griffiths, & Weeks, 2012; Serena, Thomas, & Williams, Status and habitat relationships of Platypus in the Dandenong Creek Catchment: II. Results of surveys and radio-tracking studies, September 1997 - March 1998, 1998; Otley, Munks, & Hindell, 2000) with densities roughly estimated at 1-2/km in a small creek around Melbourne (Serena, Use of time and space by Platypus (Ornithorhynchus anatinus: Monotremata) along a Victorian stream, 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 with adults consuming approximately 15-30 percent of their bodyweight daily (Krueger, Hunter, & Serena, 1992; Holland & Jackson, 2002). Other habitat variables known to be important for platypuses include large riparian trees, overhanging vegetation, pools 1-3m deep, and near vertical or undercut banks at least 0.5 m above the water (Serena, Use of time and space by Platypus (Ornithorhynchus anatinus: Monotremata) along a Victorian stream, 1998; Ellam, Bryant, & O'Connor, 1998; Bethge, Munks, Otley, & Nicol, 2003; Grant T. , 2004; Serena, Worley, Swinnerton, & Williams, 2001; Worley & Serena, 2000). Reproduction in Platypus has been linked with rainfall (and presumably reliable flows) in the months preceding breeding (August – December) (Serena, Williams, Weeks, & Griffiths, 2014; Grant & Temple-Smith, Field biology of the platypus (Ornithorynchus anatinus): Historical and current perspectives, 1998). Whilst various individual local Councils across Australia have prepared recovery plans for platypus, no formal, overarching recovery plan has been prepared at the state or federal level for platypus.



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Source: EMM (2022); WaterNSW (2021); Esri (2019); DFSI (2017); GA (2013)

KEY
- ▭ Project footprint
- — Major road
- — Named watercourse
- ▨ Named waterbody
- ▨ NPWS reserve
- ▨ State forest

Known threatened species
- ● Eel-tailed Catfish
- ● Silver Perch
- ● Murray Cod
- ● Platypus

Potential distribution of threatened species
- — Eel-tailed Catfish
- — Silver Perch
- — Southern Purple Spotted Gudgeon

Potential distribution of the Southern Purple-spotted Gudgeon, Murray Cod, Murray-Darling Basin population of Eel-tailed Catfish, Silver Perch and Platypus

Dungowan Dam and pipeline project
Aquatic ecology assessment
Figure 5.8

EMM
creating opportunities

5.10 Groundwater-dependent ecosystems

5.10.1 Waterway baseflow ecosystems

The *Groundwater Dependent Ecosystems Atlas* (Bureau of Meteorology, 2022b) indicates that three waterways in the vicinity of the project are considered to be groundwater-dependent to varying degrees; The Peel River, Goonoo Goonoo Creek and the Namoi River.

The upper Peel River is considered to range from having a moderate to high potential to support GDE (Figure 5.9) (Bureau of Meteorology, 2022b), likely receiving baseflow from alluvial groundwater systems which enable the river to be permanently inundated if surface flow ceases. Small pockets of alluvium are connected with permanent waterways and usually provide small baseflow contributions after heavy rain. This means that parts of the waterway should contain areas of permanent surface water at most times of the year, potentially providing areas of aquatic fauna refuge. However, the operation of bores for agricultural extraction has the potential to draw down local groundwater aquifers and result in drying of permanent biota refuge pools, in conjunction with increased land development, drought, river regulation, and climate change (Bestland, et al., 2017). Downstream of the new Dungowan Dam, the lower Peel River, Goonoo Goonoo Creek and the Namoi River are considered to receive baseflow (ranging from low to high potential to support GDE) (Bureau of Meteorology, 2022b) and are also likely to contain permanent water, potentially reduced to pools during dry conditions.

Relative to the project, these waterways are important in terms of sustaining semi-permanent to permanent aquatic ecological communities, as well as ecosystems downstream of the project. The identified waterways are considered to be gaining waterways, which would be permanently inundated, except during extreme drought conditions. The groundwater system (alluvial aquifer) is likely to contribute baseflow to the Peel River, Goonoo Goonoo Creek and Namoi River.

5.10.2 Subterranean fauna ecosystems

Stygofauna inhabiting alluvial and fractured rock aquifers are considered to be obligate GDEs. It is suggested that stygofauna aid in maintaining groundwater quality by regulating the concentration of organic matter (food source) and maintaining interstitial space between soil particles to encourage groundwater flow (Tomlinson, Boulton, Hancock, & Cook, 2007; Serov & Kuginis, 2017). Subterranean fauna communities, and individual species, are not yet listed as requiring protection under Commonwealth or NSW legislation; however, GDEs require protection under the WM Act and associate policies. Therefore, investigation into their presence or absence within the project is required, and potential direct and indirect impacts to communities, if present, needs to be quantified.

Based on the literature review, it is possible that stygofauna may occur within, or adjacent to, the project, with at least 10 assessments undertaken to within 200 km of the site have recorded stygofauna with similar geologies (eg alluvial, fractured rock) (Annexure B). With particular regard to the Namoi catchment, at least 14 taxa have been recorded from within the catchment, including subterranean representatives from the orders Ostracoda, Copepoda, Syncarida, Malacostraca, Oligochaeta and Acarina (Korbel, Lim, & Hose, 2013).

The geology of the project comprises a mix of sandstone, schist, chert and occasionally limestone. The Namoi alluvium consists of undifferentiated alluvial plain (sand, silt, clay, gravel of alluvial/fluvial deposits, colluvium), which occurs directly downstream and beneath the dam wall. It is possible that these geologies may support subterranean fauna where they intersect groundwater aquifers.

5.11 Existing threats

In 2020 the NSW Department of Primary Industries (2020a) prepared a report on aquatic ecological values for the Peel River between Chaffey Dam and Tamworth. No habitat mapping has previously been undertaken for Dungowan Creek. This report highlights a number of threats to the Peel River. Details are provided below.

5.11.1 Fish passage

Barriers to fish passage currently exist in the Peel River between Chaffey Dam and Tamworth. NSW Department of Primary Industries (2020a) reports five manmade barriers and one willow choke barrier existed at the time of the assessment. A number of manmade barriers are to be removed as part of the offsets pathway utilised to offset the barrier to fish passage created by the new Dungowan Dam, creating further connectivity within the Peel River. These are detailed in Section 11.1.

5.11.2 Exotic species

The NSW Department of Primary Industries (2020a) report highlights 25 exotic flora species that are present between Chaffey Dam and Tamworth. A number of exotic flora species listed within the report fall under the *Biosecurity Act 2015* and are Weeds of National Significance (WoNS) (Department of Primary Industries, 2020a).

5.11.3 Erosion

Erosion was reported as covering a total of 0.09 ha across 17 sites between Chaffey Dam and Tamworth. Erosion in waterways increases siltation, increases turbidity and increases eutrophication (Department of Primary Industries, 2013a). Additional impacts are: loss of fish habitat, increased turbidity resulting in a loss of submerged aquatic macrophytes and increased risk of algal blooms (Reid, Thoms, Chilcott, & Fitzsimmons, 2016).

5.11.4 Stock access

The NSW Department of Primary Industries (2020a) report states that there was "very little stock damage occurring", at the time of the assessment and that only 13 of 56 Management Reaches contained stock damage. It is reported that a total of 0.2 ha of stock damage was recorded between Chaffey Dam and Tamworth at the time of the assessment. Riparian fencing is prevalent along the Peel River, likely as a result of property boundary fencing (Department of Primary Industries, 2020a). Stock access can lead to erosion, which in turn leads to sedimentation and a decrease in water quality and eutrophication of waterways. Livestock manure also impacts downstream water quality and can impact the health of others using the waterway (Department of Primary Industries, 2020a).

5.11.5 Cold water pollution

Lugg and Copeland (2014) predict that during spring and summer cold water pollution persists for approximately 54 kilometres downstream of Chaffey Dam. Chaffey Dam is fitted with a multi-level offtake (MLO), however the use of the MLO is constrained by the occurrence of toxic algae blooms in the surface water of Chaffey Dam (Sherman, et al., 2001). If algal blooms exceed water quality guidelines, dam operators are required to comply with the Regional Algal Contingency Plans and draw water from 10 metres below supply level in order to minimise algae seeding downstream (Ingleton, et al., 2008; Department of Primary Industries, 2020a; Department of Primary Industries, 2020b).

Source: EMM (2022); WaterNSW (2021); Esri (2019); BoM (2019); DFSI (2017); GA (2013)

KEY

- ▭ Project footprint
- 🟨 Potential Groundwater Dependant Ecosystems

Existing environment

- ═ Major road
- — Minor road
- — Named watercourse
- 🟦 Named waterbody
- 🟩 State forest

Potential Groundwater Dependant Ecosystems in the vicinity of the project

Dungowan Dam and pipeline project
Aquatic ecology assessment
Figure 5.9

creating opportunities

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6 Field survey results

Provided below are the findings from the field surveys conducted on the Peel River, Dungowan Creek and Terrible Billy Creek, Jones Oaky Creek, Johnston Oaky Creek, Big Oaky Creek, Oaky Creeks within the new Dungowan Dam footprint. Field surveys were completed over two separate field seasons with the initial field survey completed in August 2020 and the second and final field survey completed in February-March 2022.

6.1 Key fish habitat and habitat characterisation

General habitat characteristics are summarised in Table 6.2 and the results of the key fish habitat assessments undertaken at 26 sites during the August 2020 field survey are summarised below and in Table 6.1:

- one 4th order and three 6th order waterways were classified as Type 1 highly sensitive key fish habitat and Class 1 major key fish habitat;
- two 4th order and one 5th order waterways were classified as Type 1 highly sensitive key fish habitat and Class 3 minimal key fish habitat;
- one 4th order waterway was classified as Type 1 highly sensitive key fish habitat and Class 4 unlikely key fish habitat;
- one 4th order waterway was classified as Type 2 moderately sensitive key fish habitat and Class 2 moderate key fish habitat; and
- 12 3rd order waterways were classified as Type 3 minimally sensitive key fish habitat and Class 4 unlikely key fish habitat.

Additional sites were surveyed in February/March of 2022. General habitat characteristics were assessed for the additional sites and are summarised below and in Table 6.1:

- twenty four 6th order waterways were classified as Type 1 highly sensitive key fish habitat and Class 1 major key fish habitat;
- one 6th order waterway was classified as Type 2 moderately sensitive key fish habitat and Class 1 major key fish habitat; and
- two 4th order were classified as Type 3 minimally sensitive key fish habitat and Class 4 unlikely key fish habitat.

The Type 1 highly sensitive key fish habitat waterways assessed in August 2020 included Dungowan Creek, Terrible Billy Creek, Jones Oaky Creek, Johnston Oaky Creek, Big Oaky Creek, Oaky Creek and the Peel River. Dungowan Creek intersects with both the new FSL as well as the new pipeline alignment and may also be subject to indirect impacts as a result of construction and operation of the new Dungowan Dam. Terrible Billy Creek and Jones Oaky Creek will be inundated, at least in part, by the FSL. Johnston Oaky Creek, Big Oaky Creek, Oaky Creek and the Peel River intersect, or are located adjacent to, the new pipeline alignment and may be subject to indirect construction impacts.

A combination of the presence of either in-stream snags or gravel beds, and mapping provided by the DPI Fisheries indicating that the waterway may supports threatened aquatic species (Southern Purple -spotted Gudgeon, Eel-tailed Catfish) led to Dungowan Creek being assigned the Type 1 highly sensitive key fish habitat and Class 1 major key fish habitat classifications. Dungowan Creek was characterised by riffle sequences with cobble and gravel bed and sections of intact riparian vegetation providing refuge and breeding habitat. Not all sites had large woody debris and snags present; however, it was evident that recent high flow had passed through the system, with scouring and erosion present at most sites, likely clearing debris from the waterway.

Terrible Billy Creek was classified as Type 1 highly sensitive key fish habitat due to presence of gravel beds, large woody debris, in-stream aquatic vegetation and riparian vegetation. DPI Fisheries mapping indicates that the waterway may support threatened aquatic species (Southern Purple -spotted Gudgeon). A large concrete structure across the river, downstream of the survey site, created a drop off approximately 0.5 m in height (Photograph 6.1). This would likely be a fish barrier preventing upstream fish passage, particularly for smaller fish species and during drier conditions.

Jones Oaky Creek was classified as Type 1 highly sensitive key fish habitat and Class 3 minimal key fish habitat due to cobble and gravel beds present in the waterway, as well as riparian and in-stream vegetation and large woody debris. While the waterway contained intermittently flowing water and defined banks (outlined by the Class 2 definition), it is unlikely the small shallow pools remain inundated during long periods without rainfall. In addition, there was only sporadic refuge, breeding or feeding areas comprising gravel beds, riparian and in-stream aquatic vegetation present during times of inundation. Although potential habitat features are present during times of inundation, small natural rock bars may present barriers to smaller fish species traversing upstream.

Johnston Oaky Creek was classified as Type 1 highly sensitive key fish habitat due to the presence of gravel and cobbles in the riverbed. Whilst the waterway’s intermittently flowing stream and defined banks matched the description given for Class 2 moderate key fish habitat, no freshwater aquatic vegetation was observed at the time of surveys, and it is likely the waterway remains inundated for short times following rain events. The waterway was classified as Class 3 minimal key fish habitat due to the sporadic refuge, breeding or feeding areas comprising gravel beds, and limited areas of riparian vegetation present during times of inundation. Although potential habitat features are present during times of inundation, a complete barrier exists upstream of the creek’s confluence with Dungowan Creek, making it unlikely for fish species to traverse further upstream.

Big Oaky Creek was classified as Type 1 highly sensitive key fish habitat due to the presence of gravel beds in areas of the waterway. The lack of aquatic vegetation, and the intermittent nature of water in small semi-permanent pools, likely only occurring after rainfall, resulted in a Class 3 classification of the waterway.

Oaky Creek was classified as Type 1 highly sensitive key fish habitat due to presence of gravel beds downstream of a causeway. It is likely this waterway only experiences brief intermittent flow following rain events, with no free-standing water or pools evident despite a significant recent rainfall event, leading to its Class 4 classification. A concrete block which forms part of the causeway is a fish barrier preventing upstream fish passage.

The Peel River, classified as Type 1 highly sensitive key fish habitat or Type 2 moderately sensitive key fish habitat (site dependant) and Class 1 major key fish habitat, was typically characterised by run and pool sequences over cobble and gravel beds with large woody debris, in-stream aquatic vegetation and riparian vegetation which provide breeding and refuge habitat. Some sites were void of instream woody debris and supported little to no riparian vegetation leading to those sites (PR02) being classified as Type 2 moderately sensitive key fish habitat. It is likely that the river remains permanently flowing or flooded and DPI Fisheries mapping indicates that the waterway may support threatened aquatic species (Southern Purple -spotted Gudgeon, Murray Cod, Eel-tailed Catfish and platypus).

The Type 3 minimally sensitive key fish habitat waterways included Paradise Creek, Hell Hole Gully and 11 unnamed waterways. Paradise Creek will be inundated, at least in part, by the FSL. Hell Hole Gully is located adjacent to the new pipeline alignment and will be crossed by a road, resulting in potential direct and indirect construction impacts. Two of the 11 unnamed waterways will be inundated, at least in part, by the FSL, while the remaining unnamed waterways intersect, or are located adjacent to, the new pipeline alignment and may be subject to indirect construction impacts.

Paradise Creek – Clear, flowing water to approximately 0.06 m deep. Riparian vegetation is intact, with heavy erosion and scouring evident on the bank edges and incised riverbed, leaving exposed roots and bed material washed away to uncover a harder rock subsurface layer. Banks and sediment are comprised of clay, gravel, pebbles, cobble and bedrock. Riparian vegetation provides spawning and refuge habitat.

Hell Hole Gully and all 11 unnamed waterways were classified as Class 4 unlikely key fish habitat. This was a result of the waterways not containing any of the required aquatic habitat features (Table 4.6) and likely only containing surface water following rainfall events. None of the sites contained water at the time of survey despite recent substantial rainfall. In addition, there was little to no defined bed or bank structure and no evidence of native aquatic vegetation observed within the unnamed waterways, with the exception of site UN07 which contained small, shallow pools. Waterway structure at site UN07 was largely undefined and was situated between two farm dams immediately upstream and downstream of the site. It was deduced that surface water at the site is likely to be ephemeral, as submerged pasture grasses were present within the shallow pools. No riparian or aquatic vegetation was present. A pipe culvert downstream within Hell Hole Gully presents a complete barrier to fish passage.

Table 6.1 Summary of stream order, waterway type and waterway class at each aquatic ecology site assessed during the field surveys

Project component	Waterway	Site	Strahler (1952) order	Key Fish Habitat: Waterway Type	Key Fish Habitat: Waterway Class
Proposed Dam	Jones Oaky Creek	JC01	4th	Type 1	Class 3
Proposed Dam	Paradise Creek	PC01	4th	Type 2	Class 2
Proposed Dam	Terrible Billy Creek	TBC01	4th	Type 1	Class 1
Proposed Dam	Unnamed waterway	UN01	3rd	Type 3	Class 4
Proposed Dam	Unnamed waterway	UN02	3rd	Type 3	Class 4
Proposed Dam	Dungowan Creek	DC01	6th	Type 1	Class 1
Proposed Dam	Dungowan Creek	DC02	6th	Type 1	Class 1
Proposed Dam	Dungowan Creek	DC03	6th	Type 1	Class 1
Proposed Dam	Dungowan Creek	DC04	6th	Type 1	Class 1
Proposed Dam	Dungowan Creek	DC05	6th	Type 1	Class 1
Proposed Pipeline	Big Oaky Creek	BOC01	4th	Type 1	Class 3
Proposed Pipeline	Dungowan Creek	DC06	6th	Type 1	Class 1
Proposed Pipeline	Dungowan Creek	DC07	6th	Type 1	Class 1
Proposed Pipeline	Dungowan Creek	DC08	6th	Type 1	Class 1
Proposed Pipeline	Dungowan Creek	DC09	6th	Type 1	Class 1
Proposed Pipeline	Dungowan Creek	DC10	6th	Type 1	Class 1
Proposed Pipeline	Dungowan Creek	DC11	6th	Type 1	Class 1
Proposed Pipeline	Dungowan Creek	DC12	6th	Type 1	Class 1
Proposed Pipeline	Dungowan Creek	DC13	6th	Type 1	Class 1
Proposed Pipeline	Dungowan Creek	DC14	6th	Type 1	Class 1

Table 6.1 Summary of stream order, waterway type and waterway class at each aquatic ecology site assessed during the field surveys

Project component	Waterway	Site	Strahler (1952) order	Key Fish Habitat: Waterway Type	Key Fish Habitat: Waterway Class
Proposed Pipeline	Dungowan Creek	DC15	6th	Type 1	Class 1
Proposed Pipeline	Dungowan Creek	DC16	6th	Type 1	Class 1
Proposed Pipeline	Peel River	PR02	6th	Type 1	Class 1
Proposed Pipeline	Peel River	PR03	6th	Type 2	Class 1
Proposed Pipeline	Hell Hole Gully	HHG01	3rd	Type 3	Class 4
Proposed Pipeline	Johnston Oaky Creek	JOC01	5th	Type 1	Class 3
Proposed Pipeline	Oaky Creek	OC01	4th	Type 1	Class 4
Proposed Pipeline	Oaky Creek	OC02	4th	Type 3	Class 4
Proposed Pipeline	Unnamed waterway	UN03	3rd	Type 3	Class 4
Proposed Pipeline	Unnamed waterway	UN04	3rd	Type 3	Class 4
Proposed Pipeline	Unnamed waterway	UN05	3rd	Type 3	Class 4
Proposed Pipeline	Unnamed waterway	UN06	3rd	Type 3	Class 4
Proposed Pipeline	Unnamed waterway	UN07	3rd	Type 3	Class 4
Proposed Pipeline	Unnamed waterway	UN08	3rd	Type 3	Class 4
Proposed Pipeline	Unnamed waterway	UN10	3rd	Type 3	Class 4
Proposed Pipeline	Unnamed waterway	UN11	3rd	Type 3	Class 4
Proposed Pipeline	Unnamed waterway	UN12	3rd	Type 3	Class 4
Proposed Pipeline	Unknown Creek (dry)	UN13	4th	Type 3	Class 4
Proposed Dam	Peel River	PR01	6th	Type 1	Class 1
Chaffey Dam	Peel River	PHF01	6th	Type 1	Class 1
Chaffey Dam	Peel River	PHF04	6th	Type 1	Class 1
Chaffey Dam	Peel River	PHF06	6th	Type 1	Class 1
Chaffey Dam	Peel River	PHF08	6th	Type 1	Class 1
Chaffey Dam	Peel River	PHF09	6th	Type 1	Class 1
Chaffey Dam	Peel River	PHF11	6th	Type 1	Class 1
Chaffey Dam	Peel River	PHF12	6th	Type 1	Class 1
Chaffey Dam	Peel River	PHF13	6th	Type 1	Class 1
Chaffey Dam	Peel River	PHF14	6th	Type 1	Class 1
Chaffey Dam	Peel River	PHF15	6th	Type 1	Class 1
Chaffey Dam	Peel River	PHF17	6th	Type 1	Class 1

Table 6.1 Summary of stream order, waterway type and waterway class at each aquatic ecology site assessed during the field surveys

Project component	Waterway	Site	Strahler (1952) order	Key Fish Habitat: Waterway Type	Key Fish Habitat: Waterway Class
Chaffey Dam	Peel River	PHF19	6th	Type 1	Class 1
Chaffey Dam	Peel River	PHF22A	6th	Type 1	Class 1
Chaffey Dam	Peel River	PHF22B	6th	Type 1	Class 1

Table 6.2 Habitat characteristics at each aquatic ecology site assessed during the field surveys

Project component	Waterway	Site	Description
Proposed Dam	Jones Oaky Creek	JC01	Clear, flowing water with long riffle sequences and shallow, small pools to approximately 0.07 m deep. Riparian zone is largely cleared with remnant trees and Lomandra along the bank edge in some areas. Banks consist of clay, cobbles, boulders and gravel, which is also present on the riverbed. There is evidence of feral pig impacts along areas of bank. A section of green filamentous algae is present downstream of the site. The creek appears to experience periods of large volumes of water flow, evident by an incised channel and eroded banks, as well as an overflow of bed material onto adjacent levee banks. Gravel beds, riparian and in-stream vegetation and large woody debris provide potential refuge and breeding habitat. Natural rock bars may present a fish passage barrier for smaller fish species.
Proposed Dam	Paradise Creek	PC01	Clear, flowing water to approximately 0.06 m deep. Riparian vegetation is intact, with heavy erosion and scouring evident on the bank edges and incised riverbed, leaving exposed roots and bed material washed away to uncover a harder rock subsurface layer. Banks and sediment are comprised of clay, gravel, pebbles, cobble and bedrock. Riparian vegetation provides spawning and refuge habitat.
Proposed Dam	Terrible Billy Creek	TBC01	Clear, flowing water to approximately 0.1 m deep with riffle sequences. Banks are comprised of clay, cobbles, boulders and contain sections of bedrock. Riparian zone is intact in sections and partially cleared in others from historic grazing. Gravel beds, large woody debris, in-stream aquatic vegetation and riparian vegetation provide important habitat for refuge and breeding. A concrete causeway-like structure immediately downstream of the site presents a complete fish barrier (Photograph 6.1).
Proposed Dam	Unnamed waterway	UN01	No surface water was present in the waterway at the time of survey. The waterway appears to be a shallow swale, potentially holding draining water for brief periods of time after rainfall. Riparian zone is cleared, with pasture grasses dominating the groundcover, most likely from historic grazing. No spawning or refuge habitats were observed.
Proposed Dam	Unnamed waterway	UN02	No surface water was present in the waterway at the time of survey, and no water holding capacity was observed. The waterway traverses a steeper gradient at this site. Riparian vegetation largely cleared with pasture grasses and weeds dominating the groundcover. Banks consist of clay and gravel with some cobbles in an incised channel. Erosion and collapsed banks are evident, appearing to be the result of larger volumes of water following rain. Surrounding land use historic grazing.

Table 6.2 **Habitat characteristics at each aquatic ecology site assessed during the field surveys**

Project component	Waterway	Site	Description
Proposed Dam	Dungowan Creek	DC01	Flowing, turbid water with riffle sequences to approximately 0.2 m deep. Riparian zone is mostly cleared, with remnant trees along the bank edges with trailing vegetation in sections. A river crossing is located at the site, with erosion and collapsed banks adjacent to the vehicle tracks. The crossing does not present a barrier to fish passage. Sedimentation is present in one section on a meander bend, which has formed an anoxic layer on the bed in that area. Banks are comprised of clay, with sections of gravel and cobbles in the bed as well as banks. Gravel and beds and riparian vegetation would provide important breeding and refuge habitat along the waterway.
Proposed Dam	Dungowan Creek	DC02	Flowing, turbid water with a deeper, fast flowing centre and riffle sections approximately 0.2 m deep towards the banks. Riparian zone is intact along the banks and cleared beyond in sections from historic grazing and a dam access road. Trailing vegetation is present in areas. Banks are comprised of clay, cobbles, boulders and gravel, which are also present in the riverbed. Some erosion is evident on banks. Gravel beds, riparian vegetation and large woody debris provide important refuge and breeding habitat.
Proposed Dam	Dungowan Creek	DC03	Flowing, turbid water approximately 0.3 m deep with riffle sequences and rock bars. Riparian zone is intact along the banks and cleared beyond in sections from grazing Trailing vegetation is present in areas. Banks are comprised of clay, cobbles boulders, rock bars and gravel, which are also present in the riverbed. Some erosion is evident on banks, and the waterway appears to experience heavy flow at times, evident by scouring of bed material in sections. A long-necked turtle and wombat burrow were observed at the site. Disturbance by feral pigs on banks present. Gravel beds, riparian vegetation, rock bars and large woody debris provide important refuge and breeding habitat.
Proposed Dam	Dungowan Creek	DC04	Flowing, slightly turbid water approximately 0.5 m deep with sections of riffle. Riparian zone is largely cleared with some remnant trees lining the banks with little cover or trailing vegetation present. Banks are comprised of clay and cobbles, with one side containing bedrock. Clay, sand, gravel, cobble, boulders and rock bars are present in the riverbed. Erosion is evident on banks and stock are able to access and cross the waterway. Gravel beds, riparian vegetation and large woody debris provide important refuge and breeding habitat.
Proposed Dam	Dungowan Creek	DC05	Flowing, turbid water to approximately 0.5 m deep. Riparian zone is mostly cleared for pastoralism, with stands of remnant trees lining the banks, providing some shade and overhanging vegetation in some areas. Some erosion is present on the banks, mostly adjacent to a bridge road crossing. The bridge does not present a fish barrier. Banks are comprised of clay, gravel, pebble and cobble. Gravel beds, riparian vegetation and large woody debris provide important refuge and breeding habitat.

Table 6.2 Habitat characteristics at each aquatic ecology site assessed during the field surveys

Project component	Waterway	Site	Description
Proposed Pipeline	Big Oaky Creek	BOC01	Flowing, clear, shallow water to approximately 0.15 m deep. Riparian zone largely cleared with some remnant trees close to the bank edges. Banks are eroded in areas, and are comprised mainly of clay, gravel and cobble with bedrock immediately upstream of a bridge crossing. Some concrete slab structures are present on the riverbed under the bridge, which may provide a partial barrier to fish passage during very low flow. The creek appears to have experienced recent heavy flow; however, scouring is minimised potentially due to the flow arresting nature of the bridge and concrete blocks. Gravel beds may provide spawning and habitat for fish if able to access this part of the creek.
Proposed Pipeline	Dungowan Creek	DC06	A comparatively wide section of creek, with flowing, slightly turbid water approximately 0.17 m deep and characterised by riffle/run sequences. Riparian zone is mostly cleared, beyond a narrow corridor adjacent to the waterway, from historic for grazing, with remnant trees lining the bank. Limited trailing vegetation is present in areas. Banks are comprised of mostly consolidated sand and clay, with some gravel sections present in the waterway. Some erosion and sedimentation is evident on banks which have been impacted by feral pigs in places. No in-stream woody debris present; however, riparian vegetation may provide important refuge and breeding habitat.
Proposed Pipeline	Dungowan Creek	DC07	Flowing, turbid water approximately 0.15 m deep with riffle sequences and rock bars. Riparian zone is mostly cleared, beyond a narrow corridor adjacent to the waterway, from historic grazing, with remnant trees and a shrub layer lining the bank. Limited trailing vegetation and fallen timber is present in-stream and on bank edges. Banks are comprised of clay, bedrock and cobbles, which are also present in the riverbed. Some erosion is evident on banks. Riparian vegetation may provide important refuge and breeding habitat.
Proposed Pipeline	Dungowan Creek	DC08	The waterway is approximately 10-15 m wide and consists of a run with pools and riffles absent. Substrate was consistent throughout the observed stretch and was made up of cobble, pebble and sand. Riparian quality was moderate with the site supporting both an under- and overstorey. The overstorey was dominated by Casuarina species and Eucalyptus species. The understorey consisted primarily of weedy species. Ground cover was predominantly weedy and was dominated by pasture gasses. The site supported evidence of previous high flows.
Proposed Pipeline	Dungowan Creek	DC09	The waterway is approximately 5-10 m wide and is comprised of runs, riffles and pools. Pools range in depth from 1-3m deep. Banks were undercut with the gently sloping banks with at 1:0.5 (horizontal : vertical) grade. There was evidence of recent higher flows and erosion to banks. Coarse particulate organic matter (CPOM) was present across the site as were large snags and boulders. Substrate consisted was dominated by gravel and cobble with some sand. A large rock formation and boulders at a pool formed a backwater.

Table 6.2 Habitat characteristics at each aquatic ecology site assessed during the field surveys

Project component	Waterway	Site	Description
Proposed Pipeline	Dungowan Creek	DC10	The waterway at this site is approximately 10m in width and supports both runs and riffles. Some instream snags were observed. Substrate consisted of a mixture of cobble, pebble and sand. Banks varied from vertical to low gradian banks across the site. Riparian vegetation was patchy with little to no understorey present. Overstorey was dominated by Casuarina species. Grass cover was 100 percent and was dominated by pasture grasses.
Proposed Pipeline	Dungowan Creek	DC11	The waterway is approximately 15 m wide and supports both run and riffle habitat. Water depth was shallow however evidence of previous high flows is present. A fallen tree provides instream habitat as do a number of instream snags. Banks are low and undercut in sections. Erosion is evident. Substrate appears uniform throughout the site and consists of cobble, pebble and sand. The riparian zone is of low quality and consists of scattered Casuarina species. The understorey is absent and groundcover is dominated by weedy pasture grasses.
Proposed Pipeline	Dungowan Creek	DC12	The waterway is a sequence of runs, pools and riffles with stream shading up to 70 percent. The stream is 10-15 m wide with steep banks approximately 2 m deep. The substrate consists of gravel and sand with some rock present. Some large snags are present within the stream. Some evidence of intermittent high flows such as erosion to the banks. Stock have open access to the right bank. Banks are undercut, consist of clay/silt and are considered suitable for Platypus. CPOM is present and would typically be higher however recent high flows have washed the majority of CPOM downstream. The stream bed is dominated by gravel and sand with some cobble and boulder. The riparian zone is dominated by Casuarina and Eucalyptus species. An understorey is present and is dominated by Privet species. Ground cover consists of Kikuyu (*Pennisetum clandestinum*) and Wandering Trad (*Tradescantia fluminensis*).
Proposed Pipeline	Dungowan Creek	DC13	Stream width ranges from 5-10 m in width and supports both run and riffle habitat. Substrate consists of Boulder, cobble, pebble and sand. Banks range from steep and tall with considerable erosion to flat with some grass. Stock have access to the right bank. Riparian quality is low with much of the riparian zone removed. Remaining scattered overstorey consists of Casuarina species and Willow species. The understorey is mostly absent and grass cover is dominated by weedy pasture grasses.
Proposed Pipeline	Dungowan Creek	DC14	The stream consists of pools up to 1.5m deep with a cobble/pebble/sand substrate. The stream supports run and pool habitat with some short riffles. Stream shading is 39 percent. Some snags present. Stock have unrestricted access to the waterway. Riparian zone is patchy and dominated by exotics including Willow species. Understorey/ shrub layer absent from riparian zone. Banks are primarily silt and clay with some banks being undercut.
Proposed Pipeline	Dungowan Creek	DC15	The stream substrate consisted of gravel/cobble/sand with some instream snags present. Whilst supporting a sparse under- and overstorey, riparian quality was poor. Riparian species consisted of Casuarina Species and Willow species in addition to some conifer species.

Table 6.2 Habitat characteristics at each aquatic ecology site assessed during the field surveys

Project component	Waterway	Site	Description
Proposed Pipeline	Dungowan Creek	DC16	The waterway was approximately 5m in width and consisted of run and riffle habitat. Substrate consisted of sand, pebble, cobble and boulder which was consistent throughout. Banks were shallow and rocky in large areas. Areas not covered in rock supported both native and weedy vegetation. Banks were undercut in areas. The riparian zone was narrow but intact along the waterway and dominated by Casuarina species. The understorey was largely absent with groundcover consisting of weedy pasture grasses.
Proposed Pipeline	Peel River	PR02	The waterway was approximately 10m wide with both banks supporting agricultural use. The waterway consisted of run habitat only with riffles and pools absent. Substrate consisted of sand, pebble, cobble and boulder and was consistent throughout. The riparian zone quality was poor with the overstorey consisting of sparse patches of Eucalyptus species and Willow species. The understorey was absent with the groundcover consisting of weedy pasture grasses.
Proposed Pipeline	Peel River	PR03	Th waterway was 5-10m wide with small, grass covered banks with an incline of approximately 1:0.4. The waterway consisted of riffles and supported large snags throughout. Substrate consisted of gravel and silt. Riparian overstorey dominated by Casuarina species. Eucalyptus species and Willow Species. The understorey layer was sparse. Grass cover was 100 percent and consisted of pasture grasses.
Proposed Pipeline	Oaky Creek	OC02	Oaky Creek was dry at the time of the site visit.
Proposed Pipeline	Unknown waterway	UN13	The unknown waterway was dry at the time of the site visit.
Proposed Pipeline	Hell Hole Gully	HHG01	No surface water was present in the waterway at the time of survey. The gully most likely holds water briefly, only during rain events. A pipe culvert standing approximately 0.75 m above the gully bed on the downstream side presents a complete fish passage barrier. Riparian vegetation is largely cleared, with remnant trees and exotic weeds.
Proposed Pipeline	Johnston Oaky Creek	JOC01	Clear, flowing water to approximately 0.09 m deep. Riparian zone is largely cleared, dominated by pasture grasses with few remnant trees. Banks show signs of erosion and are comprised of mostly clay and cobble, with gravel in the riverbed. The creek appears to experience heavy flow, with scouring evident along the creek. A pipe culvert immediately upstream of the site is likely to provide a complete barrier to fish passage during low flow where water levels are not high enough to run through the culvert, and high flow, where flow velocity is likely to exceed fish swim ability.

Table 6.2 Habitat characteristics at each aquatic ecology site assessed during the field surveys

Project component	Waterway	Site	Description
Proposed Pipeline	Oaky Creek	OC01	No surface water was present at the time of surveys. It is likely the creek only holds water briefly, during rain events. Banks are defined, though eroded, and are comprised of clay with gravel and cobbles present on the downstream side of a causeway in an incised channel. The causeway does not present a fish barrier, however, a concrete slab immediately downstream of the causeway, approximately 1.5 m high, would impede fish passage during flow. The riparian zone is cleared with few remnant trees near the banks.
Proposed Pipeline	Unnamed waterway	UN03	No surface water present at the time of surveys and appears not to have had flow from recent rains. A small Weir wall approximately 1 m high with a stepped pipe culvert is present upstream, which would present a complete barrier to fish passage if water were present. No riparian zone exists, and the drainage line shows signs of erosion and impacts by livestock.
Proposed Pipeline	Unnamed waterway	UN04	No surface water was present during survey and no evidence of flow during recent rainfall was observed. No riparian zone exists, and banks are undefined, with no evidence of a drainage line or swale. A diverting pump and pipe are present at the site.
Proposed Pipeline	Unnamed waterway	UN05	Standing, clear shallow water in small pools approximately 0.1 m deep. It is likely the drainage line hold water for brief periods after rain events. Banks are eroded and incised and consist of clay with some cobbles near a pipe culvert for a road crossing. The pipe culvert is approximately 0.5 m above the creek bed, providing a complete fish barrier when water levels are not high enough to flow through. Riparian vegetation is cleared with few remnant trees near the banks.
Proposed Pipeline	Unnamed waterway	UN06	No surface water was present during survey and no evidence of flow during recent rainfall was observed. No riparian zone exists, and banks are undefined, with no evidence of a drainage line or swale.
Proposed Pipeline	Unnamed waterway	UN07	Clear, shallow standing pools within a semi defined drainage line to approximately 0.17 m deep. A farm dam is present up and downstream. Riparian zone is cleared, with pasture grasses on the groundcover which is impacted by stock. Banks are eroded and comprised of clay and boulders with some cobbles. Algae is present in the pools.
Proposed Pipeline	Unnamed waterway	UN08	No surface water was present during survey and no evidence of flow during recent rainfall was observed. No riparian zone exists, and banks are undefined, with no evidence of a drainage line or swale. A pipe culvert is present at the site.
Proposed Pipeline	Unnamed waterway	UN10	No surface water was present during survey and no evidence of flow during recent rainfall was observed. No riparian zone exists, and banks are undefined, with no evidence of a drainage line or swale. A pipe culvert is present at the site.

Table 6.2 Habitat characteristics at each aquatic ecology site assessed during the field surveys

Project component	Waterway	Site	Description
Proposed Pipeline	Unnamed waterway	UN11	No surface water was present during survey and no evidence of flow during recent rainfall was observed. No riparian zone exists, and banks are undefined, with no evidence of a drainage line or swale. A pipe culvert is present at the site.
Proposed Pipeline	Unnamed waterway	UN12	No surface water was present during survey and no evidence of flow during recent rainfall was observed. No riparian zone exists, and banks are undefined, with no evidence of a drainage line or swale. A pipe culvert is present at the site.
Proposed Dam	Peel River	PR01	Flowing water approximately 0.9 m deep with riffle-pool sequences. Water is turbid in the middle of the river and clear at the edges. Riparian zone is largely cleared with remnant trees on the bank edge providing shade and shelter. Groundcover is dominated by pasture grasses. Macrophytes were observed, *Myriophyllum* sp. and *Pottamageton crispus*. Banks show some signs of erosion and impacts by stock, and are comprised of clay, gravel, pebble, cobbles and bedrock, with gravel, cobbles and boulders present in-stream. Large woody debris, in-stream aquatic vegetation, riparian vegetation and gravel beds provide important refuge and breeding habitat.
Chaffey Dam	Peel River	PHF01	Clear, flowing water with riffle and run sequences with some large pools. Riparian zone is partially intact with the overstory dominated by *Casurina* sp. Midstory and understory absent with ground layer dominated by weedy pasture grasses. Banks consist of clay, cobbles, boulders and gravel, which is also present on the riverbed.
Chaffey Dam	Peel River	PHF04	Clear, flowing water comprised of run and pool habitat approximately 12-15 m in width. Minimal riparian vegetation remains and is dominated by *Casurina* sp. and Privet (Ligustrum sp.). Banks are steep and undercut (approximately 6 m high) with a 1:1 grade. Substrate consists of cobble and pebble. Fish habitat present in the form of snags and undercut banks. Shading is approximately 80 percent.
Chaffey Dam	Peel River	PHF06	Clear, flowing water comprised of run and pool habitat. Remnant riparian vegetation remains in areas. The overstory is dominated by River oak and weedy species such as Willow. Midstory is dominated by River oak and Privet. Understory and groundcover is dominated by weedy species such as Johnson grass (*Sorghum halepense*). Substrate consists of pebble, gravel, sand and silt. Some emergent vegetation present. Some fish habitat present in the form of undercut banks and snags.
Chaffey Dam	Peel River	PHF08	Clear, flowing water comprised of pool and run habitat. Riparian zone is intact in sections, 10-15 m in width and dominated by *Casurina* sp. with some Willows (unidentified sp.) and other weedy species present. Midstory is dominated by weedy shrubs and the ground layer is dominated by weedy pasture grasses. The right bank has been subjected to intensive agricultural practices. Substrate comprised of cobble, gravel and sand with some silt present along the banks. Fish habitat is present in the form of snags and some undercut banks. Shading is approximately 60 percent.

Table 6.2 Habitat characteristics at each aquatic ecology site assessed during the field surveys

Project component	Waterway	Site	Description
Chaffey Dam	Peel River	PHF09	Clear, flowing water comprised of run and pool habitat. Remnant riparian vegetation is present in patches and is dominated by *Casurina* sp.. Midstory and understory are absent and ground coverage is dominated by weedy pasture grasses. Some instream vegetation is present in the form of Common Reed (*Phragmites australis*) and Watermilfoil (*Myriophyllum* sp.). Substrate is comprised of cobble and pebble and fish habitat is present in the form of snags and undercut banks.
Chaffey Dam	Peel River	PHF11	Flowing, turbid water with run sequences approximately 15 m wide in areas and approximately 0.2 m deep. Remnant riparian vegetation is present (<20 m wide). The overstory is dominated by *Casurina sp*. with trailing vegetation in sections, midstory is absent and understory and groundcover is dominated by weedy species and pasture grasses. Substrate consists of cobble, pebble, gravel, sand and silt. Fish habitat is present in the form of undercut banks in areas.
Chaffey Dam	Peel River	PHF12	The Peel River was flowing, with elevated turbidity at this site. The river form is a series of run sequences and the river is 10-15 m wide. The left bank is located within a recreation reserve and supports a larger riparian zone than the right bank. The riparian zone on the right bank is approximately 15 m wide. Both banks are dominated by *Casurina sp*. with some evidence of River redgum recruitment. Mid- and understory are minimal and consist of weedy vegetation. Substrate consists of cobble and pebble.
Chaffey Dam	Peel River	PHF13	The river was slow flowing with turbid water approximately 2 m deep and 15 m wide. The riparian zone is narrow on the left bank and wider on the right. The overstory is dominated by *Casurina sp*., Willow and Oak (unidentified sp.). Understory is dominated by weeds such as Johnson grass and Wandering Trad (*Tradescantia fluminensis*). Substrate is cobble and pebble with overlying silt. Fish habitat is present in the form of snags and undercut banks on the bends.
Chaffey Dam	Peel River	PHF14	The river is flowing, turbid water approximately 1.5 – 2 m depth and 10-15 m wide with a series of pools and runs. Riparian zone is narrow and the overstory consists of *Casurina sp*., River redgum and weedy species such as Willow and Wandering Trad. The midstory and understory were weedy and ground cover is comprised of weedy pasture grasses. The channel is incised with a bank gradient of 1:1 and approximately 6 m high. Substrate is cobble and gravel with silt on the banks. Shading was approximately 80 percent.
Chaffey Dam	Peel River	PHF15	The river was flowing with slightly turbid water. Habitat consists of run and pool habitat to approximately 2 m depth. Riparian zone is mostly cleared for agriculture, with stands of remnant trees lining the banks, providing some shade and overhanging vegetation in some areas. Riparian overstory consists of *Casurina* sp. and Willows. The understory consists of weedy species as does the ground cover. Banks are steep with a 1:1 incline. Substrate consists of silt and gravel.

Table 6.2 Habitat characteristics at each aquatic ecology site assessed during the field surveys

Project component	Waterway	Site	Description
Chaffey Dam	Peel River	PHF17	The Peel River at this site was flowing with slightly turbid water with riffle-run-pool sequences providing habitat. Water is deep in the pools and the river is approximately 10-15 m wide. The riparian zone is largely cleared with remnant trees on the bank edge providing approximately 20 percent shading. Riparian overstory (where present) is dominated by Casurina sp. Understory and groundcover are dominated by weeds and pasture grasses. Macrophytes observed included Common Reed and Curlyleaf pondweed (*Potamogeton crispus*). Banks show some signs of erosion and stock have unrestricted access. The banks are comprised of clay, gravel, pebble, cobbles and bedrock, with gravel, cobbles and boulders present in-stream.
Chaffey Dam	Peel River	PHF19	The Peel River is flowing with slightly turbid water. The sight is highly modified to support the gauge and pumphouse. Water is approximately 1.5 m deep and the river is 10 – 15 m wide. The riparian zone is more intact on the left bank and consists of *Casurina sp*. and Willows. The understory consists of weedy species and the ground cover is dominated by weedy pasture grasses. Banks are eroded in areas, and are comprised mainly of clay, gravel and cobble with bedrock immediately upstream of a bridge crossing. Some concrete slab structures are present on the riverbed under the bridge, which may provide a partial barrier to fish passage during very low flow. The river appears to have experienced recent high flow; however, scouring and erosion has been minimised potentially due to the flow arresting nature of the bridge and concrete blocks. Gravel beds may provide spawning and habitat for fish if able to access this part of the river.
Chaffey Dam	Peel River	PHF22A	A comparatively wide section of the Peel River (~20 - 30m), with flowing, slightly turbid water approximately 1.7 m deep and is a large pool formed by the weir within the urban area of Tamworth. Riparian zone is mostly cleared, beyond a narrow corridor adjacent to the waterway, with remnant trees lining the bank. Limited trailing vegetation is present in areas. Banks are comprised of mostly consolidated sand and clay, with some gravel sections present in the waterway. Some erosion and sedimentation is evident on banks which have been impacted by feral pigs in places. There is limited woody debris present; however, riparian vegetation may provide important refuge and breeding habitat.
Chaffey Dam	Peel River	PHF22B	This site is located upstream of PHF22A within the urban area of Tamworth. The site is located upstream of an old weir that forms a large pool. Habitat features are similar to site PHF22A.

Photograph 6.1 **Concrete structure at Terrible Billy Creek, presenting a potential barrier to fish passage upstream**

Photograph 6.2 **Concrete structure at Peel River (PHF19), presenting a potential barrier to fish passage upstream**

6.1.1 Water quality

During the August 2020 survey, the pH of surface water ranged from acidic (pH 6.3, JC01) to circumneutral (pH 7.1, BOC01) (Table 6.3). Six sites exceeded the ANZECC and ARMCANZ (Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Volume 1, The Guidelines (Chapters 1-7), 2000) trigger value, with sites DC01, DC06, DC07, JC01, PC01 and TBC01 falling below the lower trigger value of pH 6.9. Surface water pH was highest at Big Oaky Creek (BOC01) and the Peel River (PR01) recording values of 7.1 and 7.0, respectively.

The salinity of surface water (measured as total dissolved solids; TDS) was classified as fresh, with salinity ranging from 57 mg/L to 158 mg/L (TBC01 and JOC01, respectively). There is no trigger value for salinity measured as mg/L; however, there is a trigger value for electrical conductivity, which varied from 70 µS/cm (TBC01) to 281 µS/cm (PR01) (Table 6.3), none of which exceeded the ANZECC and ARMCANZ (2000) trigger value (350 µS/cm).

Surface water turbidity varied amongst waterways and was below the ANZECC and ARMCANZ (2000) trigger value across all sites. The lowest value, 0.3 NTU, was recorded in both Big Oaky Creek (BOC01) and Johnsons Oaky Creek (JOC01). The highest value was recorded from Dungowan Creek (8.6 NTU, DC06) (Table 4.8), with the waterway being marginally more turbid on average (5.3 NTU) when compared with the Peel River (3.7 NTU). Within Dungowan Creek, turbidity was lowest at sites DC02 and DC03 (2.0 NTU and 1.8 NTU, respectively).

Dissolved oxygen at all sites was comparable, with the lowest and highest values recorded in Dungowan Creek at sites DC02 and DC03 (9.8%) and site DC04 (11.7%), respectively (Table 6.3). On average, dissolved oxygen was similar between Dungowan Creek and the Peel River (10.2%). All sites fell below the lower trigger value of 60% for dissolved oxygen. This may be attributed to the holding time being exceeded for these samples.

Concentrations of total nitrogen and total phosphorus were comparably low across all sites, with nitrogen ranging from 0.2 mg/L (UN07) to 3.8 mg/L (JOC01), and phosphorus ranging from 0.01 mg/L (JC01, PC01) to 0.03 mg/L (DC04) (Table 6.3), with no exceedances of relevant ANZECC and ARMCANZ (2000) trigger values. Ammonia concentrations were also low (0.01 mg/L, DC02 to 0.04 mg/L, JOC01), with almost half of the sites below the analytical limit of reporting (Table 6.3). No sites exceeded the ANZECC and ARMCANZ (2000) trigger value.

Concentrations of dissolved metals were below the analytical limit of reporting for most sites, except for barium, boron, copper, iron and manganese (Table 6.3). Whilst detectable, concentrations of these dissolved metals did not exceed relevant ANZG DGVs (Water Quality Australia, 2018), where available, at any site.

During the February-March 2022 survey period six sites were analysed for water quality parameters. *In-situ* water quality measurements for pH, electrical conductivity, turbidity and dissolved oxygen were undertaken at five sites only (PR03, DC08, DC10, DC11 and DC16; Table 6.4). Dissolved oxygen (DO) was low when compared to the ANZECC and ARMCANZ (2000) trigger values (ranging from 50 percent to 56.7 percent; lower limit for ANZECC & ARMCANZ (2000) trigger values = 90 percent; Table 6.4). DO levels can be highly variable during the day and night depending on the productivity of the waterway. These results were captured at a single point in time, and it is likely that DO concentrations vary across a 24 hour period; or even seasonally. All other *In-situ water quality* parameters were within the acceptable limits for slightly disturbed south-eastern Australian upland rivers.

Nutrients were analysed for six sites with all results falling within the acceptable limits for ANZECC and ARMCANZ (2000) trigger values and ANZG DGVs (Water Quality Australia, 2018) (Table 6.4). Nitrogen was low across all sites ranging from 0.2 mg/L (PR03 and DC16) to 2.1 mg/L (DC08) (Table 6.4) as was phosphorous , ranging from <0.01 mg/L (DC08 and DC16) to 0.02 (PR03, DC10 and DC13) (Table 6.4). Nitrate and nitrite were low across all sites ranging from 0.02 mg/L (DC16) to 1.82 mg/L (DC08) (Table 6.4). Likewise Ammonia concentrations were also low across all sites, ranging from <0.01 mg/L (DC11) to 0.04 mg/L (DC13) (Table 6.4).

Metals and trace elements all fell within acceptable limits for ANZG DGVs (Water Quality Australia, 2018), where available. No ANZECC and ARMCANZ (2000) trigger values were available for metals and trace elements for slightly disturbed south-eastern Australian upland rivers. Arsenic, Cadmium, Chromium, Lead, Mercury, Nickel, Selenium and Zinc all fell below the detectable limits of the test for all sites (Table 6.4). Copper was detectable at one site only (0.001 mg/L; DC10) (Table 6.4). Iron levels were low across all sites ranging from 0.08 mg/L (PR03) to 0.36 mg/L (DC08). No ANZG DGVs (Water Quality Australia, 2018) were available for iron.

During the March 2022 survey on the Peel River, water samples were collected for analysis at five sites. Total dissolved solids (TDS) were consistent across the five sites ranging from 169 mg/L at PHF14 to 218 mg/L at PHF11. Biological oxygen demand (BOD) was below the detectable limit for PHF06, PHF11 and PHF19 and 2 mg/L at PHF01 and PHF14 (Table 6.4). There are no trigger values for TDS or BOD.

In situ water quality was collected at all sites for the Peel River surveys and are presented in Table 6.4 and Annexure F. pH exceeded the ANZECC and ARMCANZ (2000) upper trigger value at PHF01 (8.21) and was considered alkaline waters. pH at all other sites fell within the accepted ANZECC and ARMCANZ (2000) upper trigger values. Electrical conductivity exceeded the ANZECC and ARMCANZ (2000) upper trigger value of 350 (µS/cm) at PHF01, PHF06, PHF11 and PHF14. PHF19 lay within the accepted ANZECC and ARMCANZ (2000) upper trigger value although it was nearing the upper limit. All sites are considered freshwater. Turbidity lay within the accepted range for all sites and Dissolved oxygen (%) did not meet the lower ANZECC and ARMCANZ (2000) upper trigger value at any site (Table 6.4).

All major ions were consistently lower at PHF14 relative to other sites and PHF11 frequently had the highest reading. Calcium ranged from 24 mg/L at PHF14 to 33 mg/L PHF11. Sodium ranged from 20 mg/L at PHF14 to 26 mg/L at PHF11. Magnesium ranged from 15 mg/L at PHF14 to 20 mg/L at PHF01, PHF06 and PHF11. Potassium was reasonably consistent across sites ranging from 2 mg/L at PHF06, PHF11, PHF14 and PHF19 to 3 mg/L at PHF01. There is no trigger value for these major ions (Table 6.4).

Nutrients were comparatively low across the five sites and no sites exceeded ANZECC and ARMCANZ (2000) trigger value or ANZG DGVs (Water Quality Australia, 2018). Nitrogen (total) ranged from 0.7 mg/L at PHF14 and PHF19 to 1.5 mg/L at PHF06. Kjeldahl Nitrogen (total) ranged from 0.3 mg/L at PHF14 and PHF19 to 0.7 mg/L at PHF01. Nitrate was low and ranged from 0.38 mg/L at PHF14 and PHF19 to 1.00 mg/L at PHF06. All sites were below the detectable limits for nitrite and readings for nitrite + nitrate were identical to those of nitrate. Ammonia was low ranging from below the detectable limit at PHF14 to 0.15 mg/L at PHF01. Phosphorus (total) was also low ranging from 0.04 mg/L at PHF19 to 0.10 mg/L at PHF01 (v).

All metals and trace elements were low and no sites exceeded the trigger values for ANZG DGVs (Water Quality Australia, 2018). Arsenic was below the detectable limit for PHF06, PHF11 and PHF14 and had a reading of 0.001 mg/L for PHF01 and PHF19. Barium ranged from 0.009 mg/L at PHF01 to 0.016 mg/L at PHF19. Beryllium, Cadmium, Chromium and cobalt were below the detectable limits for all sites. Copper was below the detectable limit at four sites and had a reading of 0.001 at PHF11. Iron was below the detectable limit at PHF01 and had a reading of 0.07 mg/L at PHF01 and PHF14. Lead was below the detectable limit for all sites and Manganese ranged from 0.050 mg/L at PHF14 to 0.133 mg/L at PHF01. Mercury, selenium, vanadium and zinc were below the detectable limits at all sites and Nickel was below the detectable limit at PHF14 and PHF19 and ranged to 0.002 mg/L at PHF01 (Table 6.4).

Table 6.3 Water quality parameters recorded during the August 2020 field survey

Water quality parameters		Dungowan Dam								Pipeline					ANZECC & ARMCANZ (2000) trigger values		ANZG DGVs (Water Quality Australia, 2018)	
		Jones Oaky Creek	Paradise Creek	Terrible Billy Creek	Dungowan Creek				Peel River	Big Oaky Creek	Dungowan Creek		Johnsons Oaky Creek	Unnamed waterway				
		JC01	PC01	TBC01	DC01	DC02	DC03	DC04	PR01	BOC01	DC06	DC07	JOC01	UN07	Lower	Upper	DGV	GV-High
Basic	pH (unit)	6.3	6.4	6.4	6.5	6.5	6.6	6.7	7.0	7.1	6.5	6.5	6.9	6.8	6.5	8.0	-	-
	Total dissolved solids	60	100	57	86	84	70	132	149	112	85	82	158	157	-	-	-	-
	Electrical conductivity (µS/cm)	116	139	70	128	127	116	141	281	174	126	118	268	258	30	350	-	-
	Suspended solids	<5	6	<5	6	6	6	6	15	<5	10	6	<5	13	25	25	-	-
	Turbidity (NTU)	0.5	1.7	2.5	7.0	2.0	1.8	5.3	3.7	0.3	8.6	7.1	0.3	1.5	2	25	-	-
	Dissolved oxygen	10.4	10.1	9.8	10.0	9.6	9.6	11.7	10.2	10.1	10.2	10.1	10.0	10.2	90	110	-	-
Major Ions	Calcium	7	8	4	9	9	9	10	19	11	9	8	20	18	-	-	-	-
	Sodium	9	11	6	7	7	6	8	23	11	7	7	16	19	-	-	-	-
	Magnesium	4	4	2	4	5	4	5	12	6	5	4	10	9	-	-	-	-
	Potassium	<1	1	2	2	2	1	2	1	<1	2	2	<1	<1	-	-	-	-
	Bicarbonate	30	30	23	35	41	38	48	114	50	40	38	78	76	-	-	-	-
	Sulphate	16	17	<1	8	9	9	7	14	12	9	9	24	32	-	-	-	-
	Chloride	6	9	4	6	6	5	6	19	11	6	6	12	11	-	-	-	-
	Carbonate	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-
	Hydroxide	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-
	Alkalinity (total)	30	30	23	35	41	38	48	114	50	40	38	78	76	-	-	-	-
Nutrients	Nitrogen (total)	0.3	2.2	0.8	1.2	1.2	1.2	1.2	0.2	2.1	1.2	1.3	3.8	0.2	-	250	-	-
	Kjeldahl Nitrogen (total)	<0.1	0.4	0.5	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.5	0.2	-	-	-	-
	Nitrate	0.29	1.77	0.32	0.95	0.93	0.95	0.93	0.04	1.82	0.94	0.96	3.28	0.02	-	15	-	-
	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	-	15	-	-
	Nitrite + Nitrate	0.29	1.77	0.32	0.95	0.93	0.95	0.93	0.04	1.82	0.94	0.96	3.28	0.02	-	-	-	-
	Ammonia	<0.01	<0.01	<0.01	0.02	0.01	<0.01	<0.01	0.02	0.02	0.02	<0.01	0.04	0.03	-	13	-	2.30
	Phosphorus (total)	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.02	<0.01	0.02	0.01	<0.01	<0.01	-	20	-	-
	Organic carbon (total)	1	4	10	6	5	4	5	4	1	5	6	2	3	-	-	-	-
Metals & Trace Elements	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	-	-	-	0.14
	Barium	0.002	0.011	0.014	0.009	0.009	0.008	0.009	0.008	0.006	0.008	0.009	0.007	0.005	-	-	-	-
	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	-	-	-	-
	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	-	-	-	1.3
	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	-	-	-	0.0008
	Chromium	<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	-	-	-	0.04

Table 6.3 Water quality parameters recorded during the August 2020 field survey

Water quality parameters	Dungowan Dam								Pipeline					ANZECC & ARMCANZ (2000) trigger values		ANZG DGVs (Water Quality Australia, 2018)	
	Jones Oaky Creek	Paradise Creek	Terrible Billy Creek	Dungowan Creek				Peel River	Big Oaky Creek	Dungowan Creek		Johnsons Oaky Creek	Unnamed waterway				
	JC01	PC01	TBC01	DC01	DC02	DC03	DC04	PR01	BOC01	DC06	DC07	JOC01	UN07	Lower	Upper	DGV	GV-High
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	-	-	-	-
Copper	<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	-	-	-	0.0025
Iron	<0.05	<0.05	0.30	0.12	<0.05	<0.05	0.15	<0.05	<0.05	0.11	0.11	<0.05	<0.05	-	-	-	-
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	-	-	-	0.0094
Manganese	<0.001	<0.001	0.003	0.060	0.082	0.082	0.116	<0.001	0.002	0.054	0.050	<0.001	<0.001	-	-	-	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	-	-	-	0.0054
Nickel	<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	-	-	-	0.017
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	-	-	-	0.034
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	-	-	-	0.006
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	-	-	-	0.031

Note Units are mg/L unless otherwise specified; parameters are dissolved unless otherwise stated; yellow shading indicates values below the lower limit of the ANZECC and ARMCANZ (2000) trigger values for slightly disturbed south-eastern Australian upland rivers for basic, major ions and nutrient water quality parameters; DGV for arsenic is AsV; DGV for chromium is CrVI; DGV for mercury is inorganic; DGV for selenium is total; DGV species protection level for vanadium is unknown.

Table 6.4 Water quality parameters recorded from samples collected during the February-March 2022 field survey

		Peel River	Dungowan Creek					Peel River					ANZECC & ARMCANZ (2000) trigger values		ANZG DGVs (Water Quality Australia, 2018)	
	Water quality parameters	PR03	DC08	DC10	DC11	DC13	DC16	PHF01	PHF06	PHF11	PHF14	PHF19	Lower	Upper	DGV	GV-High
Basic	pH (unit)*	7.21	7.49	7.44	6.89	-	7.11	8.21	7.91	7.62	7.99	7.81	6.5	8.0	-	-
	Electrical conductivity (µS/cm)*	250.9	74.9	83.1	113.5	-	74.5	593	636	634	483	308	30	350	-	-
	Turbidity (NTU)*	23.7	2.23	5.16	5.94	-	2.34	7.11	5.79	8.78	-	16	2	25	-	-
	Dissolved oxygen (%)*	50.6	56.7	52.5	50	-	51.9	86.2	82.1	75.9	85.9	87.4	90	110	-	-
	Total dissolved solids	-	-	-	-	-	-	201	200	218	169	194	-	-	-	-
	Biological Oxygen Demand	-	-	-	-	-	-	2	<2	<2	2	<2	-	-	-	-
Nutrients	Nitrogen (total)	0.2	2.1	1.2	1.3	0.3	0.2	0.8	1.5	0.9	0.7	0.7	-	250	-	-
	Kjeldahl Nitrogen (total)	0.2	0.3	0.3	0.3	0.2	0.2	0.7	0.5	0.4	0.3	0.3	-	-	-	-
	Nitrate	-	-	-	-	-	-	0.07	1.00	0.50	0.38	0.38	-	15	-	-
	Nitrite	-	-	-	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	-	15	-	-
	Nitrite + Nitrate	0.04	1.82	0.94	0.96	0.09	0.02	0.07	1.00	0.50	0.38	0.38	-	-	-	-
	Ammonia	0.02	0.02	0.02	<0.01	0.04	0.03	0.15	0.03	0.01	<0.01	0.01	-	13	-	2.30
	Phosphorus (total)	0.02	<0.01	0.02	0.01	0.02	<0.01	0.10	0.06	0.06	0.05	0.04	-	20	-	-
Metals & Trace Elements	Arsenic	<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	-	-	-	-	-	-	0.009	0.012	0.013	0.013	0.016	-	-	-	-
	Beryllium	-	-	-	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	Cadmium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	-	-	0.0008

Table 6.4 Water quality parameters recorded from samples collected during the February-March 2022 field survey

Water quality parameters	Peel River	Dungowan Creek					Peel River					ANZECC & ARMCANZ (2000) trigger values		ANZG DGVs (Water Quality Australia, 2018)	
	PR03	DC08	DC10	DC11	DC13	DC16	PHF01	PHF06	PHF11	PHF14	PHF19	Lower	Upper	DGV	GV-High
Chromium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	0.04
Cobalt	-	-	-	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001				
Copper	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	-	-	-	0.0025
Iron	0.08	0.36	0.34	0.13	0.11	0.57	0.07	0.06	<0.05	0.07	0.06	-	-	-	-
Lead	<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	-	-	-	-	-	-	0.133	0.068	0.051	0.050	0.054	-	-	-	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	-	-	-	0.0054
Nickel	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	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	-	-	-	0.034
Zinc	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-	-	0.031

Note Units are mg/L unless otherwise specified; parameters are dissolved unless otherwise stated; yellow shading indicates values below the lower limit of the ANZECC and ARMCANZ (2000) trigger values for slightly disturbed south-eastern Australian upland rivers for basic and nutrient water quality parameters; *Indicates in situ sampling of water quality; DGV for arsenic is AsV; DGV for chromium is CrVI; DGV for mercury is inorganic; DGV for selenium is total.

6.1.2 Sediment quality

During the August 2020 field survey, sediment pH ranged from 6.9 (DC03, DC06) to 7.7 (HHG01, PC01) (Table 6.5), classified as neutral to mildly alkaline (Hazelton & Murphy, 2007). Dungowan Creek recorded comparable pH to that of other waterways (eg Peel River) with an average pH of 7.1.

Salinity (measured as total soluble salts, TSS) varied considerably across waterways and ranged from 66 mg/kg (DC02) to 375 mg/kg (DC03) (Table 6.5). Moisture content was lowest at Paradise Creek (PC01) with a value of 14% and highest at within the Peel River (PR01) with a value of 74%.

Concentrations of total nitrogen and total phosphorus varied across sites and ranged from 410 mg/kg to 6,190 mg/kg, and 306 mg/kg to 930 mg/kg, respectively (Table 6.5). The highest concentrations of nitrogen were recorded from an unnamed waterway (UN07) and the highest phosphorus concentration was recorded from the Peel River (PR01). Elevated concentrations of nitrogen and phosphorus at these sites are attributed to agricultural practises occurring within and surrounding these waterways. This, combined with the little or no groundcover or riparian vegetation observed at the sites, reduces the ability of nutrient-rich runoff to be filtered prior to entering the waterway and binding with the sediment. This results in nutrient loading within the sediment, which can resuspend into the water column following periods of high rainfall or flooding (Alam, Rolfe, & Windle, 2004).

Concentrations of metals were variable among sites with four metals below the analytical level of reporting at all sites (boron, cadmium, mercury, selenium) (Table 6.5). Only one parameter was recorded as exceeding the relevant ANZG DGV (Water Quality Australia, 2018) at nine sites; however, the DGV High values was not exceeded (Table 6.5).

During the March 2022 field survey, sediment salinity measured as total soluble salts ranged from 233 mg/kg (PHF01) to 434 mg/kg (PHF06). Moisture content was lowest at PHF01 at 20.4 % and highest at PHF06 at 58.3 % (Table 6.6).

Major ion concentrations varied between sites with Calcium ranging from 20 mg/kg at PHF01 to 100 mg/kg at PHF06. Sodium ranged from 10 mg/kg at PHF01 to 60 mg/kg at both PHF06 and PHF14. Potassium ranged from below the detectable limit at PHF01 to 20 mg/kg at both PHF06 and PHF14. Magnesium was lowest at PHF01 (10 mg/kg) and highest at PHF06 (60 mg/kg). Chloride was below the detectable limit at PHF01 and 20 mg/kg at both PHF06 and PHF14. Sulphate ranged from below the detectable limit at PHF01 to 100 mg/kg at PHF11 (Table 6.6). Nutrients varies between sites with the range for Nitrogen (total) and Kjeldahl nitrogen (total) varying greatly between the sites with the lowest and highest concentrations. Nitrogen (total) and Kjeldahl nitrogen concentrations were lowest at PHF01 with 370 mg/kg and highest at PHF06 with 2780 mg/kg. Nitrite + Nitrate ranged from 0.7 mg/kg at PHF11 to 2.7 mg/kg at PHF01. Phosphorus (total) ranged from 463 mg/kg at PHF19 to 913 mg/kg at PHF01. Organic carbon (total) ranged from 0.22 % at PHF01 to 3.81 % at PHF06 (Table 6.6).

Metals and trace elements were relatively consistent across sites with only Nickel exceeding the ANZG DGVs (Water Quality Australia, 2018) trigger values, and meeting the GV-High value at one site (Table 6.6). Arsenic ranged from below the detectable limit at PHF06 and PHF19 to 6 mg/kg at PHF19. Barium was consistent across sites and ranged from 90 mg/kg at PHF19 to 110 mg/kg at PHF06. Beryllium, Boron and Cadmium were all below the detectable limit. Chromium ranged from 28 mg/kg at PHF01 to 52 mg/kg at PHF11. Cobalt was relatively consistent across sites and ranged from 16 mg/kg at PHF06 to 20 mg/kg at PHF11 and PHF14. Copper was lowest at PHF01 at 20 mg/kg and highest at PHF14 at 36 mg/kg. Iron ranged from 33 000 mg/kg at PHF01 to 41 600 mg/kg at PHF14. Lead was below the detectable limits at all sites except PHF14 which had a concentration of 5 mg/kg. Manganese ranged from 598 mg/kg at PHF01 to 1820 mg/kg at PHF06. Mercury was below the detectable limit at all sites. As previously stated Nickel exceeded the ANZG DGVs (Water Quality Australia, 2018) trigger values at all sites, meeting the GV-High value at PHF01. Selenium was below the detectable limit at PHF01 and ranged to 9 mg/kg at both PHF11 and PHF14. Vanadium concentrations were lowest at PHF01 at 58 mg/kg and highest at PHF11 and PHF14 with 79 mg/kg recorded at each site. Zinc ranged from 40 mg/kg at PHF01 to 70 mg/kg at PHF14 (Table 6.6).

Table 6.5 **Sediment quality parameters recorded during the August 2020 field survey**

Sediment quality parameters		Jones Oaky Creek	Paradise Creek	Terrible Billy Creek	Dungowan Creek				Peel River	Big Oaky Creek	Dungowan Creek		Hell Hole Gully	Johnsons Oaky Creek	Unnamed waterway	ANZG DGVs (Water Quality Australia, 2018)	
		JC01	PC01	TBC01	DC01	DC02	DC03	DC04	PR01	BOC01	DC06	DC07	HHG01	JOC01	UN07	DGV	GV-High
Basic	pH (unit)	7.0	7.7	7.0	7.1	7.5	6.9	7.2	7.3	7.1	6.9	7.2	7.7	7.1	7.2	-	-
	Total soluble salts	119	88	135	144	66	374	89	367	124	161	99	138	134	335	-	-
	Moisture content (%)	24	14	58	36	31	50	32	74	33	49	36	18	39	61	-	-
Major Ions	Calcium	10	<10	30	20	<10	90	10	140	20	30	10	10	20	80	-	-
	Sodium	10	<10	20	20	<10	20	10	100	20	30	10	10	30	60	-	-
	Potassium	<10	<10	20	10	<10	50	<10	20	<10	20	<10	<10	20	<10	-	-
	Magnesium	<10	<10	<10	<10	<10	30	<10	70	<10	10	<10	<10	10	40	-	-
	Chloride	<10	<10	<10	30	<10	<10	<10	20	<10	<10	<10	<10	10	20	-	-
	Sulphate	<10	<10	<10	<10	<10	<10	<10	<10	<10	20	<10	<10	<10	<10	-	-
Nutrients	Nitrogen (total)	1,010	930	4,490	1,450	410	3,380	840	4,620	1,090	2,860	860	1,320	1,520	6,190	-	-
	Kjeldahl nitrogen (total)	1,010	930	4,490	1,450	410	3,380	840	4,620	1,090	2,860	860	1,320	1,520	6,190	-	-
	Nitrite + Nitrate	1	2	1	0	0	1	1	0	1	0	0	2	1	1	-	-
	Phosphorus (total)	458	462	686	550	351	698	450	930	306	731	840	413	308	581	-	-
	Organic carbon (total) (%)	1.86	0.79	12.60	3.67	0.96	10.70	2.14	6.36	2.48	9.39	1.45	1.42	3.92	6.69	-	-
Metals & Trace Elements	Arsenic	5	<5	6	9	<5	6	6	6	<5	9	5	11	6	<5	20	70
	Barium	70	90	170	100	80	240	90	110	60	130	100	70	120	70		
	Beryllium	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1	1	<1		
	Boron	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50		
	Cadmium	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.5	10
	Chromium	17	12	17	27	27	20	27	39	22	32	22	16	27	12	80	370
	Cobalt	13	10	16	18	14	29	17	17	10	25	18	13	22	11		
	Copper	35	22	35	34	25	56	34	33	16	51	30	36	55	22	65	270
	Iron	35,900	33,800	24,600	38,700	35,800	31,500	36,600	36,200	31,600	35,300	39,200	33,800	42,600	22,900		
	Lead	10	9	7	12	6	15	9	<5	5	13	9	12	11	7	50	220
	Manganese	1,290	637	1,750	1,340	1,060	3,640	1,440	1,380	962	2,530	1,250	1,400	1,710	712		
	Mercury	<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	0.15	1
	Nickel	22	10	17	22	23	30	25	44	14	28	22	16	25	8	21	52
	Selenium	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5		
	Vanadium	24	39	40	49	30	31	34	73	28	57	43	34	50	39		
	Zinc	60	57	51	56	57	63	64	63	49	54	56	76	61	54	200	410

Note Units are mg/kg unless otherwise specified; parameters are total unless otherwise stated; yellow shading indicates values above the DGV trigger of the ANZG DGVs (Water Quality Australia, 2018) for metals.

Table 6.6 Sediment quality parameters recorded from samples taken during the February- March 2022 field survey

Sediment quality parameters		**Chaffey Dam**					**ANZG DGVs (Water Quality Australia, 2018)**	
		Peel River						
		PHF01	**PHF06**	**PHF11**	**PHF14**	**PHF19**	**DGV**	**GV-High**
Basic	Total soluble salts	233	434	359	368	312	-	-
	Moisture content (%)	20.4	58.3	53.4	55.3	43.4	-	-
Major Ions	Calcium	20	100	60	80	40	-	-
	Sodium	10	60	50	60	40	-	-
	Potassium	<10	20	10	20	10	-	-
	Magnesium	10	60	40	50	30	-	-
	Chloride	<10	20	10	20	10	-	-
	Sulphate	<10	40	100	30	20	-	-
Nutrients	Nitrogen (total)	370	2780	2360	2150	1610	-	-
	Kjeldahl nitrogen (total)	370	2780	2360	2150	1610	-	-
	Nitrite + Nitrate	2.7	2.1	0.7	1.1	2.1	-	-
	Phosphorus (total)	913	664	693	546	463	-	-
	Organic carbon (total) (%)	0.22	3.81	2.78	3.36	3.16	-	-
Metals & Trace Elements	Arsenic	6	<5	5	5	<5	20	70
	Barium	100	110	100	100	90	-	-
	Beryllium	<1	<1	<1	<1	<1	-	-
	Boron	<50	<50	<50	<50	<50	-	-
	Cadmium	<1	<1	<1	<1	<1	1.5	10
	Chromium	28	41	52	50	39	80	370
	Cobalt	17	16	20	20	17	-	-
	Copper	20	31	30	36	28	65	270
	Iron	33000	35200	40200	41600	33700	-	-
	Lead	<5	<5	<5	5	<5	50	220
	Manganese	598	1820	1370	1150	876	-	-
	Mercury	<0.1	<0.1	<0.1	<0.1	<0.1	0.15	1
	Nickel	52	40	50	49	39	21	52
	Selenium	<5	7	9	9	7	-	-
	Vanadium	58	69	79	79	62	-	-
	Zinc	40	56	62	70	54	200	410

Note Units are mg/kg unless otherwise specified; parameters are total unless otherwise stated; yellow shading indicates values above the DGV trigger of the ANZG DGVs (Water Quality Australia, 2018) for metals.

6.1.3 Algae and macrophytes

i Phytoplankton

A total of 27 taxa were identified from the phytoplankton (free-floating algae) assemblage in the surface water at eight sites during the August 2020 field survey (Table 6.7). This included representatives from three phyla; Bacillariophyta (diatoms), Chlorophyta (green algae) and Cyanophyta (blue green algae). The majority of these taxa belonged to bacillariophytes (17 taxa), chlorophytes accounted for eight taxa, and two cyanophyte were recorded (Figure 6.1).

The diversity and abundance of algal taxa was variable between the sites, ranging from three to 12 taxa and from 48 cells to 289 cells (Table 6.7). The phylum Bacillariophyta was dominant in terms of diversity (17 taxa) and abundance (750cells), followed by Chlorophyta (eight taxa, 125 cells) and then Cyanophyta (two taxa, 345 cells) (Table 6.7). Bacillariophytes were recorded from all sites, while chlorophytes were present at six sites, and cyanophytes were recorded at five sites (Table 6.7). A number of taxa were only recorded from one site, including Bacillariophyta, Chlorophyta and Cyanophyta representatives.

Of the bacillariophytes, *Diatoma vulgaris* was the most abundant; however, it was only recorded at one site within the Peel River (PR01) (Table 6.7). *Aulacoseira* sp. and *Nitzschia palea* were the next most abundant and were also more widespread than *Diatoma vulgaris*, recorded from four and six sites, respectively (Table 6.7). Limited information was available in regard to the distribution of *Diatoma vulgaris*; however, both the *Aulacoseira* sp. and *Nitzschia* genera considered to be widespread genera across Australia (McCarthy, 2013), with *Aulacoseira* sp considered to be characteristic of low light and slightly eutrophic conditions (Vyverman, Muylaert, Verleyen, & Sabbe, 2007), although surface water quality did not exhibit high nutrient concentrations and while sediment along Dungowan Creek recorded high nitrogen concentrations, other waterways exhibited substantially elevated concentrations
(Table 6.3).

Representatives of Chlorococcales were the most abundant Chlorophyta order (80 cells); however the order was only recorded at one site within Jones Oaky Creek (JC01). *Chlamydomonas* sp. (28 cells) was the next most abundant and was recorded at five sites, although abundance was also highest at Jones Oaky Creek (JC01). Similarly to Dungowan Creek, surface water and sediment nutrient concentrations were elevated; however, other waterways exhibited substantially more elevated concentrations. Both the Chlorococcales order and *Chlamydomonas* genus are considered widespread, with *Chlorococcales* sp. occurring in standing waterbodies, while *Chlamydomonas* sp. occurs in ponds and lakes within both standing and flowing water (Royal Botanic Gardens Victoria, 2020; Entwisle, Sonneman, & Lewis, 1997).

Of the Cyanophyta phylum, *Planktolyngbya* sp. was the most abundant and was recorded across four sites, although it was recorded at much lower abundances compared to the Bacillariophyta (33 cells<175) (Table 6.7) and was restricted to Terrible Billy Creek and Dungowan Creek. The *Planktolyngbya* genus is widespread across Australia and typically occurs in freshwater lakes, ponds and bog environments (Entwisle, et al., 1997).

The cyanophyte *Anabaena* sp. 1 (Photograph 6.3) was recorded at very low abundances with one cell recorded from Dungowan Creek (DC01) (Table 6.7). The *Anabaena* genus is considered widespread (Entwisle, et al., 1997), forming unbranched filaments and is free floating in standing to slow flowing waters. The genus has the potential to be toxic and/or bloom-forming (Mitrovic & Bowling, 2013) and is seasonally abundant throughout late spring to autumn. Some species can produce an anatoxin which can result in livestock death after drinking and may cause skin irritation (Entwisle, 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; Mitrovic & Bowling, 2013). It is possible that the sustainably low concentration at which the taxa was recorded at is a result of high flow conditions recorded during the August 2020 field survey which may have limited the detection of the taxa across the sites, therefore there is the potential for *Anabaena* to be present during low to moderate flow conditions.

A total of 24 taxa were identified from the phytoplankton (free-floating algae) assemblage in the surface water at five sites during the February-March 2022 field survey on the Peel River (Table 6.8). This included representatives from five Phyla; Bacillariophyta (diatoms), Chlorophyta (green algae), Cryptophyta (Cryptomonads), Cyanophyta (blue green algae) and Euglenophyta (Euglenoids). Bacillariophytes, Chlorophytes and Cyanophytes included seven taxa each. Cryptophytes included two taxa and Euglenophytes was represented by one taxa (Figure 6.2).

Diversity was relatively consistent between the sites, ranging from nine to 13 taxa however abundance varies between sites ranging from 4912 cells to 105613 cells (Table 6.8). The phylums Bacillariophyta, Chlorophyta and Cyanophyta was dominant in terms of diversity (seven taxa each) followed by Cryptophyta (two taxa) and Euglenophyta (one taxa) (Table 6.8). Cyanophyta were dominant with regard to abundance (176630 cells), followed by Chlorophyta (1450 cells) then Bacillariophyta (432 cells), Cryptophyta (110 cells) and Euglenophyta (20 cells) (Table 6.8). Bacillariophytes, Chlorophytes and Cyanophytes were recorded from all sites, while Cryptophytes and Euglenophytes were recorded at one site each (Table 6.8).

Of the Bacillariophytes, *Aulacoseira* sp. was the most abundant and was recorded at four out of five sites within the Peel River (Table 6.8). *Navicula cryptocephala* was the next most abundant and was recorded at all sites. All other species of Bacillariophyte were markedly less abundant and recorded at 1-3 sites only (Table 6.8). *Aulacoseira* sp. is considered to be a widespread genera across Australia (McCarthy, 2013), with *Aulacoseira* sp. considered to be characteristic of low light and slightly eutrophic conditions (Vyverman, Muylaert, Verleyen, & Sabbe, 2007).

Multiple Chlorophyte species reported only as “Colonial green algae small spp.” was most abundant with 4270 cells and was recorded at three sites (Table 6.8). “Colonial green algae small spp.” is a descriptor that appears to include multiple species which may account for the higher abundance. “Phytoflagellates small spp.” Was the next most abundant Chlorophyte however this descriptor also appears to be referring to multiple species. *Golenkinia* sp. was the next most abundant with 410 cells and recorded at two sites (Table 6.8). *Monoraphidum* sp. had 270 cells and was recorded at three sites. The remaining species under the order Chlorophyta were less abundant and recorded at one to three sites (Table 6.8).

Of the Cyanophyta phylum, *Aphanocapsa* sp. was the most abundant (174312 cells) and was recorded across all five sites, although it was recorded at much lower abundance at PHF01 (12 cells) (Table 6.8). The genus *Aphanocapsa* widespread across the globe and has been recorded in the United States, Canada and Antarctica and typically occurs in freshwater lakes, ponds and thermal springs (Komarek, 2003).

The cyanophyte *Anabaena* sp. was recorded at very low abundances with twelve cells recorded from the Peel River (PHF01) (Table 6.8). *Dolichospermum circinale* was recorded at four sites. Both species have the ability to produce toxins. The *Anabaena* genus, its distribution and toxicity are described in the previous results from the survey undertaken in August 2020. *Dolichospermum circinale* is one of the main toxin producing algae (Dadheech, et al., 2014) and is known to occur in environments where nitrogen is low, eutrophication is present and temperatures are high (Rousso, et al., 2022).

Chroomonas sp. and *Cryptomonas* sp. were the only genus of the order Cryptophyta recorded during the March 2022 surveys. Both were in low abundance (70 cells and 40 cells respectively) and both were only recorded at one site (PHF06) (Table 6.8). These genera are reported to be common and found around the world in damp places ((Margulis & Chapman, 2009)).

Of the order Euglenophyta only one genus (*Trachelomanas* sp.) was recorded (PHF19) (Table 6.8). Abundance was low at 20 cells. *Trachelomanas* sp is a freshwater species that is considered common and widespread (Rosowski, 2003).

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

Table 6.7 Phytoplankton taxa recorded during the August 2020 field survey

Algal Taxa	Dam						
	Jones Oaky Creek	Paradise Creek	Terrible Billy Creek	Dungowan Creek				Peel River
	JC01	PC01	TBC01	DC01	DC02	DC03	DC04	PR01
Bacillariophyta								
Achnanthidium minutissimum	11	1	25		1	2		
Achnanthidium sp. 1	34			7	3			
Aulacoseira sp.*				63	29	34	19	
Diatoma vulgaris								175
Fragilaria sp. 1*			1					1
Fragilaria sp. 2*	69							
Gyrosigma sp.						1	1	8
*Melosira varians**	50	1	7	4	3		2	27
Meridion sp.	15			1	1			
Navicula cryptocephala							2	3
Nitzschia acicularis	3							
Nitzschia palea	7		1	16		10	12	65
Nitzschia sp. 1					11			
Pinnularia sp. 1			1					
Staurosira sp.								1
Surirella sp.				1				
Synedra ulna		1	9	1	5	2		3
Chlorophyta								
Chlamydomonas sp.	20			4	1	1	2	
Chlorococcales sp.	80							
Closterium sp. 1				3	1			1
Closterium sp. 3					2	1		
Eudorina sp.*							2	
Mougeotia sp. 1*								3
Oocystis sp.*				1			1	
Staurastrum sp.				1			1	
Cyanophyta								
Anabaena sp. 1*				1				

Table 6.7 Phytoplankton taxa recorded during the August 2020 field survey

Algal Taxa	Dam							
	Jones Oaky Creek	Paradise Creek	Terrible Billy Creek	Dungowan Creek				Peel River
	JC01	PC01	TBC01	DC01	DC02	DC03	DC04	PR01
Planktolyngbya sp.*			7		17	3	6	
Diversity	**9**	**3**	**7**	**12**	**11**	**8**	**10**	**10**
Abundance	**289**	**3**	**51**	**103**	**74**	**54**	**48**	**287**

Note * indicates that the representative comprises a colony, chain or filament; yellow shading indicates taxa is potentially bloom-forming and toxic.

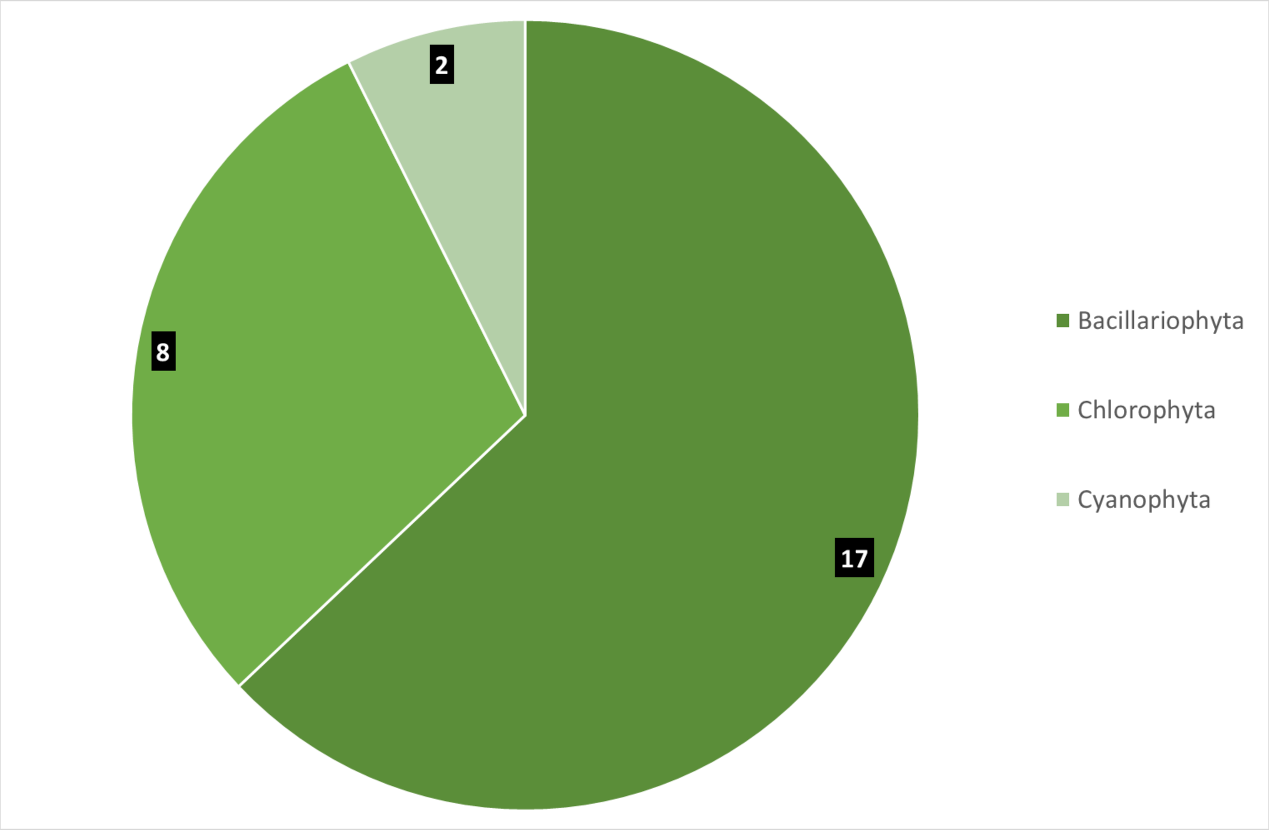
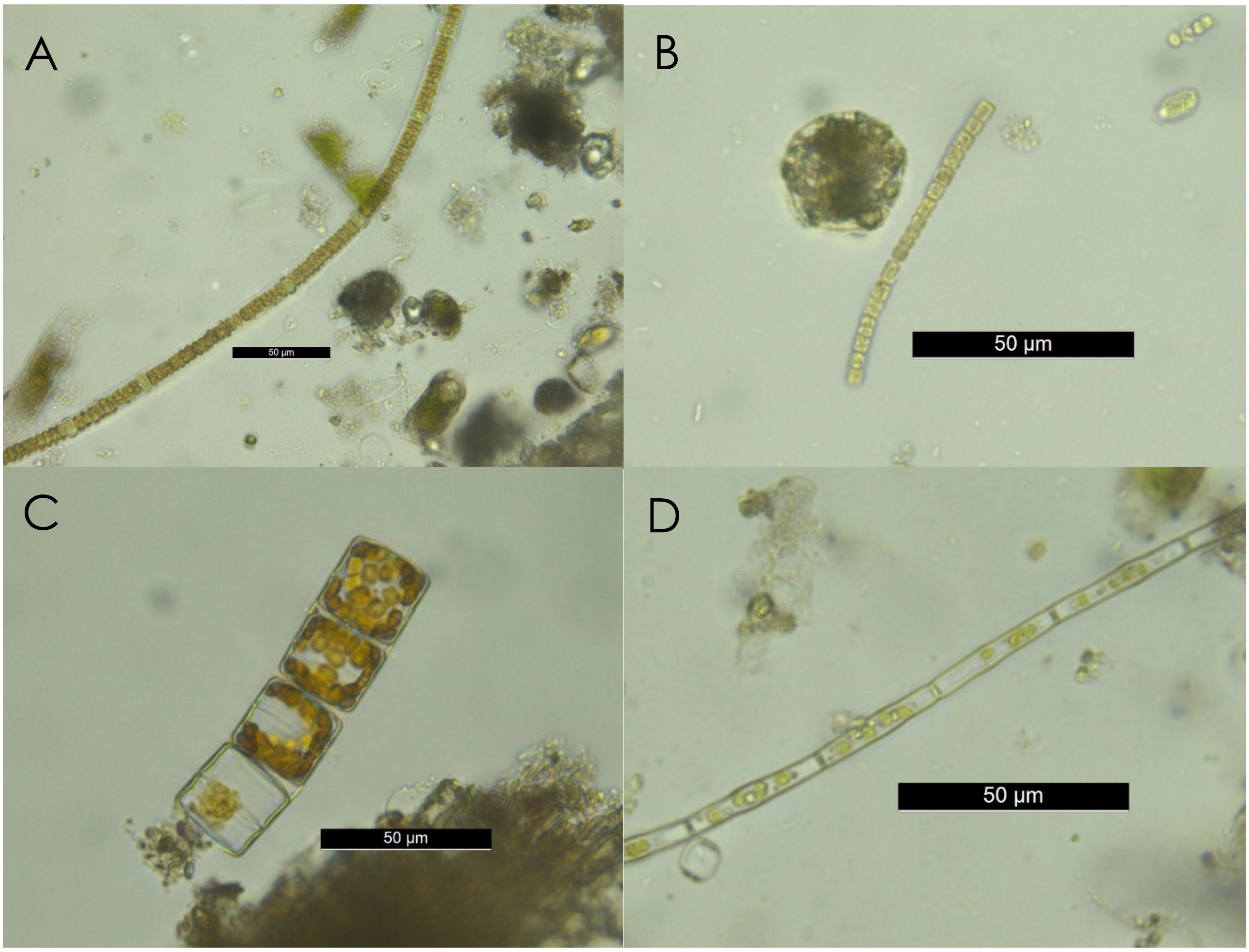


Figure 6.1 Phytoplankton taxa per phyla recorded during the August 2020 field survey



Photograph 6.3 **Phytoplankton taxa recorded during the August 2020 field survey (A) *Anabaena* sp. 1 (B) *Anabaena* sp. 2 (C) *Melosira varians* (D) *Mougeotia* sp. 1**

Table 6.8 Phytoplankton taxa recorded during the February-March 2022 field survey

	Peel River				
Algal Taxa	**PHF01**	**PHF06**	**PHF11**	**PHF14**	**PHF19**
Bacillariophyta					
Aulacoseira sp.	150	80		50	50
Cyclotella sp.			50	30	10
Gomphonema sp.		30			
Gyrosigma sp.			30		4
Navicula cryptocephala		30	120	80	24
Nitzschia sp.		10			22
Synedra ulna			40		
Chlorophyta					
Chodatella_Lagerheimia		20	40	20	
Closterium sp.	80	40			20
Colonial green algae small spp.	2600	1050	620		
Golenkinia sp.	380				30
Monoraphidum sp	70	120		80	
Phytoflagellates small spp.	220			110	300
Scenedesmus sp.					40
Cryptophyta					
Chroomonas sp.		70			
Cryptomonas sp.		40			
Cyanophyta					
Anabaena sp.	12				
Aphanocapsa sp	12	68500	34300	41300	30200
Dolichospermum circinale	1100	30	5	5	
Dolichospermum (coiled)			4		
Microcystis flos-aquae	190	280	84	350	140
Microcystis aeruginosa	98				
Pseudanabaena sp.			20		
Euglenophyta					
Trachelomanas sp.					20
Diversity	**11**	**13**	**11**	**9**	**12**
Abundance	**4912**	**70300**	**105613**	**42025**	**30860**

Note Yellow shading indicates taxa is potentially bloom-forming and toxic.

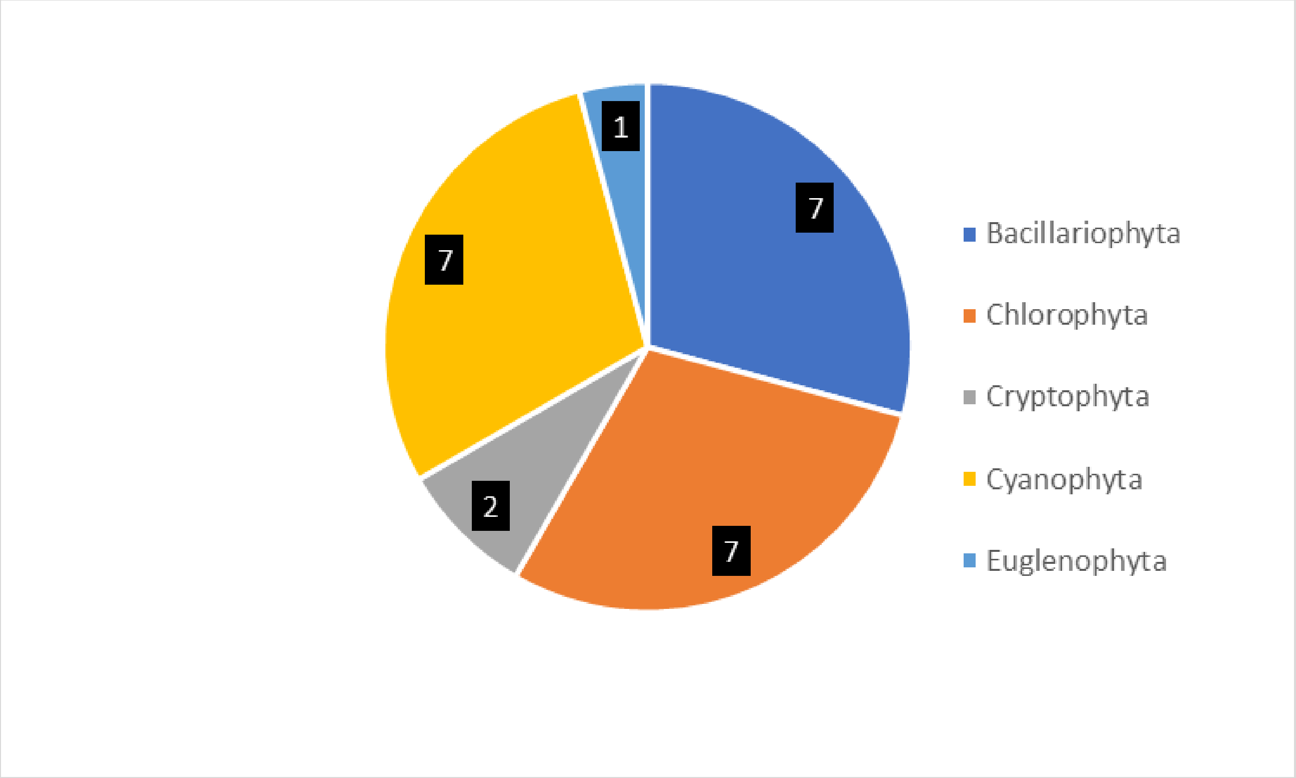


Figure 6.2 **Phytoplankton taxa per phyla recorded during the March 2022 field survey**

ii Periphyton

A total of 43 diatom taxa, representing 30 genera, were identified during the August 2020 field survey (Table 6.9), considered relatively diverse (Taukulis, 2007). The most speciose genera comprised *Gomphonema* (Photograph 6.4) (four taxa) and *Navicula* (four taxa), with the remaining genera recording one or two representatives (Table 6.9). The genera identified are considered characteristic of freshwater habitats and are ubiquitous throughout Australian lakes and streams (Taukulis, 2007; John J. , 2000).

The most diverse waterways included Dungowan Creek (between seven and nine taxa) and the Peel River (eight taxa), while Jones Oaky Creek (JC01) was the least diverse (five taxa) (Table 6.9). All sites supported an abundant diatom assemblage, recording the maximum 100 frustules per site (Table 6.9). There was no apparent correlation between diatom diversity and/or abundance and surface water or sediment nutrient concentrations, indicating that, during the August 2020 field survey, agricultural runoff was not influencing diatom growth (Table 4.8; Table 4.10). However, high rainfall, and subsequent flooding of the local area, prior to the field survey may have affected nutrient distribution and therefore diatom composition. Five species known to colonise waterways with eroded sediment and/or elevated nutrient concentrations were recorded across all sites, reflecting the generally impacted nature of the local catchment (*Hantzschia amphyioxys*, *Luticola mutica*, *Melosira varians*, *Nitzschia acicularis*, *Nitzschia palea*). One frustule of *Eunotia pectinalis*, considered to be an indicator of pristine conditions, was recorded at Paradise Creek (PC01); however, this site was characterised by erosion and scouring along the bank edges and the bed (Table 6.2).

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

A total of 32 taxa were identified from the periphyton samples collected at five sites during the February-March 2022 field survey (Table 6.10; Figure 6.2). This includes representatives from three phyla: Bacillariophyta (diatoms), Chlorophyta (green algae) and Cyanophyta (blue green algae). All taxa were identified to genus level.

Abundance varied greatly between sites with PHF19 showing the lowest abundance with 48431 cells recorded and PHF11 showing the highest abundance with 102535 algal cells recorded Table 6.10. Diversity was relatively consistent across sites, ranging from 16 taxa recorded at PHF14 and PHF19 to 19 taxa recorded at PHF01. All three phyla were recorded at each of the five survey sites (Table 6.10).

The phylum Bacillariophyta was dominant in terms of diversity (15 taxa) and abundance (178474 cells), followed by Cyanophyta (10 taxa; 20166 cells), then Chlorophyta (7 taxa; 40573 cells) (Table 6.10).

Of the bacillariophytes, *Navicula* was the most abundant. *Navicula* was recorded at all sites and ranged in abundance from 800 cells at PHF19 to 51100 cells at PHF11 (Table 6.10). *Rhoicosphenia* was next most abundant. *Rhoicosphenia* was recorded at four sites and ranged in abundance from 160 cells at PHF01 to 39300 cells at PHF06 (Table 6.10). *Aulacoseira*, *Achnanthidium* and *Cyclotella* were the least abundant of the bacillariophytes (600 cells, 320 cells and 25 cells respectively). All three taxa were recorded at one site only. *Navicula* is often found in freshwater and nutrient rich wetlands and is typically found on benthic substrate. *Navicula* is considered common and is broadly distributed across much of the world (Guiry & Guiry, 2012).

Oedogonium was the most abundant of the Chlorophyta (31927 cells) and was found across all five survey sites with the highest abundance at PHF19 (28000 cells) (Table 6.10). *Stigeoclonium* was the next most abundant (3670 cells) and was found at three of the five survey sites (Table 6.10). *Chodatella*_(*Lagerheimia*) and *Staurastrum* were the least abundant of the Chlorophyta (60 and 40 cells respectively. Both were recorded at PHF01 only (Table 6.10). *Oedogonium* are a common green algae typically found in lakes, ponds and the margins of slow moving streams and rivers (Manaaki Whenua Landcare Research, 2022).

Of the Cyanophyta phylum, *Phormidium* was the most abundant taxa with 8013 cells collected at four sites (Table 6.10). *Planktothrix* was the next most abundant with 5330 cells (collected at PHF19 only) (Table 6.10). *Dolichospermum* (straight) was the least abundant with 26 cells only and collected from PHF19 only (Table 6.10).

The cyanophytes *Anabaena* and *Dolichospermum circinale* were recorded at relatively low abundances with 515 cells of Anabaena recorded in approximately equal number at PHF11 and PHF14. A total of 140 *Dolichospermum circinale* cells were recorded at PHF01 and 38 cells at PHF19 (Table 6.10). Both species as well as *Planktothrix* have the potential to produce toxins. The *Anabaena* genus, its distribution and toxicity are described in the previous results from the survey undertaken in August 2020. *Dolichospermum* and *Planktothrix* are two of the main toxin producing algae (Dadheech, et al., 2014). *Dolichospermum* is known to occur in environments where nitrogen is low, eutrophication is present and temperatures are high (Rousso, et al., 2022). *Planktothrix* is also associated with eutrophic conditions and (temperate) warmer conditions (Kyle, Anderson, Haande, & Rohrlack, 2015).

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

Table 6.9 Diatom taxa recorded from the periphyton during the August 2020 field survey

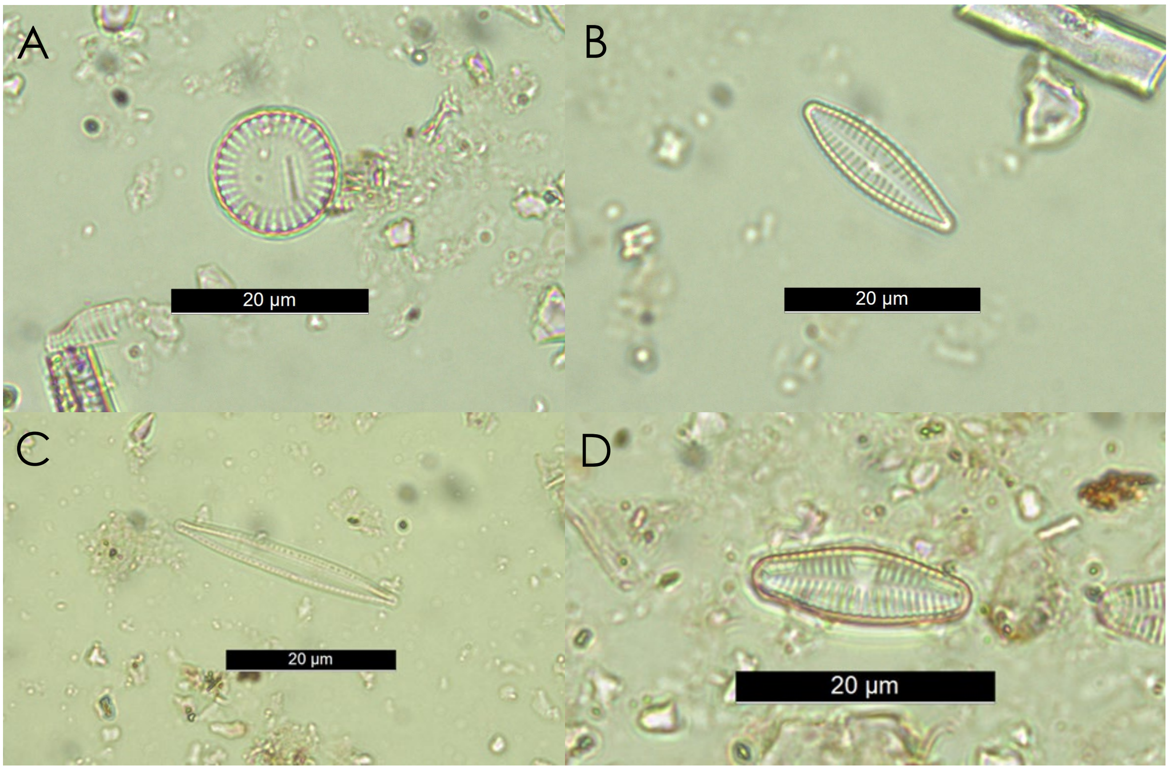
	Jones Oaky Creek	Paradise Creek	Terrible Billy Creek	Dungowan Creek				Peel River
Diatom Taxa	**JC01**	**PC01**	**TBC02**	**DC01**	**DC02**	**DC03**	**DC04**	**PR01**
Achnanthidium minutissimum					2	3		
Achnanthidium oblongella		9						
Amphicampa mirabilis								
Anomoeoneis sphaerophora								
Cocconeis placentula								
Cyclotella meneghiniana			1				1	4
Cylindrotheca closterium	1							
Cymbella cistula								
Cymbella tumida								
Diatoma vulgaris								72
Encyonema minutum			2					
Encyonopsis microcephala								
Epithemia gibba								
Eunotia bilunaris								
Eunotia pectinalis		1						
Fragilaria capucina			9	2			4	
Gomphonema affine								

Table 6.9 Diatom taxa recorded from the periphyton during the August 2020 field survey

	Jones Oaky Creek	Paradise Creek	Terrible Billy Creek	Dungowan Creek				Peel River
Diatom Taxa	**JC01**	**PC01**	**TBC02**	**DC01**	**DC02**	**DC03**	**DC04**	**PR01**
Gomphonema parvulum		8		10	8	3	2	1
Gomphonema truncatum								
Gomphonema undulatum								
Gyrosigma spencerii								
Hantzschia amphyioxys				1				
Hippodonta capitata						1		
Kolbesia ploenensis								
Lemnicola exigua								
Luticola mutica	3							
Melosira varians		19	27		6	3		7
Meridion circulare	12			4	3			
Navicula cryptocephala						7		1
Navicula rhynchocephala				1			4	
Navicula subrynchocephala					5	11		
Navicula viridula								9
Nitzschia acicularis								3
Nitzschia palea		15	4	45	11	11	24	3

Table 6.9 Diatom taxa recorded from the periphyton during the August 2020 field survey

	Jones Oaky Creek	Paradise Creek	Terrible Billy Creek	Dungowan Creek				Peel River
Diatom Taxa	**JC01**	**PC01**	**TBC02**	**DC01**	**DC02**	**DC03**	**DC04**	**PR01**
Pinnularia subcapitata								
Pinnularia viridis								
Planothidium lanceolatum	79	48	57	37	58	58	64	
Pleurosigma elongatum						3	1	
Staurosira construens								
Staurosira construens var. *venter*								
Synedra acus	5							
Synedra ulna								
Tryblionella apiculata					7			
Diversity	**5**	**6**	**6**	**7**	**8**	**9**	**7**	**8**
Abundance	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**



Photograph 6.4 Diatom species recorded during the August 2020 field survey (A) *Cyclotella meneghiniana* (B) *Gomphonema parvulum* (C) *Nitzschia palea* (D) *Planothidium lanceolatum*

Table 6.10 Periphyton taxa and abundance recorded during the February-March 2022 field survey

	Peel River				
	PHF01	**PHF06**	**PHF11**	**PHF14**	**PHF19**
Bacillariophyta					
Achnanthidium					320
Aulacoseira	600				
Bacillaria			2200	1600	3950
Cocconeis		700	300	175	
Cyclotella				25	
Cymbella	4		1100		
Diatoma	60	2950	900		
Gomphonema	500	6800	700	375	2800
Gyrosigma			1100	100	150
Melosira	820	2400	3800	1980	4650
Navicula	2700	950	51100	2600	800
Nitzschia	40	750	1900	375	900
Pennales		2250	19600	1520	
Rhoicosphenia	160	39300	9200	900	
Synedra	1600		600	50	120
Chlorophyta					
Cladophera	156	1480	90		230
Chodatella_(Lagerheimia)	60				
Oedogonium	532	1790	1480	125	28000
Rhizoclonium	168		2550		
Spirogyra	16	36			150
Staurastrum	40				
Stigeoclonium	1140	2400		130	
Cyanophyta					
Anabaena			275	240	
Calothrix		186			
Dolichospermum circinale	140				38
Dolichospermum (straight)					26
Lyngbya	904	62	1660	114	

Table 6.10 Periphyton taxa and abundance recorded during the February-March 2022 field survey

	Peel River				
	PHF01	PHF06	PHF11	PHF14	PHF19
Oscillatoria		220			
Phormidium		2580	3980	554	899
Planktothrix					5330
Pseudoanabaena		1100			68
Scytonema	1790				
Diversity	**19**	**17**	**18**	**16**	**16**
Abundance	**11430**	**65954**	**102535**	**10863**	**48431**

Note Yellow shading indicates taxa is potentially bloom-forming and toxic.

iii Macrophytes

A total of three macrophytes from three angiosperm families were recorded from two sites during the August 2020 field survey (Table 6.2). Mat Rush (*Lomandra hystrix*; Asparagaceae) was recorded within Jones Oaky Creek (JC01), and Water Milfoil (*Myriophyllum* sp.; Haloragaceae) and Curlyleaf Pondweed (*Potamogeton crispus*; Potamogetonaceae) were recorded within the Peel River (PR01). The absence of macrophytes at the remaining six sites may be attributed to the ephemeral nature of the waterway, the location of the waterway within an agricultural area, or recent high rainfall and resultant scouring and erosion of the waterway.

A total of three macrophyte species from three angiosperm families were recorded from two sites on the Peel River during the February-March 2022 field surveys (Table 6.2). Common Reed (Phragmites australis: Poaceae) and Watermilfoil were recorded at PHF09 (Table 6.2) and Common Reed and Curlyleaf Pondweed were recorded at (PHF17).

Mat Rush grows on sandy soils near streams and is widespread throughout upland and mountainous rainforest areas within NSW and Queensland (WA Department of Biodiversity, Conservation and Attractions, 2022a). The genus *Potamogeton* may inhabit a wide range of stationary to high flow fresh to saline waterways, and *Potamogeton crispus* is native to a number of countries including Australia. It is a widespread, common species and is generally restricted to lowland areas. It grows in muddy or silty substrates and tolerates elevated concentrations of nutrients (WA Department of Biodiversity, Conservation and Attractions, 2022b). Water Milfoil is found Australia wide, with the *Myriophyllum* genus present within a range of habitats and a range of growth forms (ie submerged or emergent). The specimen was not able to be identified due to limited emergent growth and a lack of inflorescence. Common Reed is widely naturalised throughout Australia. Common Reed can form very large dense stands and often out competes other macrophytes having the effect of reducing biodiversity. Common Reed can reproduce via seed production or asexually via rhizomes. Disturbance that removes competitors and enriches nutrients strongly promotes the spread of this species (WA Department of Biodiversity, Conservation and Attractions, 2022c).

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

6.1.4 Aquatic invertebrates

SIGNAL2 is a biotic index based on the tolerance or intolerance of biota (macroinvertebrates) to water pollution. Sites with high scores are likely to have low nutrient, salinity and turbidity levels and high oxygen levels but its accuracy in identifying toxicants is less certain (EPA, 2021). As some biological objectives use the SIGNAL scores, these have been provided but SIGNAL2 uses updated, refined scores (Chessman, 2003).

The Ephemoptera, Plecoptera, Trichoptera (EPT) score indicates the number of families that are sensitive to pollution that are present at the site with a low score usually indicating that there has been some type of disturbance. Together, these scores give a good picture of the health of the waterway at a site and potentially what is causing any disturbance. Taxa richness, measured by the number of macroinvertebrate families collected, can give a good overview of the health of a waterway. High numbers (invertebrate families or diversity) are associated with diverse habitats present at the site but can also be influenced by mild nutrient enrichment which can increase the food supply. The score can be combined with SIGNAL2 scores as in Figure 6.3 to help interpret results.

Table 6.11 Biotic indices for all sites sampled in 2022 by Austral and historically sampled sites (marked with *). All values are for edge sites unless in brackets (riffle sites).

Waterway	Sampled year	Site	SIGNAL	SIGNAL2	Number of families	EPT
Dungowan Creek	2020	DC01	5.18	4.45	11	4
	2022	DC08	5.25	4.3	20	6
	2022	DC09	5.7	4.25	20	8
	2020	DC02	5.89	4.61	18	7
	2022	DC10	5.27	4.09	22	7
	2020	DC03	5.79	4.71	14	6
	2020	DC04	5.69	4.44	16	6
Peel River	2022	PHF01	5.4 (5.00)	3.7 (4.73)	10 (9)	3 (3)
	2022	PHF06	5.47	4.32	19	6
	2020	PR01	5.38	3.88	27	7
	2022	PHF11	5.88 (5.35)	4.19 (4.77)	16 (6)	4 (5)
	2022	PHF14	5.43	4.52	21	7
	2022	PRO3	5.59	4.41	17	5
	2022	PHF19	5.42	4	19	7
Terrible Billy Ck	2020	TBC01	6.31	5.08	14	6
Jones Oakey Ck	2020	JC01	5.57	4.86	14	6
Paradise Ck	2020	PC01	6.29	5.07	14	5

Sites DC01, DC02, DC03 and DC04 on Dungowan Creek, site PR01 on the Peel River and sites TBC01, JC01 and PC01 on Terrible Billy, Jones Oakey, and Paradise Creeks (tributaries of Dungowan Creek) were sampled by EMM in 2020. All other sites listed above were sampled by Austral Research and Consulting in late January, February and March in 2022. Most sites consisted of pools but two sites, PHF01 and PHF11 on the Peel River had riffle habitat present at the time of the survey which was sampled and the data presented in brackets in the above table.

The following sites were located close together but were sampled across the two surveys efforts (2020 and 2022),

- DC01 and DCO8 are approximately 200 meters apart;
- DC02 and DC10 are approximately 85 meters; and
- PHF06 and PR01 are approximately 600 meters apart.

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 6.3 where quadrant boundaries are defined according to Chessman (2003) with the top right quadrant containing 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) however site PR01 which has the greatest number of taxa (27) and the second highest number of EPT taxa (7) has the second lowest SIGNAL2 score (3.88). As this is a historical site and was not sampled by Austral it is difficult to make further comment. PHF01 on the Peel River immediately below the dam has the lowest scores overall and may be evidence of impacted flows and CWP. The macroinvertebrate data collected provides a baseline data set that may assist with future waterway monitoring including monitoring the impacts of the project.

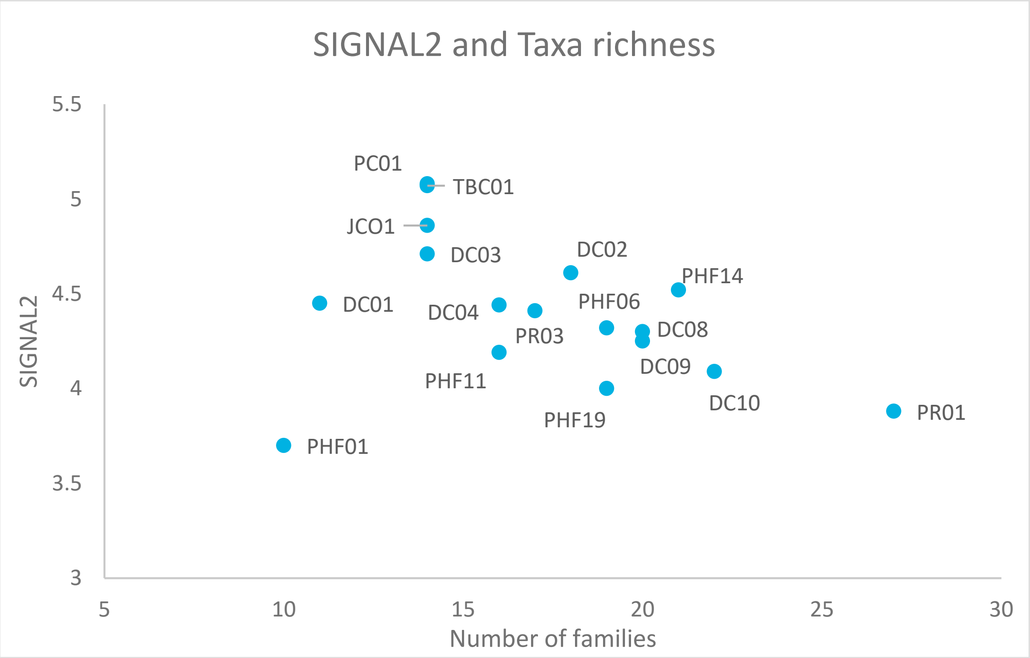


Figure 6.3 SIGNAL2 index plotted against number of families recorded for each site.

6.1.5 Aquatic vertebrates

A total of six aquatic vertebrate fauna species were recorded during the August 2020 field survey, including representatives from five families (Table 6.12). Five fish species, comprising one threatened species and one species of a threatened population were recorded (Murray Cod and Eel-tailed Catfish, respectively). The remaining species comprised a species of carp gudgeon, the River Blackfish[9] and the Australian Smelt. Observations of fish species were restricted to the Peel River, with no fish species recorded by any method from any of the other seven sites (Table 6.12). The Murray Cod was recorded via two survey methods (electrofisher, observation) and comprised juvenile (Photograph 6.5) and adult specimens. The Eel-tailed Catfish was recorded via two methods (eDNA, electrofisher) with the live specimen considered to be a juvenile due to its length of 4 cm (Photograph 6.5).

A total of 15 aquatic vertebrate fauna species were recorded during the February-March 2022 field survey or through eDNA, including representatives from 12 families (Table 6.13). Fourteen fish species, comprising two threatened species and one species of a threatened population were recorded (Murray cod, Silver Perch and Eel-tailed catfish, respectively). Eight species are listed as forming part of the assemblage that comprise a Threatened Ecological Community (Darling River EEC; Bony bream, Carp gudgeon, River blackfish, Murray cod, Golden perch, Eel-tailed catfish, Australian smelt and Silver Perch). The remaining native species comprised Mountain galaxias only, which was observed at 6 sites within Dungowan Creek (DC08, DC09, DC10, DC11, DC12 and DC16) and one site in the Peel River (PHF15). Five exotic species were observed during the field survey. Species comprised Goldfish (Carassius auratus), Common carp, Eastern mosquitofish, Rainbow trout (*Oncorhynchus mykiss*) and Brown trout (*Salmo trutta*). Common Carp was observed in both Dungowan Creek and the Peel River (Table 6.13). Goldfish and Eastern mosquitofish were observed within the Peel River only (Table 6.13). Rainbow trout and Brown trout were observed in Dungowan Creek only and were only recorded via eDNA (Table 6.13).

Murray cod (Listed as Vulnerable under the EPBC Act) were observed at 12 out of 25 sites via either eDNA or direct observation (Dungowan Creek: DC08, DC11, DC16; Peel River: PR03, PHF01, PHF08 – PHF12, PHF14, PHF15 and PHF23B) and Silver Perch (Listed as Critically Endangered under the EPBC Act) was observed at one site (PHF22A) and recorded via eDNA at one site (PR03). Eel-tailed catfish (Listed as a member of an Endangered population in the Murray-Darling Basin under the FM Act) was observed at 11 out of 14 sites on the Peel River only (PHF01 – PHF13, PHF15, PHF17 and PHF23B) (Table 6.13).

Murray cod tolerate a range of warm water habitats from clear rocky streams to turbid low flow rivers, often occupying main channels of rivers and larger tributaries where it is known to actively hunt throughout the water column (Department of Agriculture, Water and the Environment, 2022a). It has been observed to have a strong association with substantial structural woody habitat close to the riverbank and in parts of the river with deeper low flow water, of which were present at the site during surveys. The presence of large woody debris, trailing riparian vegetation and rocky substrate were observed at most sites, which could provide suitable habitat for the species, particularly in deeper pools. Observations and eDNA results confirm the species is present within both Dungowan Creek and the Peel River.

Silver Perch are known to occupy cool clear water of the upper reaches and highlands and it is thought that they prefer fast flowing conditions around rapids (Merrick & Schmida, 1984) as they have been observed congregating below rapids and weirs (Allen, Midgley, & Allen, 2002). However, this may be coincidental and may coincide with fish encountering a barrier as they attempt to migrate upstream, rather than a preference for flowing water, as evidenced by a lack of fast flowing water within the area of the last known naturally occurring population. It is also suggested that they prefer open water rather than areas of snags and debris (Cadwallader & Backhouse, 1983) demonstrated by visual observation within impoundments; however, DPI Fisheries data indicates that most individuals are caught near snagged habitat. Silver Perch are an omnivorous species, with a diet including insects,

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[9] The River Blackfish is part of a threatened population within the Snowy River catchment but is not considered to be threatened within the Namoi catchment

small crustaceans and vegetation. Silver Perch were last stocked within Chaffey Dam in 2010 (Department of Primary Industries, 2022b) however it is not known whether Chaffey Dam supports a viable, breeding population. Dungowan Creek and the Peel River support habitat types that may be appropriate for Silver Perch in the form of rapids, riffles, and barriers with many sites supporting snagged habitat. Deep pools also exist within both waterways which may provide habitat to the species. Additionally, macroinvertebrates, crustaceans and macrophytes were present at many sites, all of which are potential food sources for Silver Perch. Silver Perch presence within the Peel River was confirmed via both eDNA analysis and direct observation. Whilst there is potential for these records and observations to be stocked individuals, as the Peel River is within the known distribution of the species and supports appropriate habitat it must be assumed that a viable population exists in the area.

The Eel-tailed catfish prefers clear, slow flowing or still water, but are known to inhabit flowing streams with turbid water where suitable habitat exists (Department of Primary Industries, 2022d). They require pebble and gravel substrates for construction of their nests, in which their eggs are guarded. The species feeds on freshwater prawns, yabbies, small fish, snails and aquatic insects and zooplankton. DPI Fisheries mapping data suggests that the species is predicted to be distributed throughout the Peel River and part of Dungowan Creek. Although not detected in Dungowan Creek, cobble and gravel beds as well as food sources such as aquatic invertebrates were present at most sites, potentially providing suitable habitat and food sources. Literature supported the occurrence of the species within Dungowan Creek (GHD, 2019). Direct observation confirms the species is present within the Peel River.

Platypus was recorded at multiple sites during the February-March 2022 field survey (Table 6.13). Platypus was recorded via incidental observation within Dungowan Creek (DC12), then confirmed via positive eDNA results. Positive eDNA results for Platypus were also found at four sites within the Peel River (PR03, PHF11, PHF14 and PHF 19) and equivocal eDNA results were found at both Dungowan Creek and the Peel River (DC10, DC14, DC16, PHF01 and PHF06) (Table 6.13). The location of threatened species recorded during the February-March 2022 field survey are shown in Figure 6.4.

The Platypus is a semi-aquatic mammal that depends entirely on freshwater systems, exhibiting a preference for aquatic habitats comprising a riparian zone with consolidated earth banks stabilised by large trees, overhanging vegetation, abundant in-stream organic matter, coarse woody debris, and coarse channel substrates, as well as a combination of wide stream sections and shallow pools (Bino, 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, Use of time and space by Platypus (Ornithorhynchus anatinus: Monotremata) along a Victorian stream, 1998) indicates that there is a correlation between platypus numbers and 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 overhanging 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. Despite a lack of direct observations eDNA results confirmed the species is present within both Dungowan Creek and the Peel River.

The Lowland Darling River EEC is a lowland riverine environment and is characterised by a variety of habitats of deep channels, pools, wetlands, gravel beds and floodplains, it includes all natural creeks, streams, rivers, lagoons, billabongs, lakes, anabranches, flow diversions to anabranches and floodplains of the Darling (Department of Primary Industries, 2007). The Lowland Darling River EEC is critical for supporting the life cycles of the species comprising its community including 21 native fish species and hundreds of species of native invertebrates. These habitats support an abundance of native fish and invertebrate species, of which many have not been comprehensively studied (Department of Primary Industries, 2007a). The Darling River EEC extends from the base of the Chaffey Dam wall downstream along the Peel River as well as extending some distance up Dungowan Creek from the confluence with the Peel River (Figure 5.6). Given the location of the project within, and adjacent to the

Darling River EEC and the large number of species observed during the surveys that comprise the assemblage that form the Darling River EEC, potential impacts to the Peel River and Dungowan Creek must be assumed to be potential impacts to the Darling River EEC.

Table 6.12 Aquatic vertebrate species presence/absence recorded during the August 2020 field survey

	Jones Oaky Creek	Paradise Creek	Terrible Billy Creek	Dungowan Creek				Peel River
Aquatic vertebrate taxa	**JC01**	**PC01**	**TBC01**	**DC01**	**DC02**	**DC03**	**DC04**	**PR01**
Fish								
Eleotridae								
Carp gudgeon species (*Hypseleotris* sp.)$^{+}$								✓
Percichthyidae								
Murray Cod (*Maccullochella peelii*)$^{+}$								✓
River Blackfish (*Gadopsis marmoratus*)$^{+}$								✓
Plotosidae								
Eel-tailed Catfish (*Tandanus tandanus*)$^{+}$								✓*
Retropinnidae								
Australian Smelt (*Retropinna semoni*)$^{+}$								✓
Mammal								
Ornithorhynchidae								
Platypus (*Ornithorhynchus anatinus*)				✓^				✓*

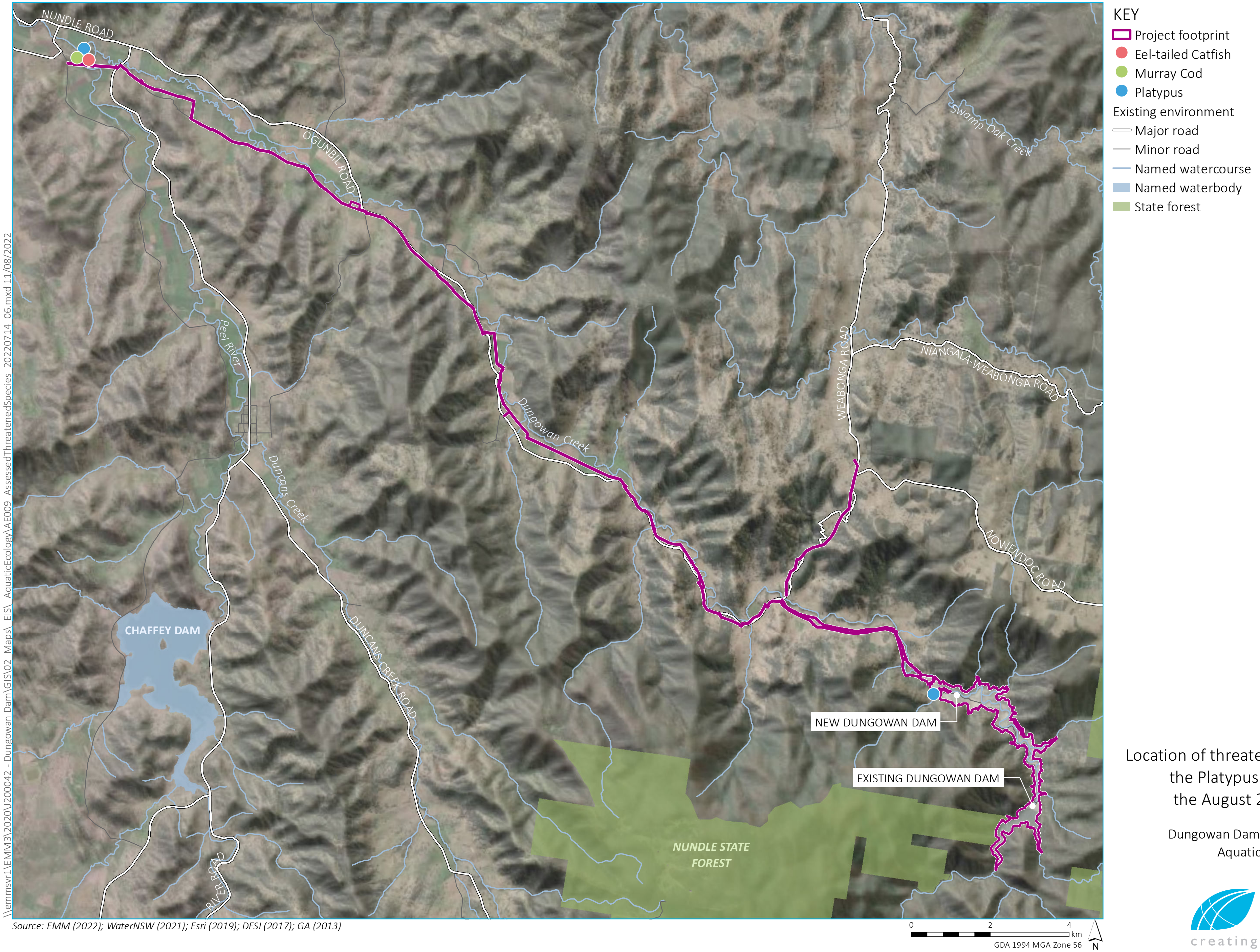
Note Yellow shading indicates a species listed under the FM Act; blue shading indicates a species listed under the EPBC Act; grey shading indicates a species including on the DAWE (2000) provisional management list; ^ indicates result is from an equivocal eDNA result; * indicates at least one result is from a positive eDNA result. $^{+}$Indicates a species listed under the Darling River EEC.

Photograph 6.5 (A) juvenile Murray Cod and (B) juvenile Eel-tailed Catfish recorded during the August 2020 field survey

Table 6.13 Aquatic vertebrate species presence/absence recorded during the February-March 2022 field survey for both Dungowan and Chaffey Dams

Aquatic vertebrate taxa	Dungowan Creek									Peel River															
	DC08	DC09	DC10	DC11	DC12	DC13	DC14	DC15	DC16	PR02	PR03	PHF01	PHF04	PHF06	PHF08	PHF09	PHF11	PHF12	PHF13	PHF14	PHF15	PHF17	PHF19	PHF22A	PHF22B
Native Fish																									
Clupeidae																									
Bony Bream (*Nematalosa erebi*)$^{+}$																								✓	✓
Eleotridae																									
Carp gudgeon species (*Hypseleotris* sp.)$^{+}$					✓						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Galaxiidae																									
Mountain galaxias (*Galaxias olidus*)	✓	✓	✓	✓	✓				✓												✓				
Gadopsidae																									
River Blackfish (*Gadopsis marmoratus*)$^{+}$	✓*	✓	✓*	✓	✓*	✓	✓		✓*		✓*	✓	✓	✓	✓	✓	✓								
Percichthyidae																									
Murray Cod (*Maccullochella peelii*)$^{+}$	✓^			✓					✓		✓*	✓			✓	✓	✓	✓		✓		✓			✓
Golden perch (*Macquaria ambigua*)$^{+}$											✓*													✓	✓
Plotosidae																									
Eel-tailed Catfish (*Tandanus tandanus*)$^{+}$												✓	✓	✓	✓	✓	✓	✓	✓		✓	✓			✓
Retropinnidae																									
Australian Smelt (*Retropinna semoni*)$^{+}$	✓										✓	✓	✓	✓	✓	✓					✓			✓	✓
Terapontidae																									
Silver Perch (*Bidyanus bidyanus*)+											✓^													✓	
Exotic Fish																									
Cyprinidae																									
Goldfish (*Carassius auratus*)																								✓	✓
Common Carp (*Cyprinus carpio*)			✓^						✓^		✓		✓											✓	✓
Poeciliidae																									
Eastern mosquitofish (*Gambusia holbrooki*)											✓				✓		✓		✓					✓	✓
Salmonidae																									
Rainbow Trout (*Oncorynchus mykiss*)	✓*		✓*		✓*																				
Brown Trout (*Salmo trutta*)			✓^																						
Mammals																									
Ornithorhynchidae																									
Platypus (*Ornithorhynchus anatinus*)			✓^		✓*		✓^		✓^		✓*	✓^		✓^			✓*			✓*			✓*		

Note Yellow shading indicates a species listed under the FM Act; blue shading indicates a species listed under the EPBC Act; grey shading indicates a species included on the DAWE (2000) provisional management list; ^ indicates result is from an equivocal eDNA result; * indicates at least one result is from a positive eDNA result. $^{+}$Indicates a species listed under the Darling River EEC.



Source: EMM (2022); WaterNSW (2021); Esri (2019); DFSI (2017); GA (2013)

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Location of threatened species and the Platypus recorded during the August 2020 field survey

Dungowan Dam and pipeline project
Aquatic ecology assessment
Figure 6.4

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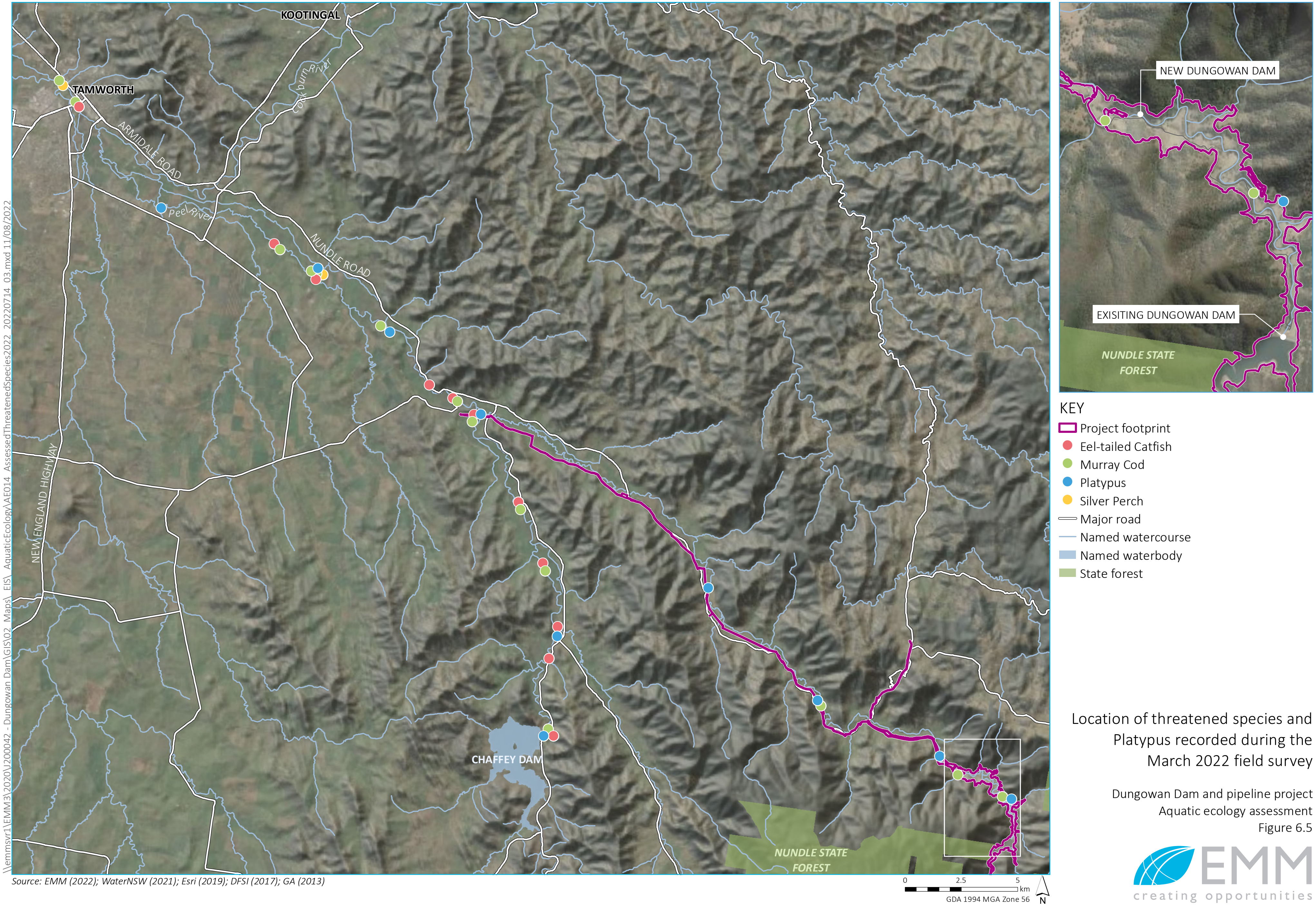

Source: EMM (2022); WaterNSW (2021); Esri (2019); DFSI (2017); GA (2013)

Location of threatened species and Platypus recorded during the March 2022 field survey

Dungowan Dam and pipeline project
Aquatic ecology assessment
Figure 6.5

EMM
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7 Ecological values and environmental receptors

7.1 Aquatic ecological values

The key aquatic ecological values have been identified and discussed in previous chapters (Chapter 5 and Chapter 6) based on the desktop assessments and field investigations and include:

- Native Fish and key fish habitat:
  - Murray-Darling Basin population of Eel-tailed Catfish.
  - Murray Cod.
  - Silver Perch.
- Platypus.
- Lowland Darling River EEC.
- Groundwater Dependant Ecosystems.

7.1.1 Native fish

Many native fish species which were previously found across the Murray-Darling Basin currently have significantly reduced spatial distribution. Reduced spatial distribution has been linked to the introduction of exotic species, fishing, installation of fish barriers such as weirs and dams, cold water pollution due to the operation of dams, water quality changes, and flow regime changes.

The Basin-wide environmental watering strategy (BWS) identifies the Namoi catchment as a target Murray-Darling Basin catchment for expanding the 'core range' of threatened native fish species (ie where populations are in reasonable condition and abundance). This objective is supported by Environmental Water Requirements (EWRs) (described in the Namoi LTWP), which have been developed to support fish migration, spawning, and recruitment at times of the year appropriate to fish species life cycles. The LTWP describes that delivery of the EWRs may result in native fish populations, which currently exist in the Peel River being maintained and becoming more robust and abundant, and native fish species, which previously inhabited the river may return.

Fish species targeted by the LTWP for the Peel River include Murray cod, Silver Perch, Eel-tailed catfish, Southern Purple-spotted Gudgeon and Mountain galaxias. The Peel River between Chaffey Dam and Dungowan Creek is known to support Murray cod and Silver Perch, partly due to artificial stocking of Chaffey Dam (Department of Primary Industries, 2022b). The collection of many young of year (YoY) Murray cod and Eel-tailed catfish in the Peel River and Dungowan Creek indicates that the region supports self sustaining populations of both species, although YoY were less frequently encountered in Dungowan Creek during the surveys.

During drought / cease to flow conditions, fish populations within the Peel River may be maintained within pool refuges. During these times, water levels within pools may be maintained for a time by connection with the alluvial groundwater system, but regular flushing of pools is required to prevent fish kills.

7.1.2 Platypus

Habitat for platypus is prevalent throughout the Peel River and Dungowan Creek. Visual observations during field surveys and eDNA analyses revealed that platypus is present within both Dungowan Creek and the Peel River (Table 6.12 and Table 6.13). Platypus were recently listed as Near Threatened by the International Union for the Conservation of Nature (IUCN) (Woinarski & Burbidge, 2016; Woinarski, et al., 2014) and Vulnerable in Victoria. While the Platypus is not currently listed under the FM Act or the EPBC Act, there is currently a lack of knowledge regarding species abundance at a local catchment level (Australian Museum, 2019) and the species is subject to similar impacts as threatened fish, including waterway bank erosion, channel sedimentation, regulated waterways, barriers to water flow (eg dams and weirs), riparian zone degradation and loss of riparian vegetation (Bino, et al., 2019; Temple-Smith & Grant, 2003). The Platypus was included on the DAWE (2020) provisional list of animal species identified as requiring immediate urgent management intervention in February 2020, following the 2019/2020 bushfire season in southern and eastern Australia (20 March 2020). During times of drought or low flow there is the potential for the loss of shallow riffle habitat within Dungowan Creek, which is considered feeding habitat for platypus.

7.1.3 Lowland Darling River EEC

The Lowland Darling River EEC is a lowland riverine environment and is characterised by a variety of habitats of deep channels, pools, wetlands, gravel beds and floodplains, it includes all natural creeks, streams, rivers, lagoons, billabongs, lakes, anabranches, flow diversions to anabranches and floodplains of the Darling River ((Department of Primary Industries, 2007a)). The Lowland Darling River EEC is critical for supporting the life cycles of the species comprising its community of which many have not been comprehensively studied, including 21 native fish species and hundreds of species of native invertebrates. These habitats support an abundance of native fish and invertebrate species, of which many have not been comprehensively studied (Department of Primary Industries, 2007b).

This EEC includes all native fish and aquatic invertebrates within all waterways associated with the Darling River, including the Peel River downstream of Chaffey Dam ((Fisheries Scientific Committee, 2007)). The Lowland Darling River EEC occurs within the area of direct impact and has the potential to be directly impacted by changes to flow within the Peel River, or indirectly impacted by construction and changes to flow occurring on Dungowan Creek. A significant cause of degradation to the Lowland Darling River EEC within the Namoi catchment is the modification of natural flow attributed to river regulation (Department of Primary Industries, 2007b). Other factors contributing to habitat degradation include agricultural practices, removal of in-stream woody debris and cold water release from dams.

7.1.4 Groundwater Dependant Ecosystems

The upper Peel River is considered to range from having a moderate to high potential to support GDE (Figure 5.9) (Bureau of Meteorology, 2022b), likely receiving baseflow from alluvial groundwater systems, which enable the river to be permanently inundated if surface flow ceases. Small pockets of alluvium are connected with permanent waterways and usually provide small baseflow contributions after heavy rain. This means that parts of the waterway should contain areas of permanent surface water at most times of the year, potentially providing areas of aquatic fauna refuge. Downstream of the new Dungowan Dam, the lower Peel River, Goonoo Goonoo Creek and the Namoi River (Figure 5.9) are considered to receive baseflow (ranging from low to high potential to support GDE) (Bureau of Meteorology, 2022b) and are also likely to contain permanent water, potentially reduced to pools during dry conditions. These waterways are important in terms of sustaining semi-permanent to permanent aquatic ecological communities, as well as ecosystems downstream of the project. The identified waterways are considered to be gaining waterways which would be permanently inundated, except during extreme drought conditions. The groundwater system (alluvial aquifer) is likely to contribute baseflow to the Peel River, Goonoo Goonoo Creek and Namoi River.

7.2 Environmental receptors and impact pathways

The Namoi LTWP (Department of Planning, Industry and Environment, 2020) describes priority environmental assets and values within the Peel Regulated River and Upper Peel Tributaries as rivers, creeks, wetlands & their associated floodplains & water-dependent native vegetation which support:

- water-dependent bird species;
- native fish species and native fish habitat;
- native water-dependent plant communities; and
- registered cultural assets.

It is noted that the LTWP states that “no water-dependent cultural assets were found in the known site data” for the Peel Regulated River and Upper Peel Tributaries, however a cultural mapping exercise undertaken as part of the Aboriginal Cultural Heritage Assessment (EMM, 2022f) did identify some cultural connections to the rivers and creeks in the locality. These included associations with the Catfish as a Creation Ancestor, and frequent mention of fishing and hunting along the river in living memory that suggests that Dungowan Creek and Peel River play an important role in the culture of the local community.

Water dependent bird species impacts have been addressed in the BDAR - appended to the EIS (EMM, 2022d) and water dependent cultural assets have been addressed in the Aboriginal Cultural Heritage Assessment – appended to the EIS (EMM, 2022f). Native water dependent plant communities consider only the macrophytes as riparian vegetation is addressed in the BDAR (EMM, 2022d). In addition to the above aquatic receptors identified in the Namoi LTWP (Department of Planning, Industry and Environment, 2020) three additional aquatic receptors have been identified and will be considered in the impact assessment:

- Platypus.
- GDE.
- Lowland Darling River EEC.

Base on the desktop review and the collection of field data (Section 6) the construction and operation of the project has the potential to impact aquatic ecology values (Receptors). Table 7.1 summarises the potential pathways for a project activity to impact identified aquatic values during the different stages of the project, construction (C), operation (O) and decommissioning (D) stages. These pathways and potential impacts are discussed in detail along with potential mitigations strategies for the various stages of the project in Chapter 8 and Chapter 9.

Table 7.1 Pathway for impacts and Aquatic Receptors Impacted. Note Project stage O = operation, C = Construction, D = Dam decommissioning.

Pathway	Aquatic Env Receptors possibly impacted					Comments
	Native fish and key fish habitat	Macrophytes	GDE	Platypus	Lowland Darling River EEC	
Poor Water quality as a result of construction activity	C, D	C	-	C	C, D	Poor water quality from construction activities including turbid water discharges and fuels and oils from machinery. Poor water quality has the potential to impact native fish and key fish habitat during construction and decommissioning of the old Dungowan dam. Discharges of turbid water and chemical spills are a risk. Native aquatic vegetation (submerged macrophytes) where present will be susceptible risk associated with turbid water. Platypus are less likely to be directly impacted however poor water quality has the potential to impact food resources.
Fish barriers	O, C	-	-	O, C	O, C	Native fish and key fish habitat have the potential to be impacted during the operation and construction of the new Dungowan Dam. Construction activities will include temporary coffer dams that will impact fish passage. Operational changes that result in lower flows have the potential to restrict fish passage over riffles. Construction of the dam will form a new barrier that will result in the loss of access to ~6.19km of key fish habitat within Dungowan Creek and total of 26.5 km of 3rd order or above waterways. Platypus have the potential to be impacted during the operation and construction of the new Dungowan Dam. Construction activities will include temporary coffer dams that may entrap Platypus during nightly foraging activities and temporarily restrict access to foraging habitat. Operational changes that result in lower flows have the potential to alter riffle habitat and impact feeding habitat. The Lowland Darling River EEC may be impacted by the operation and construction of the new Dungowan Dam though impacts to the EEC's identified fish community. Construction activities will include temporary coffer dams that will impact fish passage. Operational changes that result in lower flows have the potential to restrict fish passage over riffles. Construction of the dam will form a new barrier that will result in the loss of access to 26.5km of Type 1 key fish habitat for the species included in the EEC.

Table 7.1 Pathway for impacts and Aquatic Receptors Impacted. Note Project stage O = operation, C = Construction, D = Dam decommissioning.

Pathway	Aquatic Env Receptors possibly impacted					Comments
	Native fish and key fish habitat	Macrophytes	GDE	Platypus	Lowland Darling River EEC	
Lowering of groundwater	O	O	C, O	O	O	Construction activities that result in the dewatering of groundwater that may temporarily or permanently lower the water table has the potential to impact GDE (stygofauna) through the loss of habitat. Changes to stream flow (Dungowan Creek and Peel River) has the potential to impact the groundwater depending on the interactions between the surface water systems and the groundwater. These changes may result in impacts related associated with altered hydrology if the system becomes a loosing waterway (surface water flows to groundwater), if this is the case the potential impacts of altered hydrology are relevant to the environmental receptors as a result of the operation of the project.
Cold water pollution	O	-	-	O	O	A range of temperature impact to native fish species may occur. CWP has the potential to impact the Lowland Darling River EEC with potential impacts to breeding and recruitment within the impacted area.
Trenching activities and physical removal of habitat	D	C	-	C	C	Physical works and the removal of the existing Dungowan Dam may impact native fish during these works. Likely impact from poor water quality and potential for direct disturbance if fish are using the habitat in the area of works. Macrophytes may be directly impacted by construction activities at crossing locations where trenching is proposed. Platypus burrows may be impacted if present in the proposed crossing locations either directly if disturbed or indirectly if located nearby as a result of the construction activities disturbing natural behaviours. Lowland Darling River EEC may be impacted be trenching activities and the direct removal of habitat. Trenching has the potential to disrupt natural movement patterns and natural behaviours for the EEC. Direct habitat removal may impact breeding opportunities for some species included in the EEC.
Altered hydrology	O, C	O	-	O, C	C, O	Alterations to flow have the potential to impact the life history of native fish and platypus downstream of the project. Loss of breeding and/or foraging habitat may occur should flows be reduced, or increased significantly. Pulse flows have the potential to wash eggs and juveniles downstream into less appropriate habitat putting pressure on the survival of native fish.

8 Construction impacts

8.1 Dam construction

Potential impacts to aquatic ecology values as a result of the new Dungowan Dam construction are discussed below.

8.1.1 Chemicals and fuel spills

Chemical spills or low-level exposure of the aquatic environment to chemicals (eg run-off from machinery, including potential vehicle accidents) would most likely involve hydrocarbon products such as fuels and lubricants. The most likely areas for spills to originate are within the construction footprint during refuelling procedures or from an equipment failure (fuel leak or hydraulic hose failure) during the construction works.

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

8.1.2 Loss of fish passage and impact to key fish habitat

Whilst the existing Dungowan Dam is a barrier to fish movement, no fish passage infrastructure is included in the design of the new Dungowan Dam and, as such, will also pose a barrier to fish passage. In essence, the existing barrier to fish passage on Dungowan Creek will be removed from its current location and established 6.19 km (stream length) downstream.

The construction of the new Dungowan dam will result in a loss of connectivity to fish habitat via two pathways:

1. The loss of fish passage connectivity to key fish habitat above the new Dungowan Dam (including waterways with a 3rd order classification but excluding waterways above the old Dungowan Dam)

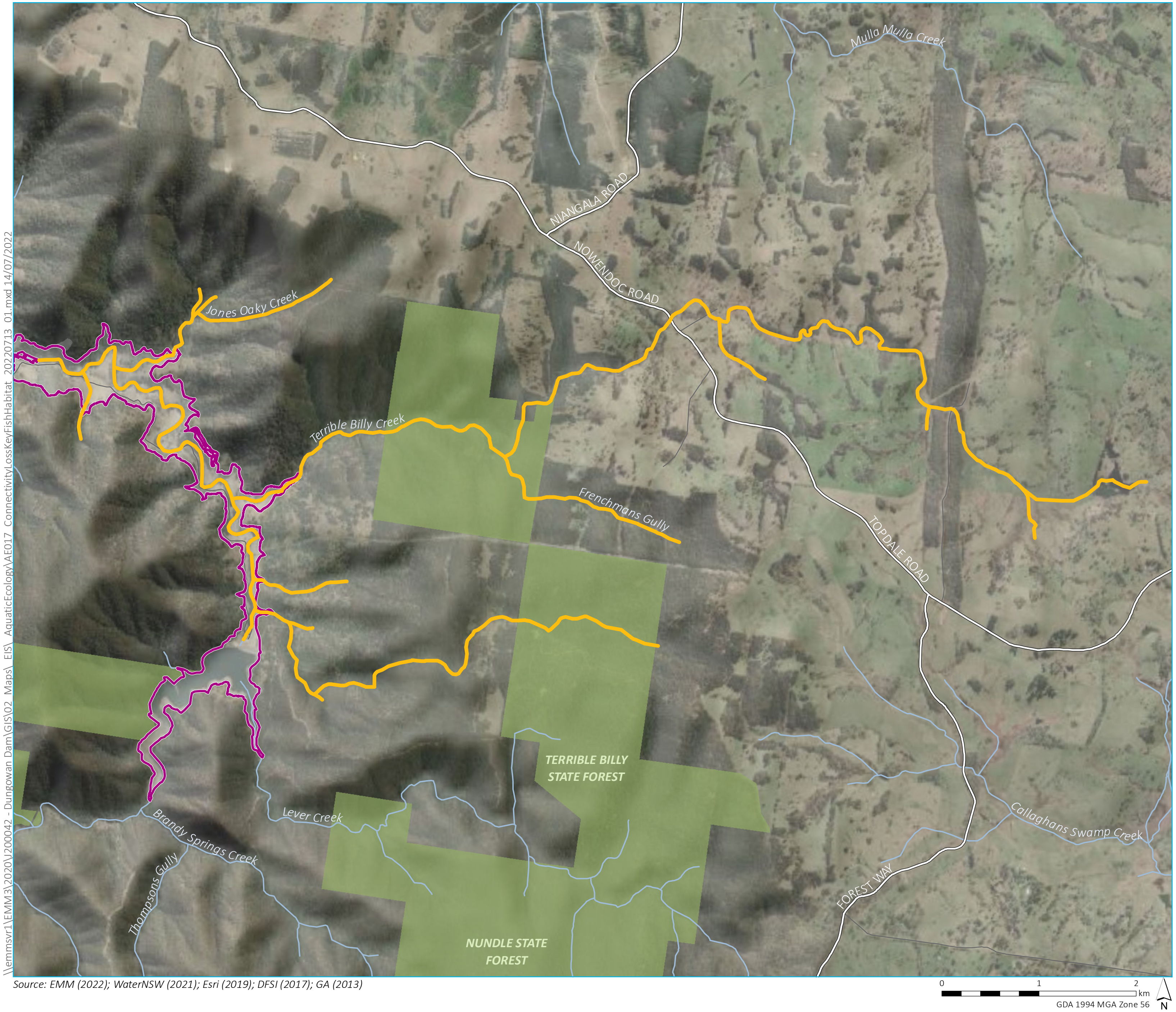
2. The direct impact to key fish habitat as a result of the construction works and inundation of the dam up to FSL.

Impacts as a result of the two separate pathways are discussed below. The following calculations and discussion exclude key fish habitat located above the old Dungowan Dam wall, as this area is already considered a loss to key fish habitat.

i Loss of fish passage connectivity to key fish habitat above the new Dungowan Dam

The loss of fish passage as a result of the new Dungowan Dam construction is detailed in Figure 8.1, and represents a total stream length of 34.2km of waterways classified as 3rd order or above that will lose connectivity. The total length of Dungowan Creek that will be impacted by the project will be 6.19 km (Table 8.1). The other named waterways that will lose connectivity include Terrible Billy Creek (16.9 km), Paradise Creek (5.9 km) and Jones Oaky Creek (3.3 km).

The new Dungowan Dam will not contain any fishway infrastructure to manage this impact. The approach to managing these fish passage impacts have been agreed with DPI Fisheries as downstream existing fish passage barrier remediation, which are discussed in Section 11.1.



Source: EMM (2022); WaterNSW (2021); Esri (2019); DFSI (2017); GA (2013)

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Loss of connectivity of KFH (3rd order or greater) above the new Dungowan Dam

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Aquatic ecology assessment
Figure 8.1

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Table 8.1 Stream length of key fish habitat lost as a result of the construction of the new Dungowan Dam (loss of connectivity)

Waterway name	Strahler Stream order	Class	Length (km)
Paradise Creek	4	Type 3	5.96
(Unnamed waterway)	3		1.02
Dungowan Creek	6	Type 1	6.19
Terrible Billy Creek	4	Type 1	16.97
Jones Oaky Creek	4	Type 1	3.32
(Unnamed waterway)	3		0.74
Total			**34.19**

This loss will be offset by the removal of four barriers to fish passage that currently exist on the Peel River. This offsets pathway is discussed further in section 11.1.

ii Direct impact to key fish habitat from the project

The locations and area calculations of key fish habitat to be impacted as a result of construction works within waterways and following the new Dungowan Dam inundation is outlined below (Table 8.2). These calculations do not include areas located above the FSL. The area for the waterways impacted has been calculated from based on LiDar using GIS software.

Calculations included key fish habitat type ranging from Type 1 highly sensitive key fish habitat to Type 3 minimally sensitive key fish habitat (Table 8.2). There will be a loss of 21390 m^2 of 3rd order stream classified as Type 3 key fish habitat. A loss of 26881 m^2 of 4th order stream classified as Type 1 key fish habitat (Table 8.2). A loss of 1133 m^2 of 4th order stream classified as Type 2 key fish habitat. A loss of 4692 m^2 of 4th order stream classified as Type 3 key fish habitat. A loss of 181 m^2 of 5th order stream classified as Type 1 key fish habitat and a loss of 165282 m^2 of 6th order stream classified as Type 1 key fish habitat (Table 8.2).

Table 8.2 Area of key fish habitat impacted as a result of the construction of the project and inundation to FSL

Waterway Name	Strahler Stream order	Class	Area (m^2)
Paradise Creek	4	Type 3	2251.87
(Unnamed waterway)	3	Type 3	897.69
Dungowan Creek	6	Type 1	164748.58
(Unnamed waterway)	3	Type 3	119.95
(Unnamed waterway)	3	Type 3	849.04
(Unnamed waterway)	4	Type 2	471.11
(Unnamed waterway)	3	Type 3	456.40
Terrible Billy Creek	4	Type 1	15011.39
Jones Oaky Creek	4	Type 1	11489.41

Table 8.2 Area of key fish habitat impacted as a result of the construction of the project and inundation to FSL

Waterway Name	Strahler Stream order	Class	Area (m^2)
(Unnamed waterway)	3	Type 3	7477.04
(Unnamed waterway)	3	Type 3	523.24
Oaky Creek	4	Type 2	662.51
Peel River	6	Type 1	533.84
Johnston Oaky Creek	5	Type 1	181.86
(Unnamed waterway)	3	Type 3	636.54
Big Oaky Creek	4	Type 1	380.85
(Unnamed waterway)	4	Type 3	2440.34
(Unnamed waterway)	3	Type 3	745.91
(Unnamed waterway)	3	Type 3	523.05
(Unnamed waterway)	3	Type 3	66.91
Hell Hole Gully	3	Type 3	95.16
Total			**210,562m^2**

8.1.3 Impacts to GDEs

The Groundwater Impact Assessment (EMM, 2022e) reports the following dam construction components have the potential to impact groundwater:

- Dungowan Dam excavation area: Groundwater is likely to be intercepted in the lower levels of Dungowan Creek when excavating the dam abutment. Temporary dewatering may interfere with nearby groundwater dependent ecosystems (GDEs)
- Spillway excavation area: groundwater is likely to be intercepted when excavating the spillway chute and stilling basin. Temporary dewatering may interfere with nearby GDEs.
- Quarry and borrow areas: groundwater could be intercepted when quarrying for construction materials. Temporary dewatering may interfere with nearby GDEs.

The Groundwater Impact Assessment reports that groundwater seepage from the Dungowan Creek Alluvium (DCA) and Peel Fractured Rock (PFR) groundwater sources to the dam and spillway excavation areas has been predicted using analytical modelling. Predictions estimate that a total of 24.9 megalitres per year (ML/yr) and 3.84 ML/yr is to be taken from the DCA and PFR respectively. Drawdown near the excavations is expected to be localised and temporary due to the sequential nature of the works which would reduce the need for ongoing dewatering during construction. Subsequently, the potential impact to GDEs and groundwater users near the dam and spillway excavation area is negligible to low. There are no groundwater users within the vicinity of the dam and spillway excavation areas and terrestrial and aquatic ecosystems were not found to have a dependent relationship with groundwater.

Further discussion of project impacts on Groundwater Dependant Ecosystems is presented in the Groundwater Impact Assessment (EMM, 2022e).

8.1.4 Water quality

Construction in and adjacent to waterways will result in a range of risks associated with poor water quality. Risks are primarily associated with runoff from cleared areas, construction zones, and stockpiles and associated discharge of turbid water to the aquatic environment.

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

- the development of a site specific CEMP;
- installation of sediment and erosion control measures;
- development of a monitoring program to monitor downstream impacts on water quality during construction and site rehabilitation, turbidity will a key monitoring parameter;
- minimisation of the construction footprint at all phases;
- timing of major earth works to coincide with low rainfall as far as practical;
- staged clearing of vegetation;
- maximise the run off within the project footprint to sedimentation dams; and
- locating stockpiles of excavated materials away from the watercourses and with appropriate runoff and sediment control measures.

8.2 Pipeline construction

8.2.1 Dungowan Creek and tributaries

The pipeline infrastructure will be installed within a 20 m wide construction footprint, including the trench and an area to accommodate construction access, set down points, pipeline stringing and storage areas. This may reduce in width at certain points to avoid constraints and to limit biodiversity impacts. The pipeline will be constructed use both trenching and under boring to cross a number of waterways, which are summarised below and presented in Figure 8.2a and b:

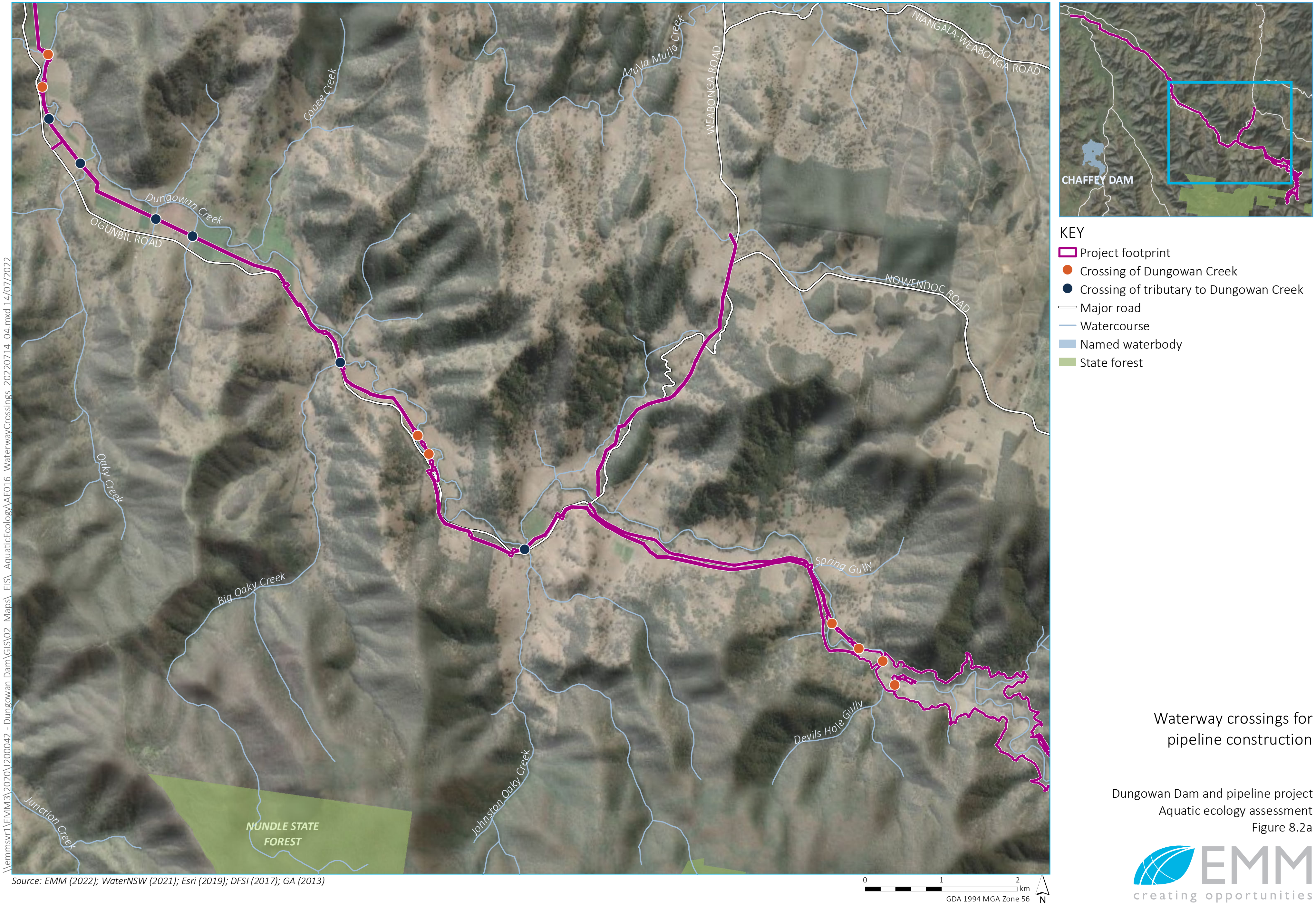
- Dungowan Creek = 8 sites (trenched construction).
- Tributaries of Dungowan = 12 sites (trenched construction).
- Peel River = 1 site (underboring).
- Unnamed tributary of the Peel River = 1 site (trenched construction).

Trenching construction is to be managed through the use of coffer dams and temporary waterway diversions, which will be constructed using bulky bags or aqua bunds with flumes used to divert flows (EMM, 2022a). Key impacts to flowing waterways including Dungowan Creek during pipeline trenching would include:

- Downstream sedimentation and decrease in water quality.
- Removal of key fish habitat in the form of snags, hard substrate and macrophytes.
- Trapping of aquatic fauna between coffer dams during dewatering.

- Entrainment of aquatic fauna during river/creek bypass activities.

Dungowan Creek has been determined to be Type 1 highly sensitive key fish habitat and Class 1 major key fish habitat and supports habitat suitable for supporting a range of Listed aquatic species such as Murray Cod as well as platypus (Table 6.13). Platypus habitat within Dungowan Creek is likely to take the form of both breeding and foraging habitat. Measures to be included in the CEMP to minimise impacts to aquatic species as a result of pipeline construction are detailed within Section 11.2.



Source: EMM (2022); WaterNSW (2021); Esri (2019); DFSI (2017); GA (2013)

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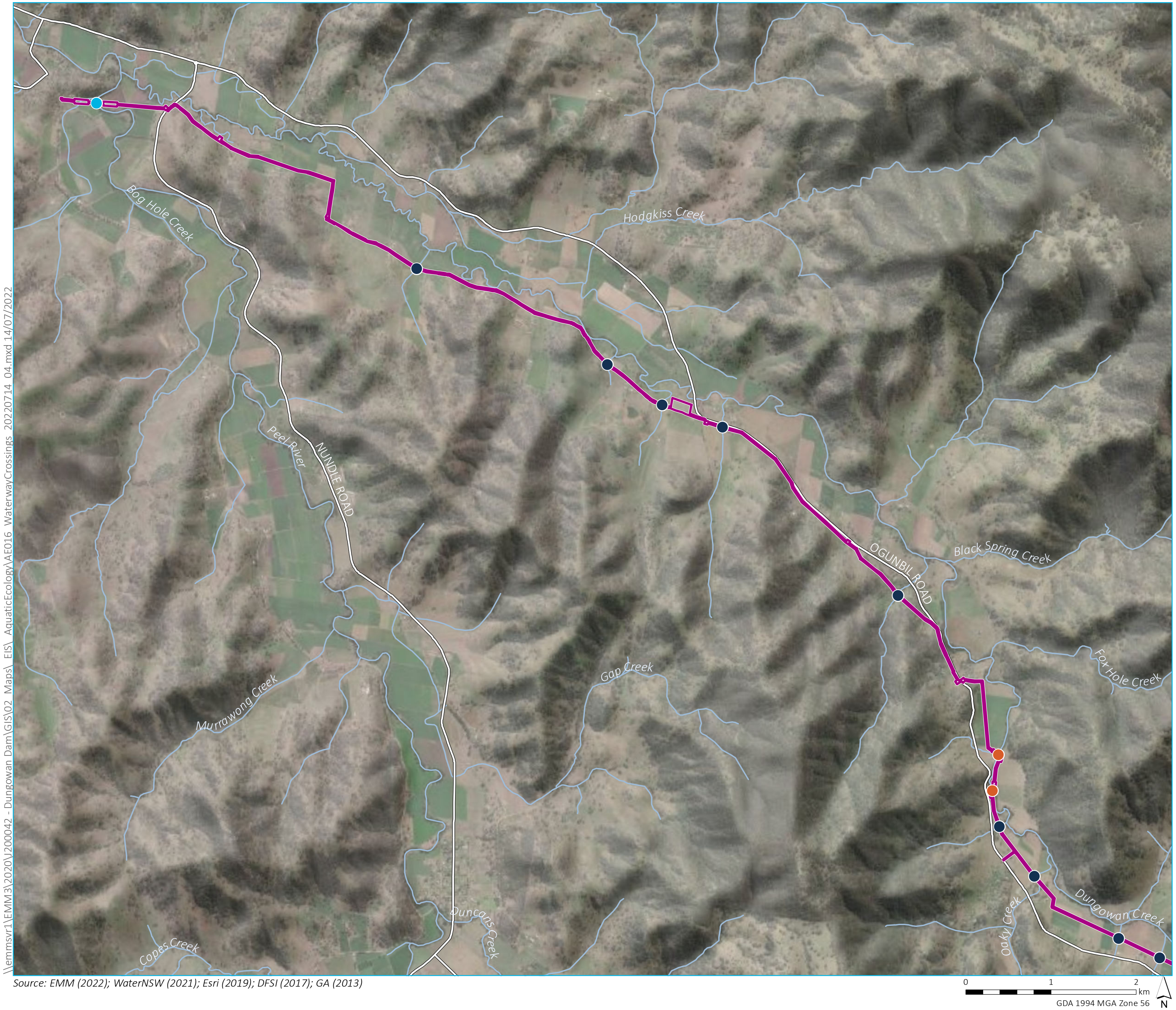
Waterway crossings for
pipeline construction

Dungowan Dam and pipeline project
Aquatic ecology assessment
Figure 8.2a

creating opportunities



Source: EMM (2022); WaterNSW (2021); Esri (2019); DFSI (2017); GA (2013)

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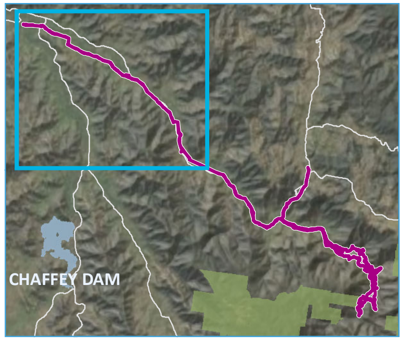

KEY

- ▭ Project footprint
- ● Crossing of Dungowan Creek
- ● Crossing of tributary to Dungowan Creek
- ● Underbore of Peel River
- ═ Major road
- — Watercourse
- ▬ Named waterbody
- ▬ State forest

Waterway crossings for
pipeline construction

Dungowan Dam and pipeline project
Aquatic ecology assessment
Figure 8.2b

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i Impacts to GDEs

The Groundwater Impact Assessment (EMM, 2022e) reports that potential impacts to GDEs with regard to pipeline construction within Dungowan Creek are limited to trenching activities and that groundwater may be intercepted during trenching activities. The trench would be constructed to 1.35 m wide by 2.2 m in depth over a length of 33 km, reducing to 1.75 m in depth along eight proposed crossings of Dungowan Creek (Figure 8.2a and b). Where the pipeline crosses low-lying alluvium or creeks, there is the potential for the interception of shallow groundwater should trenches be open during and immediately after periods of high rainfall. However, based on the available groundwater level data, groundwater seepage is likely to be negligible to small (even during higher rainfall periods) and temporary given the temporary nature of higher groundwater levels observed in the DCA following rainfall. If groundwater is intercepted during trenching, dewatering would cause localised drawdown within the vicinity of the works and has the potential to impact potential GDEs and nearby third-party bores.

ii Fauna passage during pipeline construction

The proposed waterway crossing methodology for pipeline construction is presented in the Appendix B1 to the EIS (EMM, 2022a) and would involve the following activities:

- Installation of environmental controls;
- riparian vegetation clearing;
- establishment of bunding (bulky bag or aquabund);
- dewatering;
- water bypassing;
- excavation and pipe installation;
- backfill and stabilisation of the site; and
- removal of water bypass and coffer dams.

Aquatic fauna (fish, mammal and reptile) passage will be interrupted during the construction period where creek flows will be diverted around the crossing location. Potential impacts will include:

- direct impacts to fauna at the crossing location due to soil disturbance and excavation such as platypus burrows;
- interruption to fauna passage past the crossing location;
- entrapment within the coffer dam; and
- entrainment of fauna in the bypass infrastructure.

iii Water quality

Elevated turbidity and poor water quality impacts could arise from the following activities associated with the water way crossings:

- Site establishment and vegetation clearing in the riparian zone – site establishment will involve the removal of the riparian vegetation and access to the creek crossing from the pipeline corridor. The generation of poor water quality from site establishment is possible via surface runoff over bare or unprotected ground.

- Establishment bunding and instream works – the action of establishing the bund/placement or placement of bulkybags can generate turbidity from the physical nature of the activity as well as that generated by machinery movement as part of the installation process.

- Dewatering of the trench – if the pipe trench is to be dewatered it is likely to be turbid and will not be discharged directly to Dungowan Creek.

- Water bypassing – establishing a bypass for flows is likely to be via the use of a pump and pipe around the trenched crossing at each location. The generation of turbidity from this process can be minimised by protecting suction end of the bypass from resting on loose material on the bed or bank of the creek. Protection around the discharge point to prevent the generation of turbidity will also be installed.

- Demobilisation, removal of bunding and reflooding of the works site – demobilisation including removal of sheet pilling and the reintroduction of flows to the works site has the potential to result in increased turbidity. Overland flows from the construction/pipeline corridor will remain a risk to water quality until site rehabilitation has been completed.

8.2.2 Peel River

i Underbore

The Peel River is to be crossed by the replacement pipeline at one site, detailed in Figure 8.2b.The pipeline is to be installed under the Peel River via a bore that will be drilled at a depth of at least 10m below the river bed. There are unlikely to be any direct impacts to the Peel River as a result of drilling the bore however there is potential for sedimentation of the Peel River to occur from the drilling sites either side of the river.

ii Impacts to GDEs

The Groundwater Impact Assessment (EMM, 2022e) considers the impacts on GDEs as a result of the Peel River bore. Temporary groundwater level mounding may occur where drilling is close to the shallow groundwater table due to the injection of biodegradable drilling fluids. If flow conduits are intercepted when drilling is close to the watertable, mounding could cause drilling fluids to surface into the Peel River and/or migrate to third party bores, altering groundwater quality and possibly levels. No groundwater quality impacts are expected given drilling fluids are biodegradable.

iii Water quality

No instream works are proposed on the Peel River and under boring will be used for the crossing. Potential impacts are restricted to runoff from the pipeline corridor. The CEMP will detail all of the mitigation measures that will be used to address potential water quality impacts. Mitigation measures will be implemented to meet water quality objectives and as such risks to water quality in the Peel River as a direct result of the pipeline construction are expected to be negligible.

8.3 Ancillary infrastructure

Several ancillary facilities and activities are required to enable the construction of the new Dungowan Dam and pipeline infrastructure. Ancillary infrastructure and works will broadly include:

- an accommodation camp;
- construction compounds;
- road upgrade;

- construction materials;
- quarries and borrow areas; and
- construction utilities supply.

The key impacts associated with ancillary infrastructure such as the accommodation camp, the construction compound and the road upgrade will be sedimentation of Dungowan Creek due to runoff from clearing or fill used to level surfaces. Contamination of Dungowan Creek with compounds such as hydrocarbons as a result of fuel spills is also a risk.

To mitigate risks to Dungowan Creek bunding and sediment fencing should be erected between all ancillary infrastructure and Dungowan Creek. Any storage facilities containing toxic chemicals should be located away from the creeks and be surrounded by appropriate bunding to contain spills. Further mitigation and management measures will be included in the CEMP that would be developed for the project.

8.3.1 Chemicals and fuel spills

Impacts to the aquatic environment as a result of chemical and fuel spills from ancillary facilities during construction is similar in nature to those described for the construction of the new Dungowan Dam in Section 8.1.1.

8.3.2 Quarries and borrow areas

The excavation and use of quarries and borrow areas have the potential to negatively impact water quality within Dungowan Creek. Installation of sediment and erosion control measures between any disturbed areas and Dungowan Creek would occur to minimise sediment entering the waterway.

Dust suppression strategies such as watering of roads should be undertaken when conditions require to ensure elevated levels of dust do not become an environmental problem. Appropriate bunding should be installed between the boundary of the ancillary infrastructure and Dungowan Creek and waterways adjacent to any construction areas.

8.3.3 Impacts to GDEs

The Groundwater Impact Assessment undertaken (EMM, 2022e) considers the impacts on GDEs as a result of the quarry and borrow areas.

i Quarry

There is potential for groundwater to be intercepted during excavation of the quarry. The Groundwater Impact Assessment identifies that while groundwater seepage at shallow depths would be minimal, quarrying may cause drawdown, which could impact potential GDEs within the vicinity of works.

ii Borrow Areas

Groundwater is unlikely to be intercepted when excavating borrow material. The targeted material (silty sandy clays) is situated at depths of between 0.15 to 3 m depth and is above groundwater, based on observations made during test excavation field works.

8.3.4 Water quality

Water quality impacts associated with the ancillary infrastructure will be similar to those associated with the new Dungowan Dam construction and are detailed in section 8.1.4.

8.4 Risk assessment for construction impacts

Table 8.3 outlines the risk matrix adopted when assessing construction impacts of the project. Table 8.4 outlines that consequence criteria for the construction impacts and Table 8.5 presents the risk assessment undertaken for the construction impacts of the project. Whilst some mitigation measures are included within this report a comprehensive CEMP will be prepared based on the risk assessment undertaken in this report. In addition to mitigation measures and management actions to be applied through the comprehensive CEMP, potential offsets are to be applied to offset impacts resulting from the proposed action. Offsets are further discussed in section 11.1.

Table 8.3 Risk matrix adopted for the risk assessment for construction

		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**

Table 8.4 Consequence criteria adopted for the risk assessment for the construction

	Insignificant (IN)	**Minor (MI)**	**Moderate (MO)**	**Major (MA)**	**Catastrophic (CA)**
	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

Table 8.4 Consequence criteria adopted for the risk assessment for the construction

	Insignificant (IN)	Minor (MI)	Moderate (MO)	Major (MA)	Catastrophic (CA)
Species Specific (state or nationally listed species)	No detectable permanent impacts on population of a listed species; AND/OR short term removal of >1% of the site population but <1% of the local, regional or state population of a listed species	Permanent removal of >1% of the site population but <1% of the local, regional or state population of a listed species; AND/OR short term removal of >1% of the local population but <1% of the regional or state population of a listed species	Permanent removal of >1% of the local population but <1% of the regional or state population of a listed species; AND/OR short term removal of >1% of the regional population but <1% of the state population of a listed species	Permanent removal of >1% of the regional population but <1% of the state population of a listed species; AND/OR short term removal of >1% of the state or national population of a listed species	Permanent removal of >1% of the state or national population of a listed species
Species Specific Interactions- Aquatic Ecology	No measurable permanent impacts on aquatic ecology values	Minor short term impacts, life cycle may be disrupted but for less than a year. Annual recruitment should still occur. Short and long term viability of individual species not impacted	Medium term (1-2 year) impacts, life cycle disrupted and resulting in no recruitment for a year. Short term viability of individual species impacted recovery within 1 -5 years. Long term viability of species not impacted	Long term (2-5 year) impacts, life cycle significantly disrupted no recruitment for successive years. Short term and long term viability individual species impacted recovery time frame (5-10 years)	Loss of species and population. Minimal possibility of recovery
Surface Water - Water Quality	No measurable change to surface water quality or quality changes are not measurable	Changes to Surface Water quality during the activity, no further changes noted once activity is finished	Changes to Surface Water quality due to activity, recovery up to 1 year	Changes to Surface Water Quality due to activity, recovery 1-2 years	Changes to Surface water quality, where water becomes toxic, or permanent changes to quality, recovery is greater than 2 years
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).

Table 8.5 **Risk assessment for construction Impacts**

Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments incl Uncertainty
Surface Water - Water Quality	Construction activities	Sediment discharged to downstream river and dam during construction process	Appropriate sediment and erosion control measures (iesilt fencing, revegetation, timing of construction, stormwater diversions). Assumes CEMP developed and measures in place for all construction activities.	MI	P	L	Poor water quality due to discharges possible due to natural rainfall events. Risk lowered if all mitigation and management measures followed including monitoring of the measures (ie silt fences)
Surface Water - Water Quality	Construction activities	Chemical or fuel spill from storage areas or when refuelling plant and equipment	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.
Species Specific Interactions- Aquatic Ecology	Construction activities	Loss of access to key fish habitat as a result of dam moving to a downstream location. Will result in a loss of access to 34.2 km key fish habitat including 26.4 km of type 1 key fish habitat.	Loss of key fish habitat to be addressed by the agreed offset plan that will remove fish barriers	CA	AC	E	Impacts to aquatic fauna access to key fish habitat are catastrophic as access to habitat is permanently lost. Offsets have already been agreed and documented in Section 11.1.
GDE	Excavation of Dungowan Dam abutments, and Spillway	Temporary dewatering may be required.	No Proposed mitigation measures in place	MI	L	M	Minor consequence due to localised dewatering. Likely to occur with short term impacts at a local scale. Deemed to be a medium risk.
	Quarry and borrow areas	Temporary dewatering may be required.	No Proposed mitigation measures in place	MI	P	L	Expected to be short term and localised impact if any.
	Pipeline construction	Temporary dewatering may be required.	No Proposed mitigation measures in place	MI	P	L	Expected to be short term and localised impact if any.
Species Specific (state or nationally listed species)	Pipeline Construction activities	Riparian vegetation clearing may impact Platypus burrows	Site inspections and CEMP controls to be followed. Construction to avoid nesting period.	IN	P	L	Considered insignificant assuming nesting period is avoided and CEMP controls such as site inspections are completed. Still possible that Platypus burrow may be located at a crossing location. Risk determined to be low.
Species Specific Interactions- Aquatic Ecology	Pipeline Construction activities	Disruption/prevention of fauna passage	Minimise time required for construction activity and trenching. Timing of construction activity to consider spawning/breeding requirements of aquatic fauna. Prioritise activities outside of the Platypus breeding season (Oct – March).	MI	AC	M	Consequence considered Minor as there may be a disruption to reproductive cycle of aquatic fauna for up to 1 year assuming construction is complete within a year. Impact is certain to occur and therefore risk is deemed medium. If construction occurs over more than a year consequence would increase along with risk.
	Pipeline Construction activities	Entrapment within the coffer dam	As per CEMP fauna salvage within the coffer dam to be completed prior, during and at completion of dewatering	MI	AC	M	Minor consequence as short term disruption. Reproduction should not be disrupted. Almost certain impacts some aquatic fauna. Deemed medium risk.
	Pipeline Construction activities	Entrainment of fauna in the bypass infrastructure (pumps).	Screens and fauna excluders to be fitted to all pumps and bypass infrastructure.	MI	P	L	Considered minor consequence as could impact some recruitment activities. Not likely to impact long term survival of a species. Event is possible and risk is deemed low.
	Pipeline Construction activities	Entrapment of fauna in pipeline trench This is a risk to Platypus	Entrapment of fauna in pipeline trench will be considered in the CEMP. Mitigation measures are fauna fencing and scheduled site inspection before works begin.	IN	P	L	Entrapment of fauna possible after overnight foraging or between work activates at sites during the day (ie over break periods). If CEMP measures and activities are followed likely to be an insignificant impact although it's possible that this will occur. Risk deemed low

Table 8.5 Risk assessment for construction Impacts

Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments incl Uncertainty
Surface water Quality	Construction in and around waterways	Sediment discharged to downstream river during construction process	Additional sediment and erosion control measures to be adopted around waterways.	MI	P	L	Poor water quality due to discharges possible due to natural rainfall events. Risk lowered if all mitigation and management measures followed including monitoring of the measures (ie silt fences)
		Chemical or fuel spill from storage areas or when refuelling plant and equipment	No refuelling in waterways. Refuelling to occur in bunded areas in adjacent to water ways and there is a risk of discharge/spill to waterway.	MO	R	L	Chemical and fuel spills will be rare if all mitigation measures are followed.
	Establishment of Bunding	Action of establishing bunding and machinery movement to conduct the task can generate turbid water.	Instream sediment control measures are to be adopted and a monitoring regime to adopted to monitor water quality, primarily turbidity.	MI	P	L	
	Dewatering of Pipeline trench	Risk of turbid water discharge to waterway	Any dewatered water from the pipeline trench is to be pumped to a settling basin or removed off site for treatment no direct discharge to waterway to occur.	IN	P	L	
	Establishment and operation of creek bypass	Risk of turbid water discharge to waterway at outlet site	Instream sediment control measures to be put in place. Additional protections to be in place at the outlet, ie Geo fabric and riprap to reduce likelihood of the generation of turbid water for operation of the bypass.	MO	P	M	Moderate consequence as the impacts could occur for longer than the activity, likelihood is possible based on the number of crossing and activity. Deemed a medium risk activity if all mitigation measures followed.
	Demobilisation and reinstatement of fish passage and flows.	Demobilisation and reinstatement of flows results in generation of turbid water to downstream locations	Instream sediment control measures are to be adopted and a monitoring regime to adopted to monitor water quality, primarily turbidity.	MO	L	M	Reinstatement of flows through the trenching corridor likely to result in some increases in turbidity. Consequence considered moderate as impacts may occur for a period of time after the demobilisation and reinstatement activity. Impacts will last less than a year.

9 Operational impacts

9.1 Dungowan Creek

The operation of the new Dungowan Dam will have a range of impacts on the aquatic ecology values within Dungowan Creek. Impacts will include changes to hydrology, CWP and fish passage. All potential impacts due to changes to hydrology, CWP and GDEs are based on assessments and modelled data provided as part of the Surface Water Assessment (EMM, 2022b) and Groundwater Impact Assessment (EMM, 2022e).

9.1.1 Changes to hydrology

There is potential for changes to hydrology as a result of the new Dungowan Dam infrastructure. Changes to hydrology is frequently reported as a key threat for many Listed species. Changes to flow within Dungowan Creek has the potential to negatively impact a number of species Listed under the EPBC Act and FM Act (Table 6.12 and Table 6.13).

The key period when flow stability is critical for all species observed during surveys is the spring-summer period. This is the breeding/spawning period for Eel-tailed Catfish, Silver Perch, Murray Cod, Southern Purple-spotted Gudgeon and Platypus. It is imperative that breeding requirements for all species either remain as they are under the current flow regime or are improved under the future flow regimes.

Section 5.9 of this report discusses the breeding requirements for those Listed species that have the potential to be impacted by alterations to flow within Dungowan Creek and the Peel River. Eel-tailed Catfish at a minimum require access to inundated macrophytes prior to, and during breeding. A reduction in flow may result in the abandonment of the nest and without access to inundated macrophytes the species may fail to breed. Southern Purple-spotted Gudgeon requires inundated solid substrate near complex vegetation habitat in order to breed and spawn. If alterations to flow regime result in a pulse of cold water, heavy inundation resulting in an increase in depth, or exposure of the solid substrate upon which eggs are laid breeding can be abandoned or eggs fail to hatch putting pressure on the species and decreasing the likelihood of continuation of the species. Murray Cod are cued to breed and spawn as temperatures increase to 16.5°C – 23.5°C and require inundated hard substrates such as snags, instream woody debris and submerged rocks on which to lay their eggs. A lack of flow at the appropriate time or a pulse of cold water could cause Murray Cod to abandon breeding activity or reduce the area on which eggs may be laid putting undue pressure on the species attempts to persist. Silver Perch are cued to spawn by an increase in water levels and an increase in temperatures to above 23°C. Platypus feed in shallow waters. Shallow waters are at high risk of exposure due to changes in flow regimes.

Appropriate management of the timing, volume and temperature of releases from both the new Dungowan Dam and the Chaffey Dam will be critical to minimising or negating impacts to Listed aquatic species within Dungowan Creek and the Peel River.

This section describes the potential changes to hydrology, based on modelled data presented in the Surface Water Assessment (EMM, 2022b) and determines the likely level of impact of any changes to flow on key Listed species. The general trend for changes in flow is that changes of +/-10ML/day are modelled to occur ~90% of the time. Modelled decreases in flows of ≥10ML/day are expected to be more frequent further downstream.

a Changes to flow at the proposed Dam Outlet

Figure 9.1 shows modelled changes to flow at the new Dungowan Dam outlet, with the current climate and a 20 percent increase in demand with the project infrastructure in place. Figure 9.1 shows total change in addition to seasonal changes to flow for the project. . Flows are modelled to increase by between 2.5 and >100 ML/day up to 12 percent of the time. Flows will increase by approximately 2.5 ML/day from 37 percent of the time. There will be no change to flow 41 percent of the time and flows will decrease from 1 to <100 ML/day for 10 percent of the time.

Modelled seasonal changes will result in a small increase (2-4%) in cease to flow days and there will be a greater increase in high flow days in winter with smaller changes modelled in summer and autumn. Spring flows are modelled to be similar to the annualised (total) change in flow (Figure 9.1).

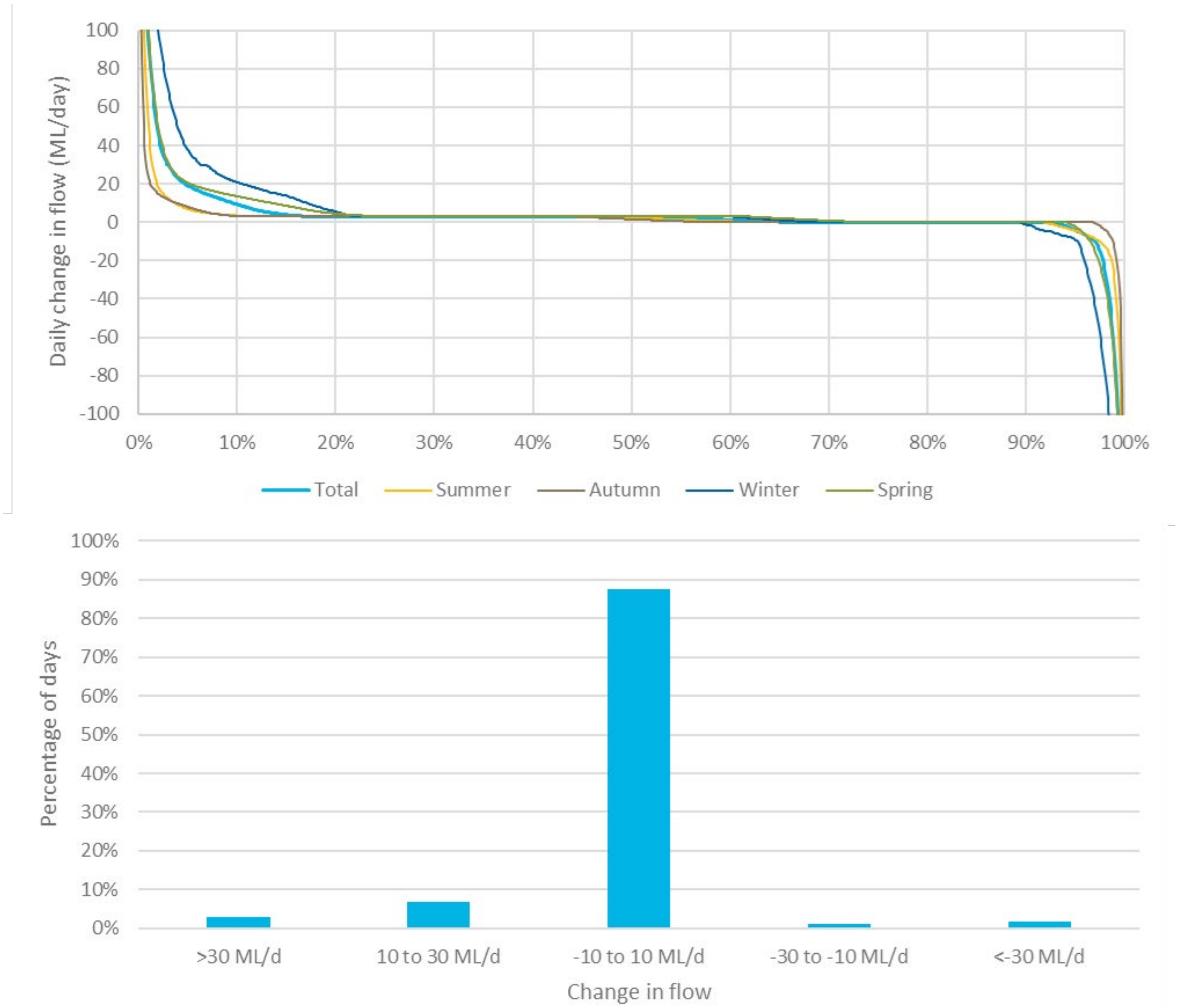


Figure 9.1 Change in daily dam releases from Dungowan Dam, current climate, +20% demand

Figure 9.2 shows modelled changes to flow at the new Dungowan Dam outlet with a future wettest climate change scenario or dry climate change scenario. Figure 9.2 shows total change in addition to seasonal changes. With a future wet climate there will be an increase in flow ranging from 2 ML/day - >100ML/day up to 16 percent of the time. Increases in flow of 2 ML/day are anticipated 41 percent of the time. No change in flow is expected 33 percent of the time. There will be a decrease in flow of between 1 too >100 ML/day 10 percent of the time. There is also a small increase in cease to flow days of ~2 percent.

Seasonal impacts are minor with greater frequency of increased flows occurring in autumn and winter. Changes for summer and spring are similar to the modelled annualised changes. With a future dry climate there will be less seasonal variation in flows (Figure 9.2) and the modelled flows are similar to the wet climate model with the major difference being a decrease in flows approximately 30 percent of the time.

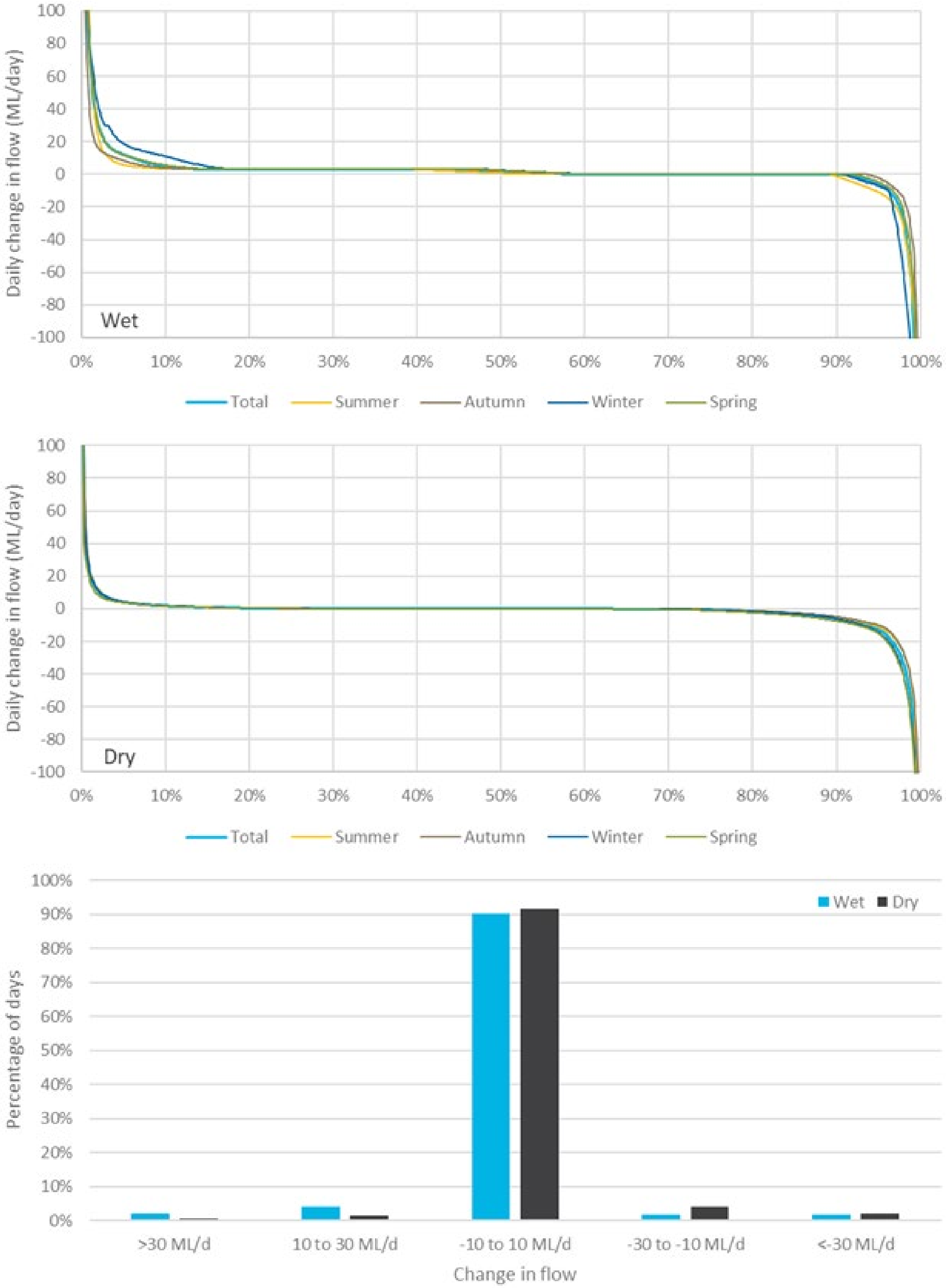


Figure 9.2 Change in daily dam releases from Dungowan Dam, future climate, +20% demand

b Changes to flow 15km downstream of the proposed Dam Outlet

Figure 9.3 shows modelled changes to flow 15 km downstream of the new Dungowan Dam outlet, with the current climate and current demand with the project infrastructure in place. Figure 9.3 shows total change in addition to seasonal changes to flow for the project. Daily changes in flow will increase from approximately 2 – 22 ML/day up to 7 percent of the time. Changes in daily flow will be nil to negligible from 58 percent of the time. Flow will then decrease from 1 - >100 ML/day from 31 percent of the time. Cease to flow period will occur for 4 percent of the time.

Seasonal impacts will be greatest in winter with a reduction in flows 20 percent of the time and an increase of cease to flow days.

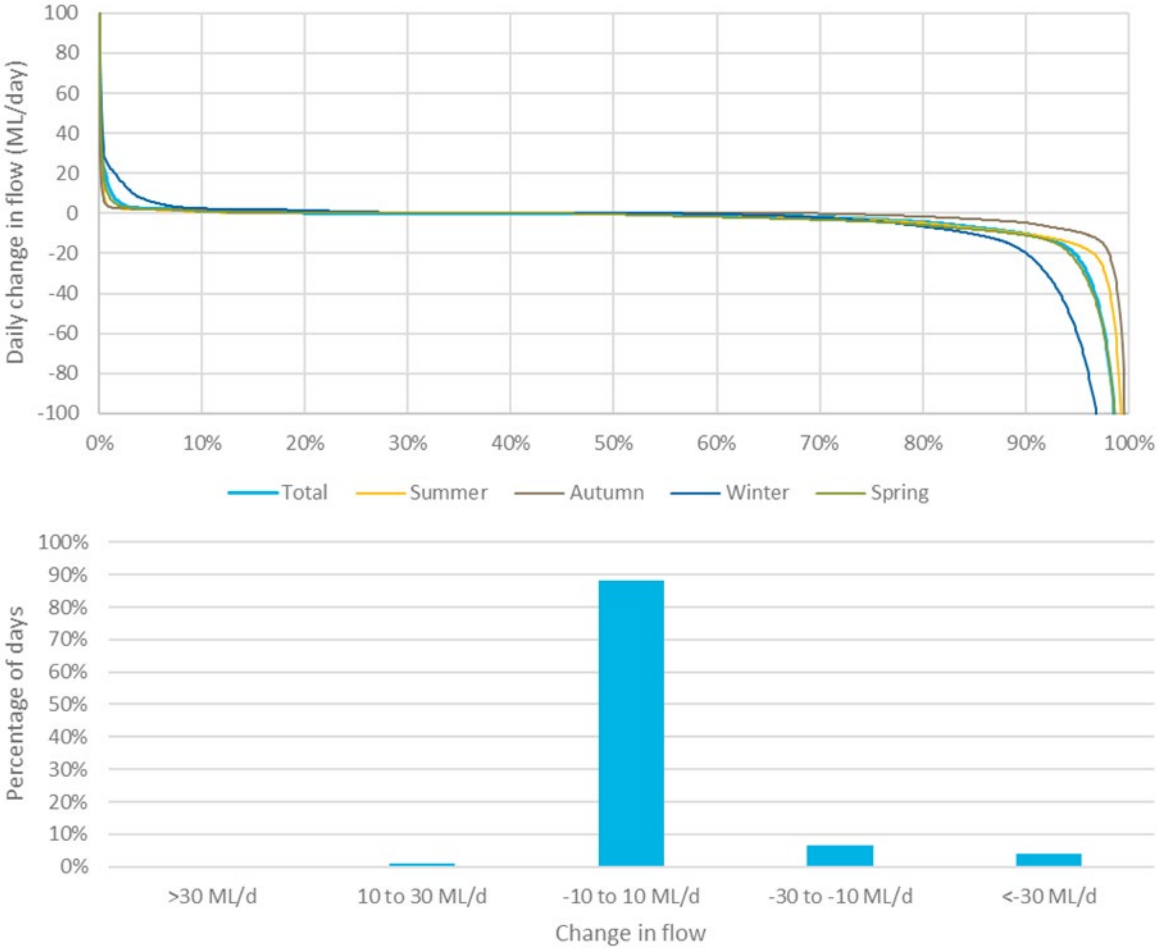


Figure 9.3 **Change in daily flow downstream of new Dungowan Dam location, current climate, current demand**

Figure 9.4 shows modelled changes to flow 15 km downstream of the Dungowan Dam outlet with a future wettest climate change scenario or dry climate change scenario with an increased water demand of 20 percent. Figure 9.4 shows total change seasonal changes. Under both the wet and dry scenario flows will increase between of 1 – 30 ML/day up to 21 percent of the time. There will be no change in flow from 35 (wet scenario) and 50 (dry scenario) percent of the time. Flows will decrease 20 percent of the time under a dry scenario and 40 percent of the time under the wet scenario. Cease to flow periods will increase under both the wet and dry scenario (Figure 9.4).

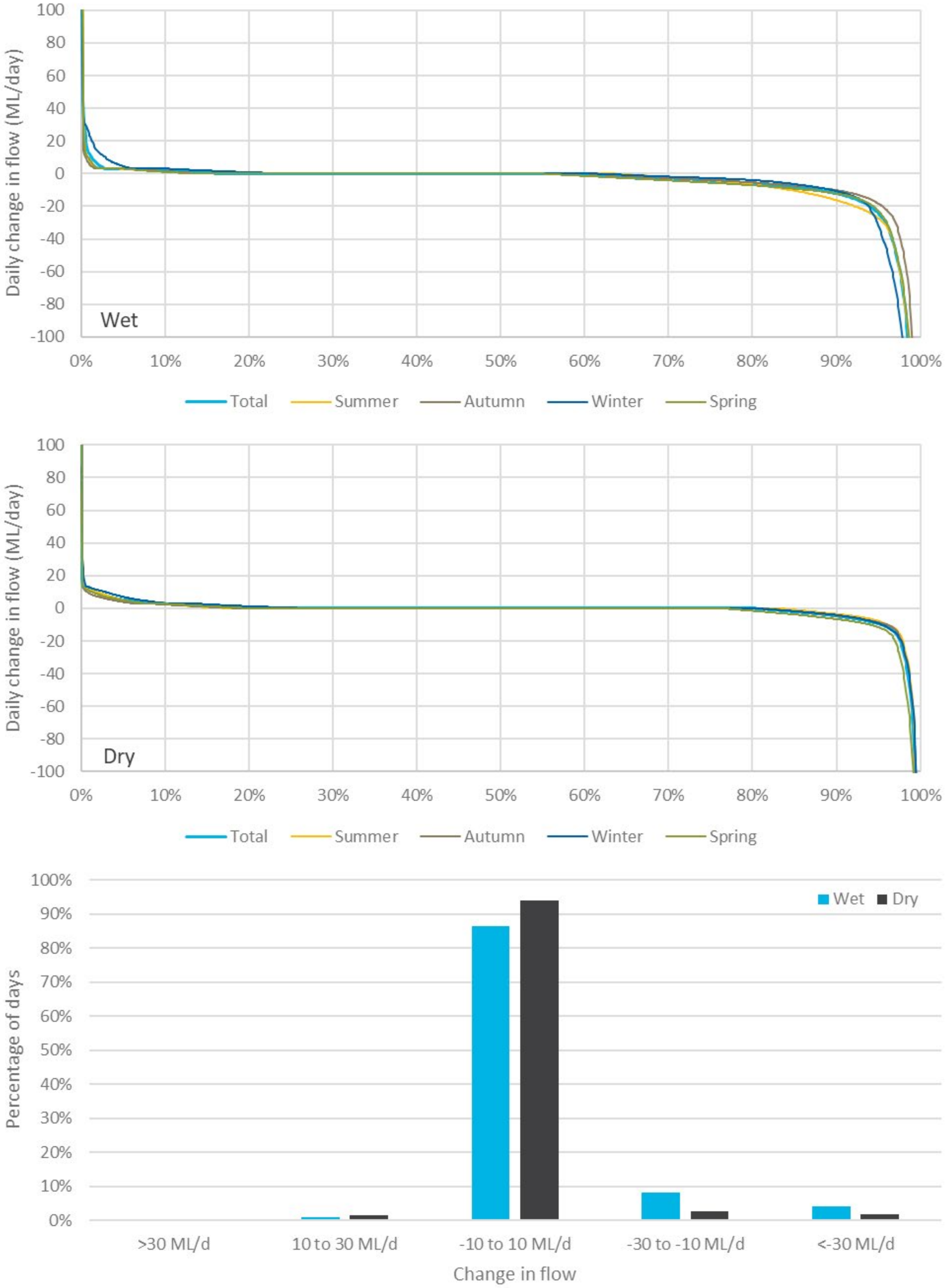


Figure 9.4 Change in daily flow downstream of new Dungowan Dam location, future climate, +20% demand

c Changes to flow at Dungowan monitoring station (419103)

Figure 9.5 shows modelled changes to flow at Dungowan monitoring station (419103). Results for this site were similar to that observed for the site 15 km downstream of the new dam (section 9.1.1b).

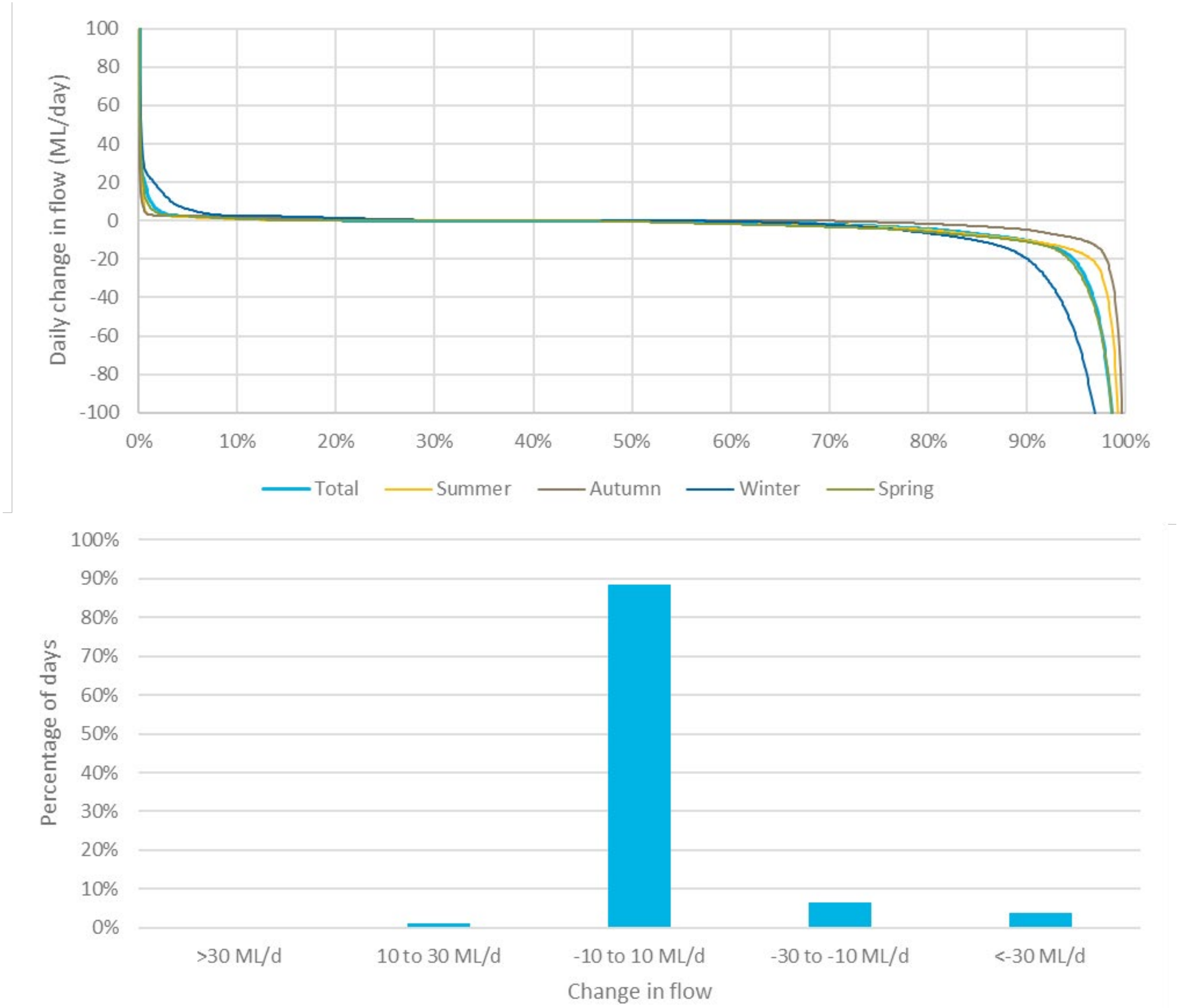


Figure 9.5 Change in daily flow at Dungowan (419103), current climate, current demand

Figure 9.6 shows modelled changes to flow at Dungowan monitoring station (419103), with a future wettest climate change scenario or dry climate change scenario. The modelled impacts were similar to that observed for the site 15 km downstream of the new Dungowan Dam. The major difference was the loss of any increased flows under a dry scenario.

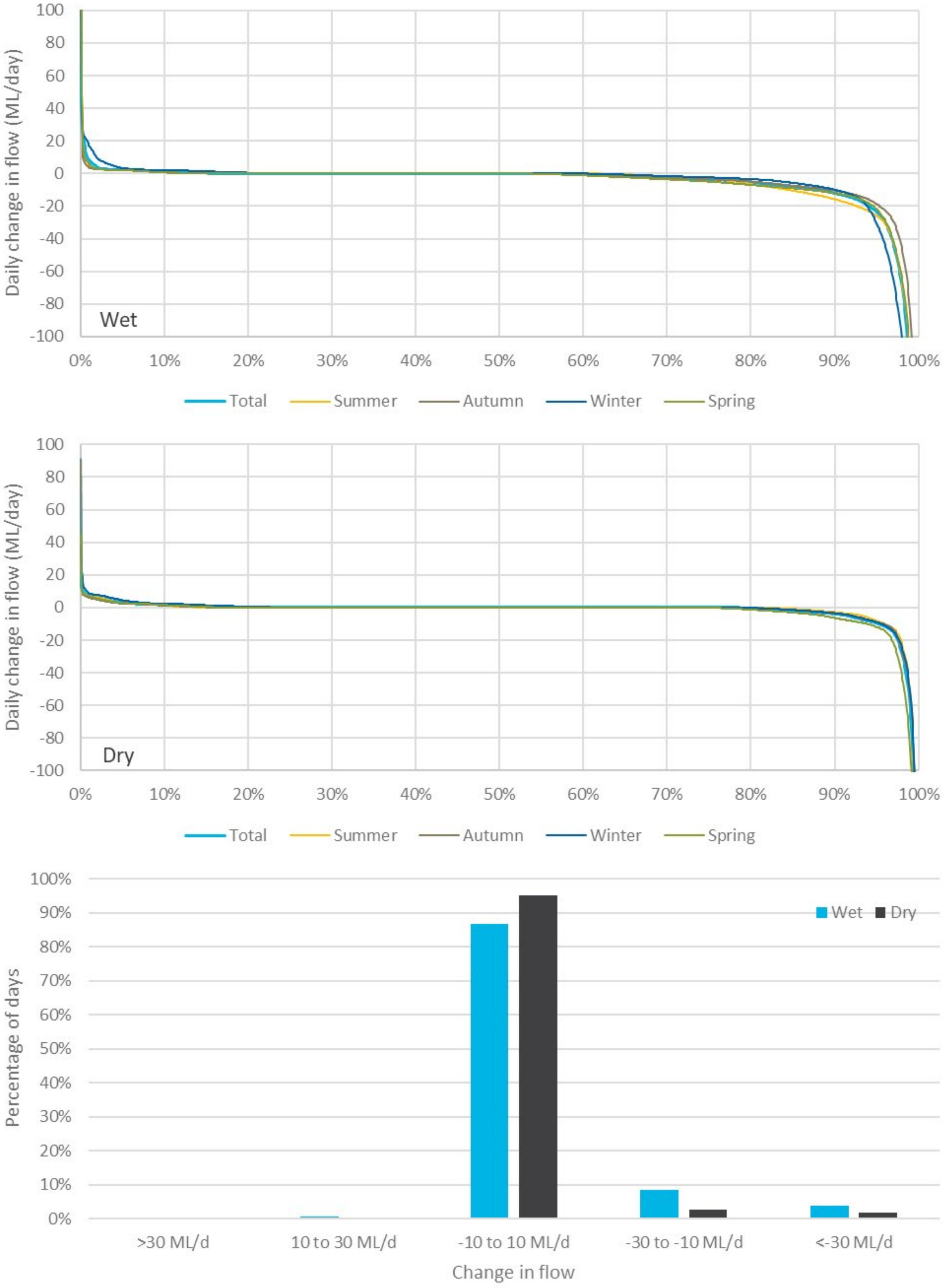


Figure 9.6 Change in daily flow at Dungowan (419103), future climate, +20% demand

9.1.2 Changes to depth

The Surface Water Assessment (EMM, 2022b) identifies that changes to depth with the new Dungowan Dam in place will be negligible. The following sections details modelled changes to depth in the current climate, a future wettest climate change scenario or dry climate change scenario.

Changes in depth in Dungowan Creek are modelled to be less that +/- 5cm most of the time (approximately 90 percent). Flow depth is modelled to increase only a small amount of the time (approximately 2 percent) with decreases in flow depth greater than 5cm expected to occur approximately 8 percent of the time. A more detailed description of the changes to depth at locations along Dungowan Creek is provided below.

i Changes to depth at the proposed Dam outlet

Note that no data has been provided for change in depth comparing the existing dam and new Dungowan Dam locations, as different geographical locations for the two dams result in different catchment areas and any comparisons are not possible.

ii Changes to depth 15 km downstream of the proposed Dam outlet

Figure 9.7 shows modelled daily changes to depth in Dungowan Creek downstream of the proposed infrastructure with the current climate and increased demand., Figure 9.7 also shows seasonal changes to depth with the project infrastructure in place. Total change in depth is modelled to increase by up to 20 cm from 3 percent of the time. Minor changes in depth of +/- 5cm are modelled to occur 91 percent of the time and reductions in depth of more than 5cm are expected for 6 percent of the time.

Increases and decreases in flow depth are modelled to be greatest in winter with more cease to flow days in winter.

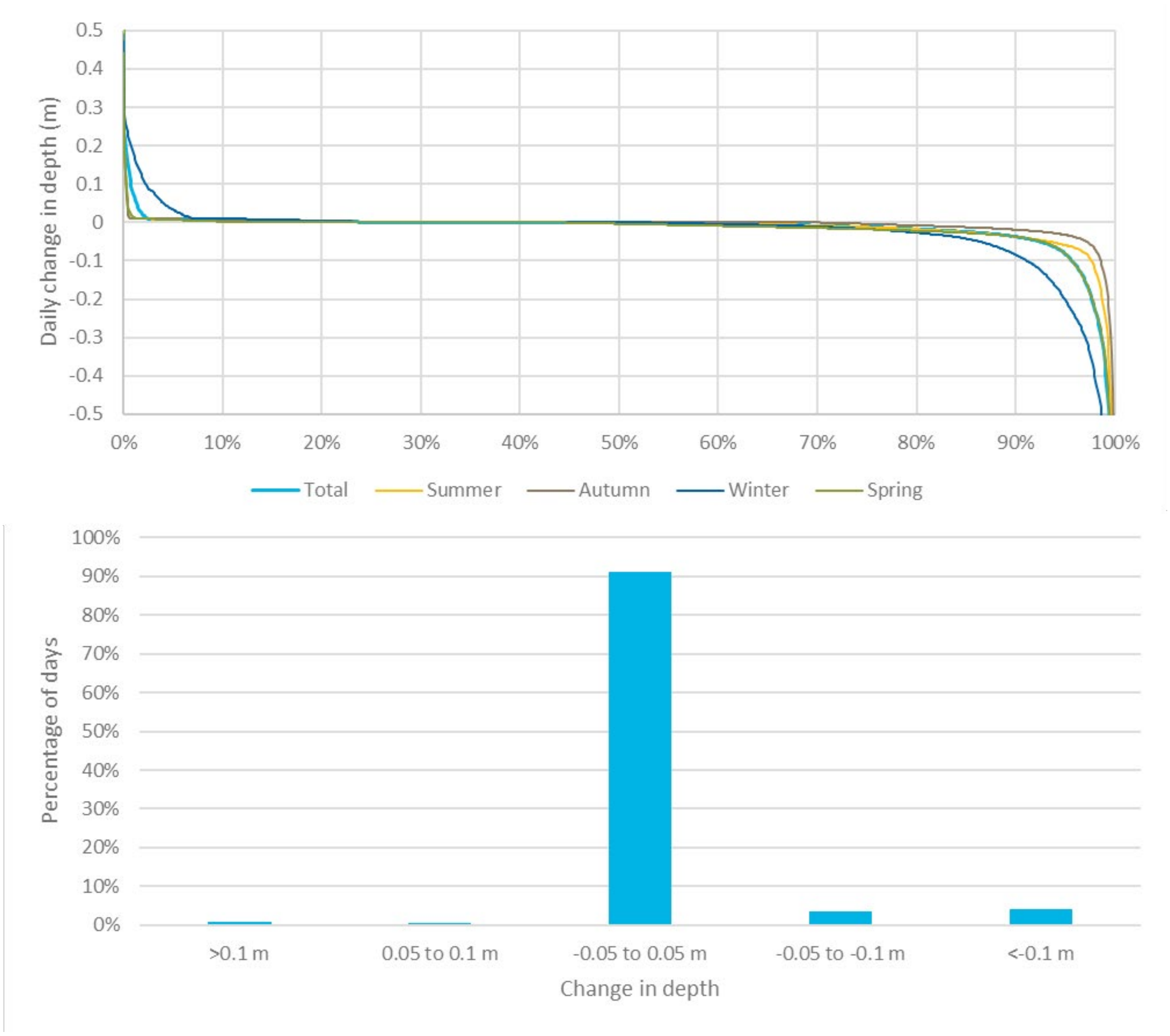


Figure 9.7 Change in daily depth downstream of new Dungowan Dam location, current climate, +20% demand

Figure 9.8 shows modelled daily changes to depth in Dungowan Creek downstream of the project infrastructure with a future wet and dry climate, +20% demand. Figure 9.8 also shows seasonal changes to depth for the project. Depth is modelled to increase by more than 5cm approximately 5 percent of the time with increases more frequent under a dry scenario. Minor changes in depth of +/- 5cm are modelled to occur 90 percent of the time and reductions in depth of more than 5cm are expected for approximately 5 percent of the time.

Increases and decreases in flow depth are modelled to be greatest in winter particularly under the wet scenario.

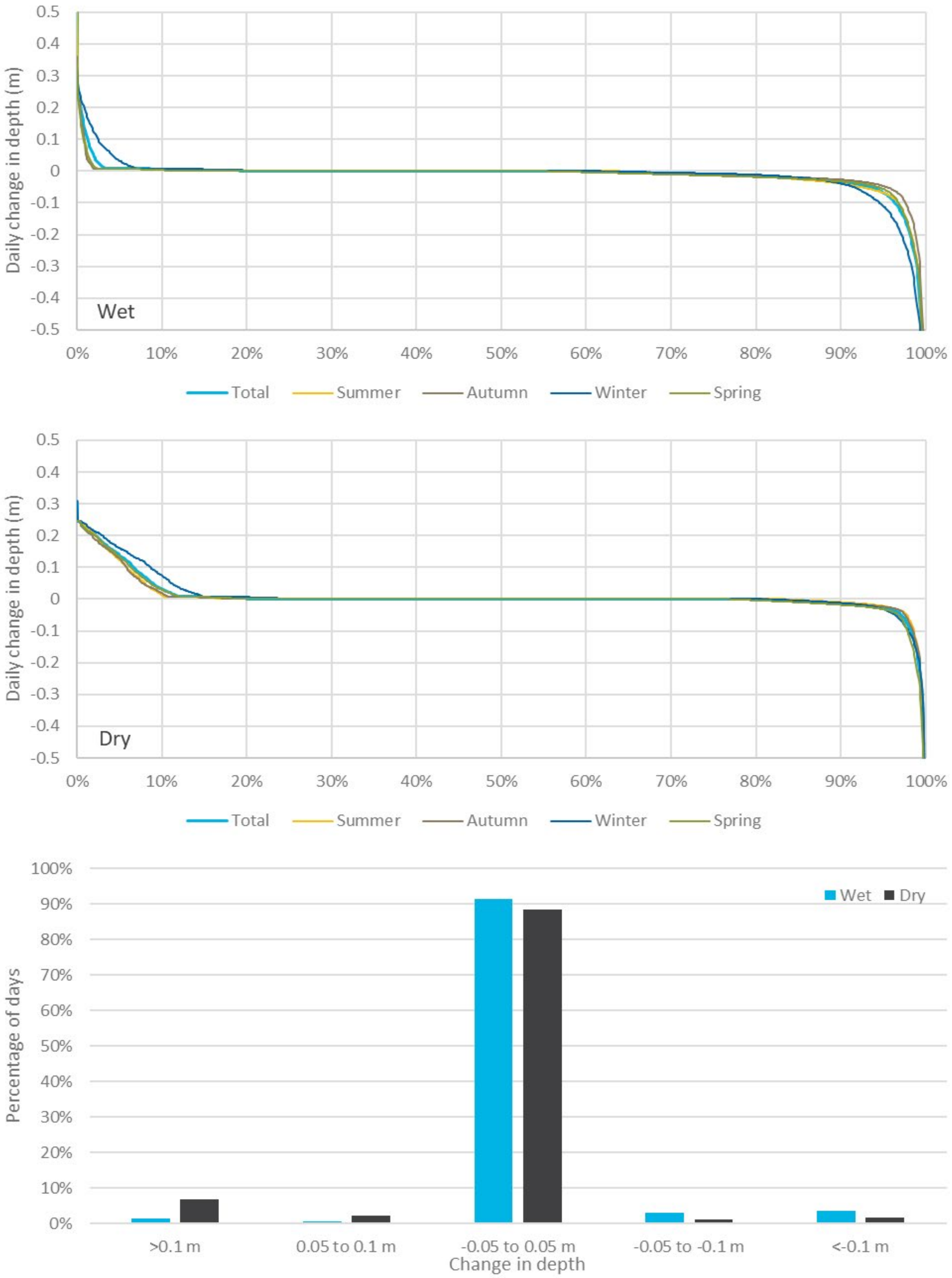


Figure 9.8 Change in daily depth downstream of new Dungowan Dam location, future climate, +20% demand

iii Changes to depth at Dungowan monitoring station (419103)

Figure 9.9 shows modelled daily changes to depth in Dungowan Creek at monitoring station (419103) with the project and the current climate and increased demand. Figure 9.9 also shows seasonal changes to depth with the project.

The modelled change for this site is similar to the site 15 km downstream of the new Dungowan Dam.

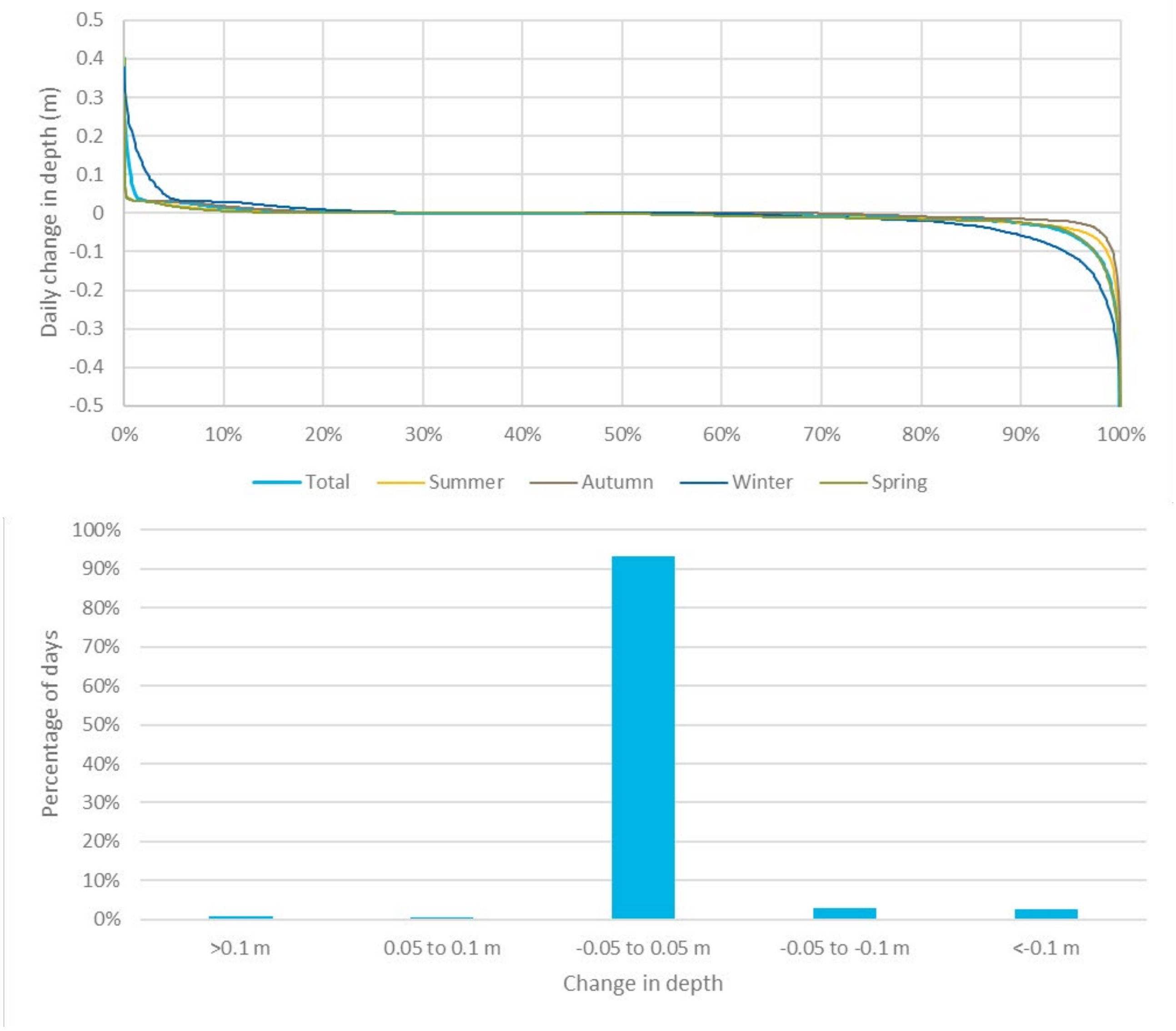


Figure 9.9 Change in daily depth at Dungowan (419103), current climate, +20% demand

Figure 9.10shows modelled changes to depth in Dungowan Creek at monitoring station (419103) with the project infrastructure and a future wettest climate change scenario or dry climate change scenario and increased demand. Figure 9.10 also shows seasonal changes to depth with the project. The modelled changes for this site is similar to the site 15 km downstream of the New Dungowan Dam.

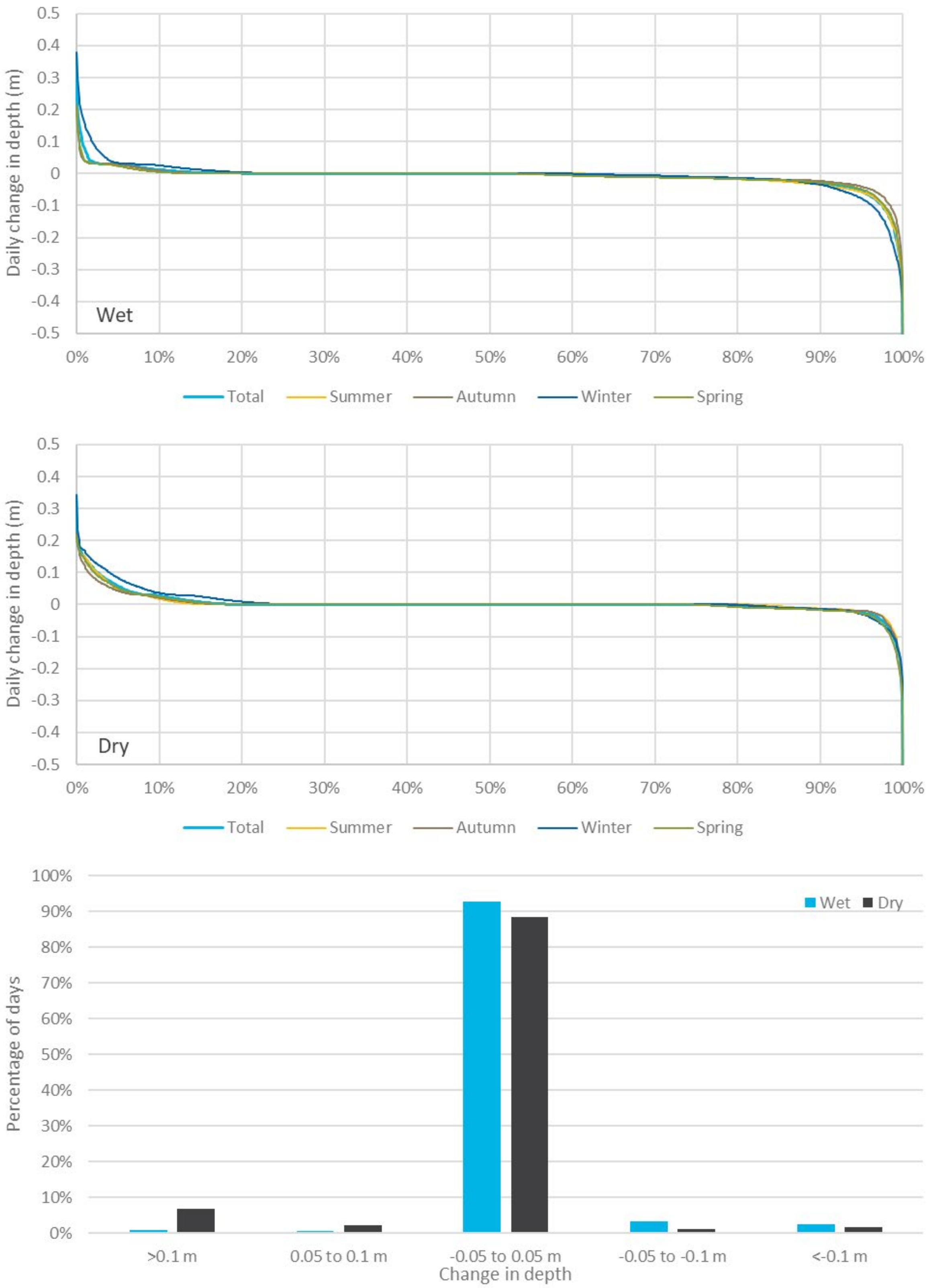


Figure 9.10 **Change in daily depth at Dungowan (419103), future climate, +20% demand**

9.1.3 EWR at Dungowan Creek

No Environmental Water Requirements (EWR) exists for Dungowan Creek however the Surface Water Assessment (EMM, 2022b) presents modelled event frequencies of each flow type with the current infrastructure in place and modelled impacts with the project infrastructure in place. Cease-to-flow events per decade are modelled to increase from six years per decade to seven years per decade as a result of the project. One ML/day flows (Q001) – 20 ML/day (Anytime release, Q020_AT) will remain the same with the project. Event frequency for 100 ML/day (Q100) – 500 ML/day (Q500_AT) will all increase marginally as a result of the project (Figure 9.11).

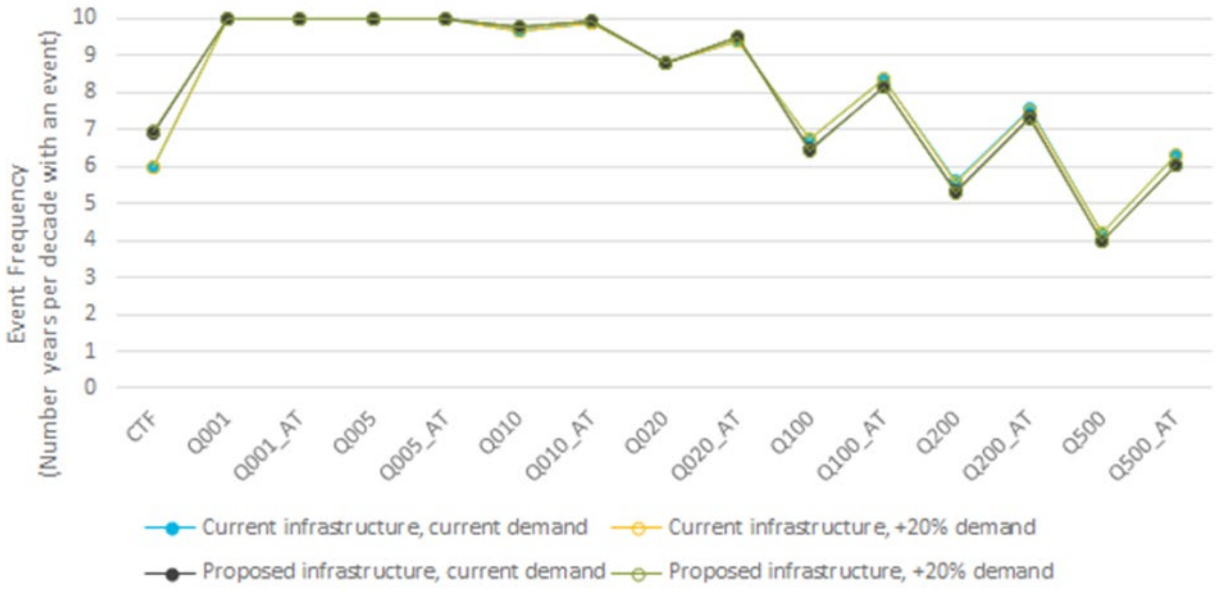


Figure 9.11 Event frequency of each flow type for Dungowan Creek with a 20% increase in demand

9.1.4 Cold water pollution

The Surface Water Assessment (EMM, 2022b) describes Dungowan Dam and Chaffey Dam as warm monomictic lakes/reservoirs, ie stratified in summer, circulate/mix all winter, and never freeze. Warm monomictic waterbodies thermally stratify once per year during the warmer months when the surface of the waterbody absorbs heat (solar radiation from the sun) increasing water temperatures near the surface. As the top of the water column heats up during the warmer months (late Spring to early Autumn), a density gradient becomes increasingly distinct and separate layers form over the water column.

Transparent and translucent releases for the existing Dungowan Dam are 10 ML/day. Modelling shows that for a 10ML/day release the temperature difference between the released water and the ambient temperature in Dungowan Creek is 2°C at 2.5 km from the new Dungowan Dam and the same as Dungowan Creek ambient temperature at <5 km downstream (EMM, 2022c). Transparent and translucent releases for the new Dungowan Dam are to increase by 3 ML/day to a total volume of 13 ML/day. Modelled data shows that increasing the volume of transparent and translucent releases to 13 ML/day extends the CWP effect by a further 500m – 1 km downstream. This modelling suggests that the temperature difference between the released water and the ambient temperature in Dungowan Creek will be 2°C at 3 - 4km rather than 2.5 km and the same as Dungowan Creek ambient temperature at 5 km (EMM, 2022c).

The CWP assessment for the new Dungowan Dam - appended to the EIS (EMM, 2022c) showed that if translucency releases were made using cold water (due to algal management measures) CWP effects for translucency release volumes could extend a distance of less than five kilometres downstream before the water warmed to that of Dungowan Creeks ambient temperature (EMM, 2022c). The Surface Water Assessment (EMM, 2022b) concluded that this as a relatively short distance in the context of cold water pollution caused by dam releases due largely to the low flow rates involved and the shallow creek depths created. The Surface Water Assessment (EMM, 2022b) also identified that if higher flows were released, these flows would likely be released either:

- via the spillway, in response to natural flood flows into the dam when at capacity;
- via the outlet pipe to draw the dam water level down for dam maintenance; or
- via the outlet pipe to draw the dam down in preparation for an anticipated flood flow.

In the case of spillway activation, water will not be discharged from deep within the dam, and cold water pollution is not expected to occur.

In the case of dam maintenance, it may be possible to schedule the maintenance for periods when CWP is less likely to pose a negative impact, or when the multi-level outlet may be used to take water from an appropriate part of the water column to reduce or eliminate the likelihood of CWP. The case of emergency drawdown during hot weather while an algal bloom is occurring thereby limiting the use of the upper water column would be extremely rare (Department of Primary Industries, 2020a).

The case of dam drawdown in preparation for flood flows is expected to be rare, especially considering the adequate design of the spillway for events up to the Probable maximum flood (PMF), which reduces the need to release water in advance of floods. Cold water pollution management measures such as selecting an offtake with minimal CWP potential would be applied in the case of drawdowns.

The outlet works for the new Dungowan Dam have been designed with the capability to minimise the likelihood of CWP events through destratification of the reservoir contents and through a multilevel offtake (EMM, 2022b). Specifically, the intake tower within the new Dungowan Dam would comprise eight ports of about 1.2 m wide by 2.0 m high to enable water intake between MOL and FSL (EMM, 2022b). During spring and summer, it will be possible to take water from higher (shallower) water levels where the change in temperature gradient between the dam and Dungowan Creek is minimal. This should, in effect, avoid negative impacts associated with CWP from the new Dungowan Dam. It is also understood that monitoring of water quality throughout the water column within the new Dungowan Dam will be undertaken on a long term basis. Parameters to be monitored include temperature, dissolved oxygen, pH, turbidity and Chlorophyll-a. Monitoring of water quality parameters within the water column enables an accurate assessment of whether CWP is likely to occur should waters be released from the new Dungowan Dam and determination of the optimum time in which to release flows from the dam.

CWP is a potential negative impact to Dungowan Creek during the spring/summer months when Dungowan Dam is stratified and when key Listed aquatic species are breeding. CWP can change the distribution of species, reduce the opportunity and success for effective reproduction and recruitment, reduce body growth, condition, metabolism, swim speed, and decrease riverine productivity. The majority of the key Listed aquatic species observed in Dungowan Creek follow breeding cues that arise, at least in part, in the form of increasing temperatures during spring. A pulse of cold water may lower ambient temperatures to the point that the breeding cue no longer exist and breeding is aborted or fails to commence.

The platypus diet consists primarily of macroinvertebrates (Krueger, Hunter, & Serena, 1992; Holland & Jackson, 2002). A study assessing macroinvertebrate assemblages pre-, during and post- construction of the Dartmouth Dam revealed that diversity of macroinvertebrate species declined during the construction of the dam due to water quality factors associated with sedimentation and an increase in stream temperature due to decreased flows (Koehn, Doeg, Harrington, & Milledge, 1995). The study then shows that significantly lowered temperatures due to Cold Water Pollution strongly contributed to the inability of macroinvertebrate assemblages to repair to the composition present prior to construction. That is, cold water pollution drove down, and supressed diversity of macroinvertebrates. The study also revealed that more tolerant species filled the niche left by those species that were not tolerant of colder waters. As a result, overall abundance of macroinvertebrates was not significantly impacted (Koehn, Doeg, Harrington, & Milledge, 1995). Cold water pollution downstream of the new Dungowan Dam has the potential to negatively impact the diversity of macroinvertebrates. However, the above evidence suggests that abundance will either repair or remain consistent despite cold water pollution, suggesting CWP from the project will have negligible impact upon platypus.

9.1.5 Impacts to GDEs

A Groundwater Impact Assessment has been undertaken in response to the issued SEARS and is appended to the EIS. Potential impacts to groundwater associated with Dungowan Creek as a result of operating the proposed dam are reported as follows:

- Dungowan Dam operation: A larger catchment will be impounded by the new Dungowan Dam compared to the existing dam as several creeks, which are currently unregulated will flow into the new dam and will cease to supply unregulated runoff to Dungowan Creek. When filling the dam following dry periods or periods of dam drawdown, the larger dam capacity will mean that a greater portion of flood flows are retained in the dam.

- Dungowan Dam inundation area: the applied load from the dam on the Dungowan Creek Alluvium (DCA) and Peel Fractured Rock (PFR) groundwater sources has the potential to cause the water pressure (groundwater level) to rise, altering the local groundwater flow regime near the inundation area and dam wall.

The Groundwater Impact Assessment (EMM, 2022e) reports that the applied load from the new Dungowan Dam on the DCA and PFR has the potential to increase pressure and cause the groundwater level to rise, altering the local groundwater flow regime near the inundation area and dam wall. The water table may find new discharge areas around or downstream of the dam wall, increasing baseflow to Dungowan Creek. Furthermore, discharge areas around the sides of the dam wall could create swampy or moist environments. Should baseflow increase to Dungowan Creek, groundwater pressures are expected to be temporary and dissipate over time as the groundwater system and rock mass gradually equilibrates to loading pressures. Therefore, impacts are expected to be minimal.

9.1.6 Downstream migration of fish over the new spillway

A number of native fish species are expected to be present upstream of the existing dam although none were identified in field surveys or from the desktop assessments. No listed species were identified or are thought to exist upstream of the existing Dungowan Dam or within the tributaries that will be inundated as part of the new Dungowan Dam. While the key fish habitat located within the inundation area of the new Dungowan Dam does support listed fish species (ie Murray Cod) the habitat is not recognised to be critical habitat for the survival of any listed species. Operational impacts will result in the exclusion of fish passage downstream of the new Dungowan Dam and these losses have been addressed in the offsets strategy for fish barriers.

Fish passage downstream is most likely to occur during spill events. The concept design for the new spillway is provided in the design drawings provide in Appendix B2 to the EIS, and have the following key design features:

- 60m wide crest
- Spillway crest level of 660.2 mAHD
- Spilling basin invert level of 597.0 mAHD
- Stilling basin length of 54m
- Stilling basin width 40m

The stilling basin will be constructed from concrete and will be 40m wide and 54m long and 10m deep with baffels installed to mitigate the risk of structural damage to the structure as a result of the high velocity's generated during spilling events, which will be in excess of 35m/sec.

Trauma or death of fish as a result of passage over the spillway is a high risk given the potential water velocities involved and the baffle structures that will be incorporated into the design. Any fish that survive the passage down the spillway will possibly be trapped in the stilling basin depending on the flow conditions. Fish passage between the stilling basin and Dungowan Creek will be possible during a spilling event only.

No current design features have been included to allow of dewatering and or fish passage from the stilling basin to Dungowan Creek.

9.2 Peel River

9.2.1 Changes to hydrology

i Potential impacts to flow within the Peel River

Flow regime modelling presented in the Surface Water Assessment (EMM, 2022b) reports the following changes to flow along the Peel River downstream of Chaffey Dam. Immediately below Chaffey Dam there would be an increase in the frequency of low flow events, caused by a reduction in the frequency of run-of-river transfers to Calala WTP and increased utilisation of the new Dungowan Dam and pipeline. It should be noted other discharges from Chaffey Dam to meet general security, high security and stock and domestic licences would continue. This effect would persist downstream from Chaffey Dam to Calala. Downstream of Calala (ie at Tamworth and downstream locations) there would be no change in the Peel River flow regime. There may be a minor increase in the frequency of small and large freshes downstream from Chaffey Dam, and no changes to the frequency of environmental flow events are expected at Carroll.

Flows in the Peel River downstream of Chaffey Dam are expected to change under the new operational guidelines for the new Dungowan Dam, with a reduction in run of river flows for town water supply from Chaffey Dam to Tamworth. Changes to flow volume may impact all species as a result of changes to habitat availability along the Peel River.

Under the current climate and current demand, a reduction in flows is modelled to occur at Chaffey Dam and extend to Piallamore. Flow reductions are modelled to occur up to 75 percent of the time with reductions of ≥10ML modelled to occur up to 40 percent of the time. The impact of lower flows (with respect to volume) is reduced further downstream at Tamworth with a reduction in flows modelled to occur up to 25 percent of the time with reductions of ≥10ML modelled to occur up to 10 percent of the time. The modelled future climate plus an additional 20 percent demand flows were similar.

The reduced incidence of reductions in flow at Tamworth is due to the substantial inflows from the Cockburn and Peel River located just upstream of Tamworth. Detailed graphical representation of modelled changes in flow for the Peel River are provided below.

ii Immediately downstream of the Chaffey Dam (419045)

Figure 9.12 shows the modelled change in flows downstream from Chaffey Dam (419045), with the current climate and current demand with the project infrastructure in place. Figure 9.12 shows total change and seasonal changes to flow. Modelling indicates the daily flow volume will increase by between 1 - >100 ML/day up to 16 percent of the time. There will be nil to negligible change in flow 10 percent of the time. There will be a reduction in flows of between 1 – 40ML/day for 64 percent of the time and a reduction of flows of 40 – 100 ML for 4% of the time. The reductions in flow was strongly influenced by the seasonal impact from summer flows.

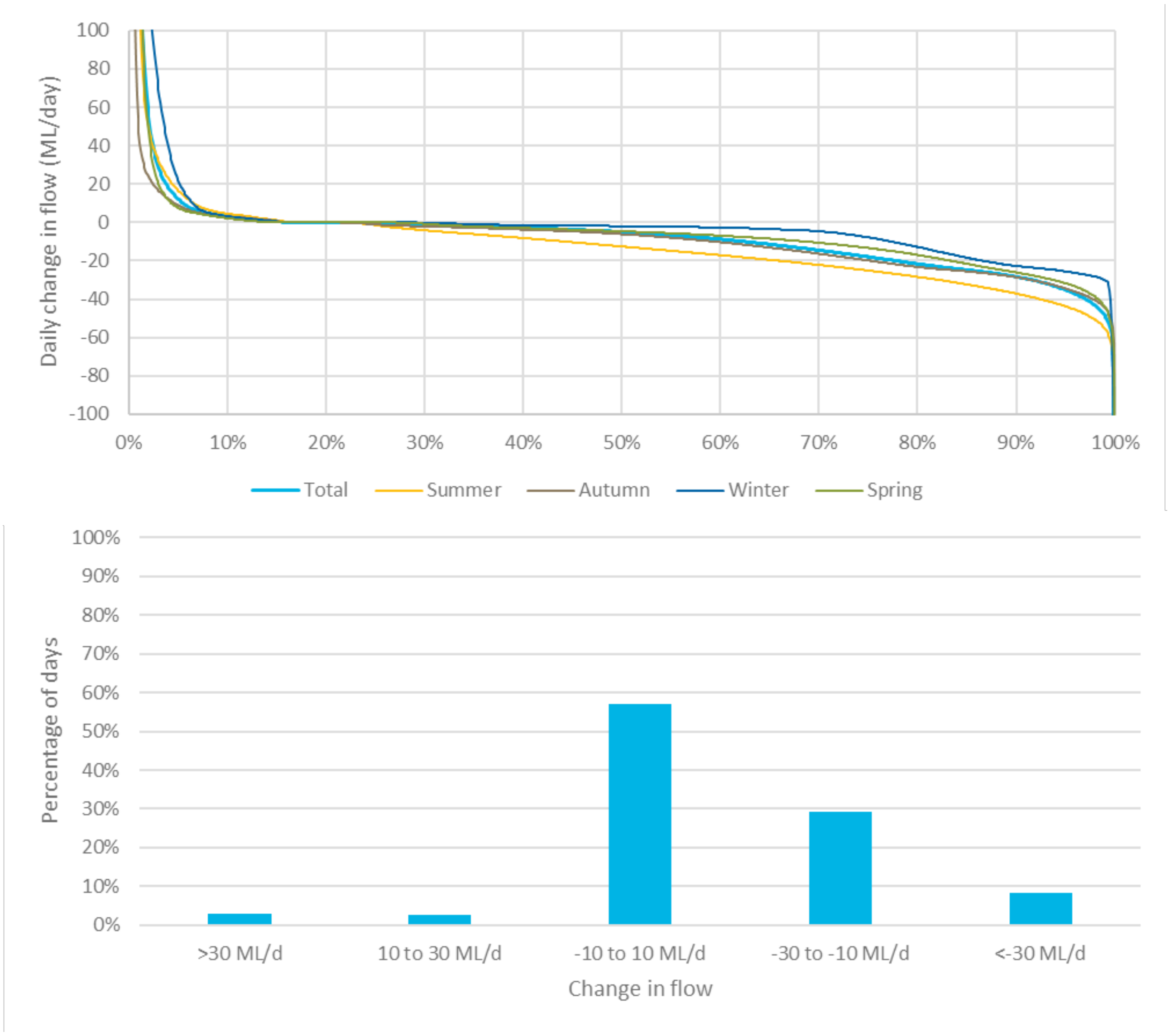


Figure 9.12 Change in daily flow downstream from Chaffey Dam (419045), current climate, current demand

Figure 9.13 shows the modelled change in flows downstream from Chaffey Dam (419045), with a future wettest climate change scenario or dry climate change scenario and increased demand with the project infrastructure in place. Figure 9.13 shows total change and seasonal changes to flow. With a future wet climate and future dry climate, the flows were similar to those observed above for the project infrastructure with the current climate and current demand (section 9.2.2ii). The major differences modelled were an increase in high flow events during the wet scenario and a reduction in the impact of reduced flows during the dry scenario. The reduction in flow modelled was similar for the wet scenario as observed above for the project infrastructure with the current climate and current demand with summer flows strongly influencing the modelled overall flows.

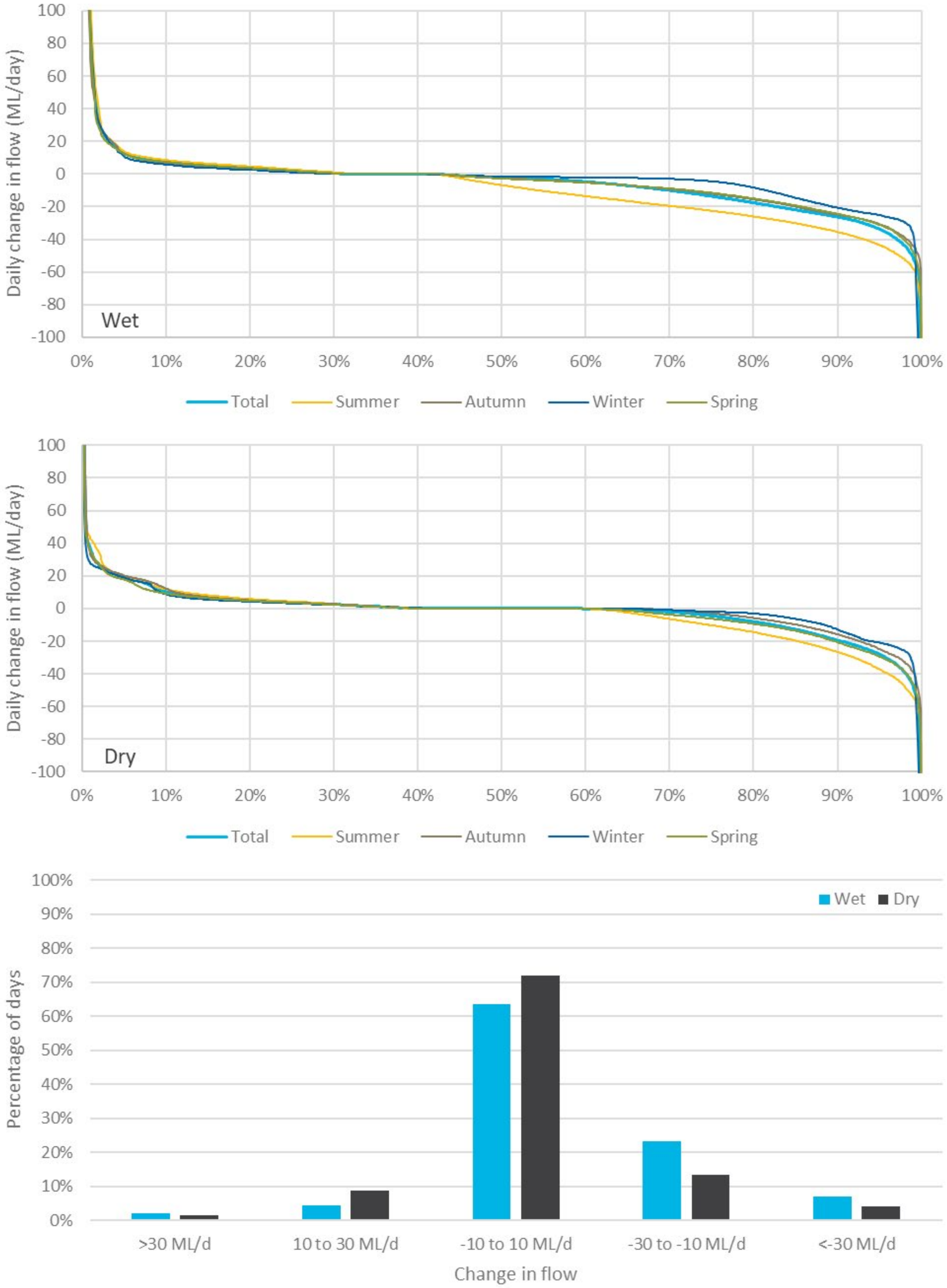


Figure 9.13 Change in daily flow downstream from Chaffey Dam (419045), future climate, +20% demand

iii Piallamore (419015)

Figure 9.14 shows the modelled change in flows at Piallamore with the current climate and current demand and the project infrastructure in place. Figure 9.14 shows total change and shows seasonal changes to flow. The modelled change in flow for Piallamore is similar to that reported immediately downstream of Chaffey Dam.

Modelling indicates the change in daily flow volume will increase by between 1 - >100 ML/day up to 16 percent of the time. There will be nil to negligible 10 percent of the time. There will be a reduction in flows of between 1 – 40ML/day for 69 percent of the time and a reduction of flows of 40 – 100 ML for 5% of the time. The modelled reduction in flow was strongly influence by the seasonal impact from summer flows.

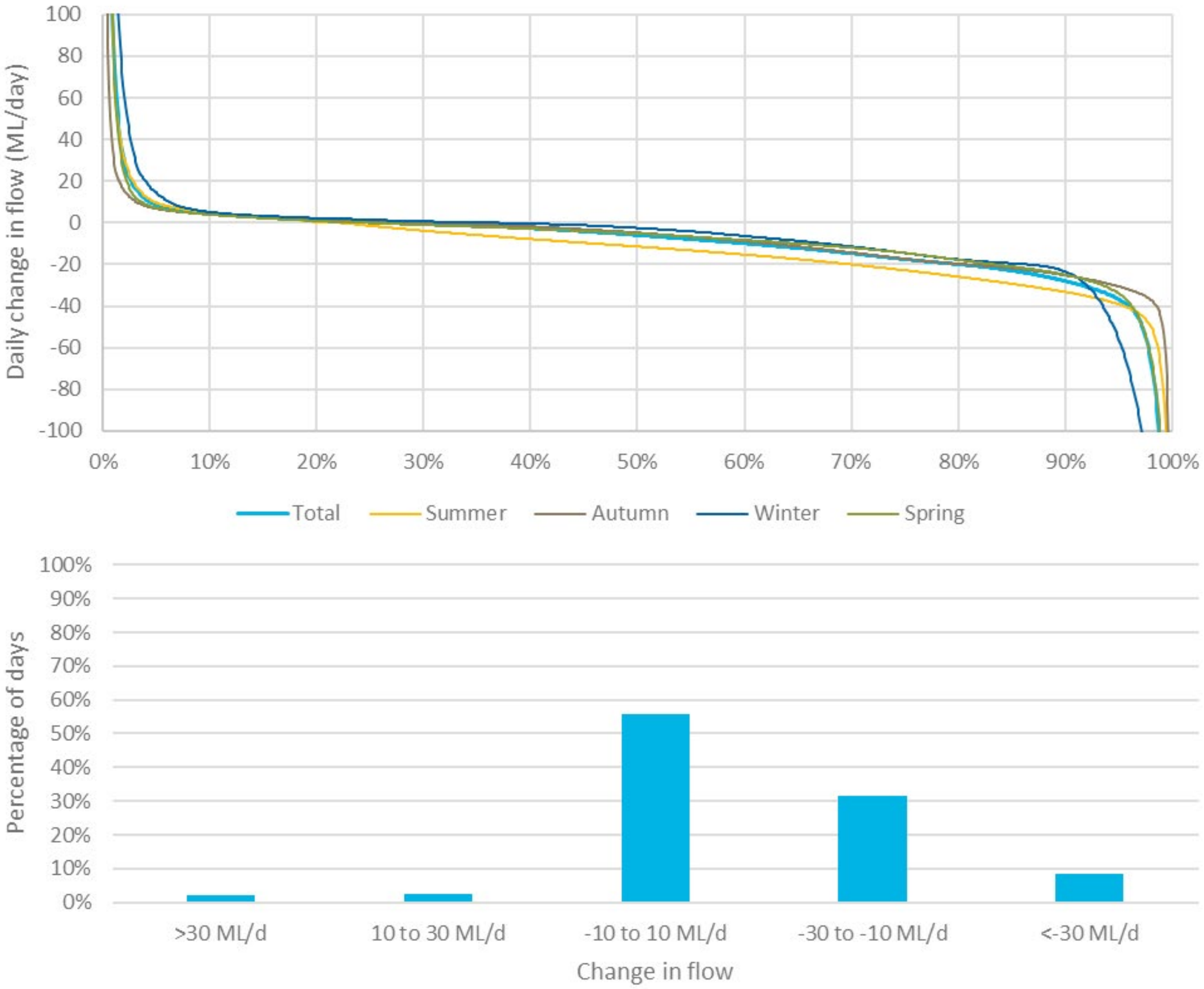


Figure 9.14 Change in daily flow at Piallamore (419015), current climate, current demand

Figure 9.15 shows the modelled change in flows at Piallamore (419015), with a future wet or dry climate and increased demand with the project infrastructure in place. Figure 9.15 shows total change and seasonal changes to flow. With a future wet climate and future dry climate, the flows were similar to those observed above for the project infrastructure with the current climate and current demand. The major differences modelled were an increase in high flow events during the wet scenario and a reduction in the impact of reduced flows during the dry scenario. The reduction in flow modelled was similar for the wetter scenario as observed above for the project infrastructure with the current climate and current demand (section 9.2.1iii) with summer flows strongly influencing the modelled overall flows, particularly under the wet scenario.

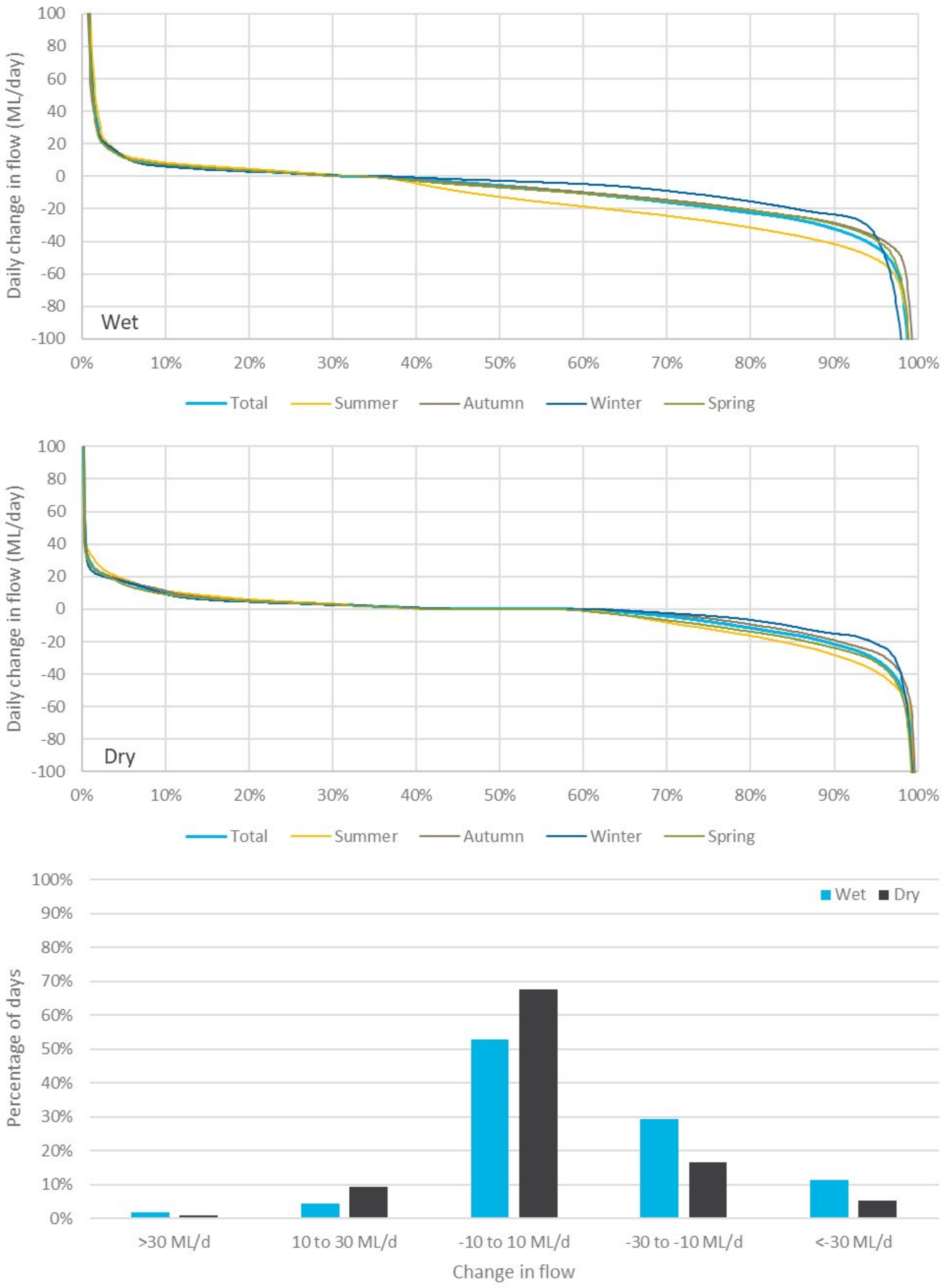


Figure 9.15 **Change in daily flow at Piallamore (419015), future climate, +20% demand**

iv Tamworth (419009)

Figure 9.16 shows the modelled changes in daily flow at Tamworth (419009) with the current climate, increased demand and with the project infrastructure in place. Figure 9.16 shows total change and seasonal changes to flow. Total change in flow is modelled to increase between 1 - >100 ML/day up to 15 percent of the time. Changes to flow will be nil to negligible 60 percent of the time. Flows will then decrease by between 1 too >100 ML/day for 25 percent of the time with increase cease to flow periods in winter.

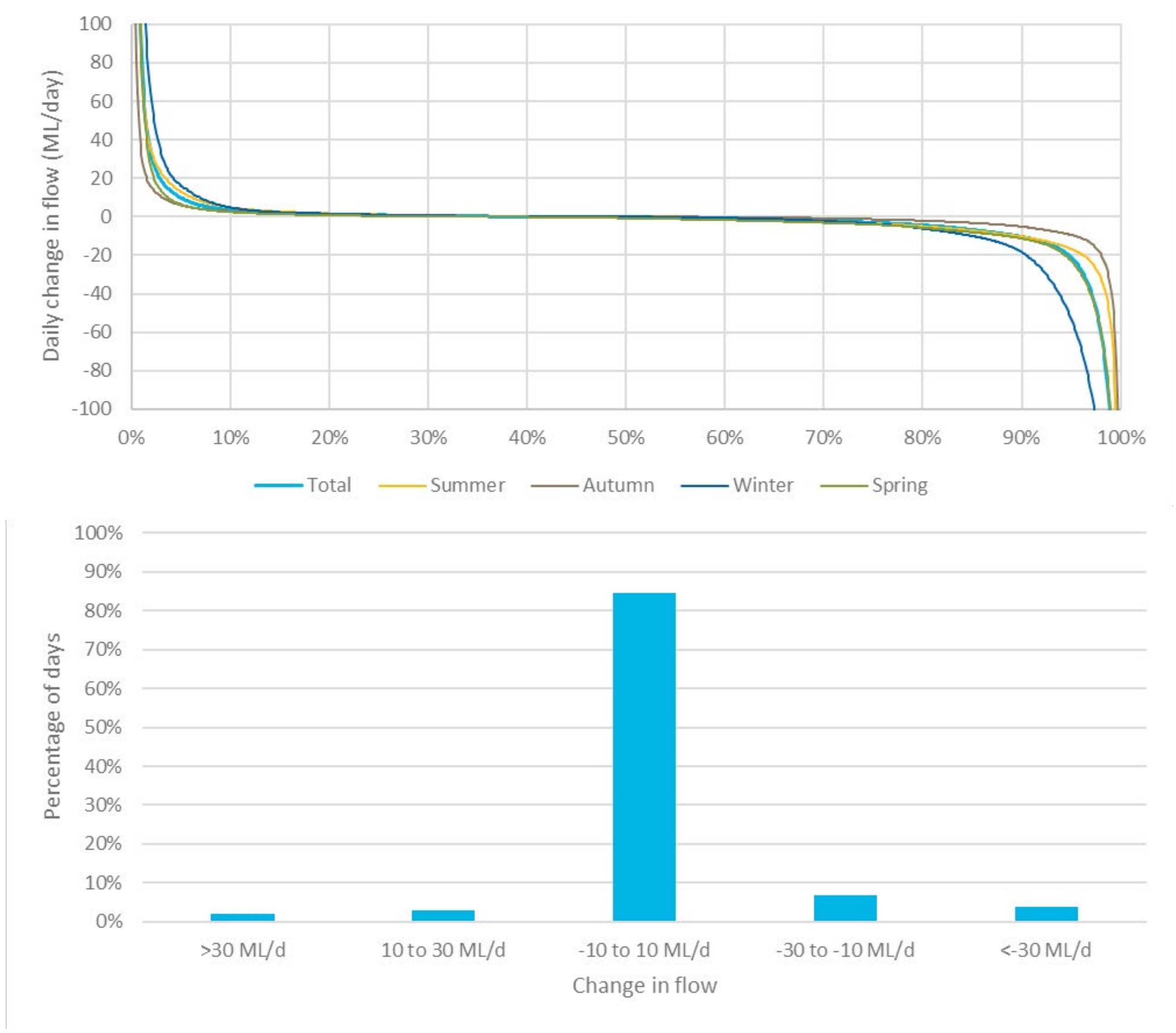


Figure 9.16 Change in daily flow at Tamworth (419009), current climate, +20% demand

9.2.2 Changes to depth

Changes in water depth in the Peel River downstream of Chaffey Dam are expected to occur under the new operational guidelines for the Dungowan Dam and pipeline with a reduction in the frequency of run of river flows for town water supply from Chaffey Dam to the Tamworth. Changes to water depth may impact a range of species as a result of changes to habitat availability along the Peel River.

Under the current climate and current demand, a reduction in water depth is modelled to occur at Chaffey Dam and extend to Piallamore. Reductions in depth of ≥ 1cm are modelled to occur up to 48 percent of the time at Chaffey Dam and Piallamore with greater modelled impacts over summer. Impacts to changes in depth are reduced at Tamworth (Paradise Weir) with reductions in depth of ≥ 1cm modelled to occur up to 18 percent of the time. Seasonal impacts on depth are negligible at Tamworth.

The reduced incidence of reductions in depth at Tamworth is due to significant inflows from the Cockburn and Peel River located just upstream of Tamworth. Detailed graphical representations of modelled changes in depth for the Peel River are provided below.

i Chaffey Dam (419045)

Figure 9.17 shows modelled daily changes to depth at Chaffey Dam (419045) with the project infrastructure, the current climate and current demand. Figure 9.17 shows total change in depth and seasonal changes to depth. Total depth is modelled to increase between 1 – 40 cm 12 percent of the time. Changes to depth are modelled to be nil to negligible from 40 percent of the time. Modelled reductions in depth of ≥ 1cm are expected to occur 48 percent of the time, with the maximum change in depth about 10cm. Summer seasonal reductions in depth are modelled to result depth of ≥ 1cm are expected to occur up to 65 percent of the time.

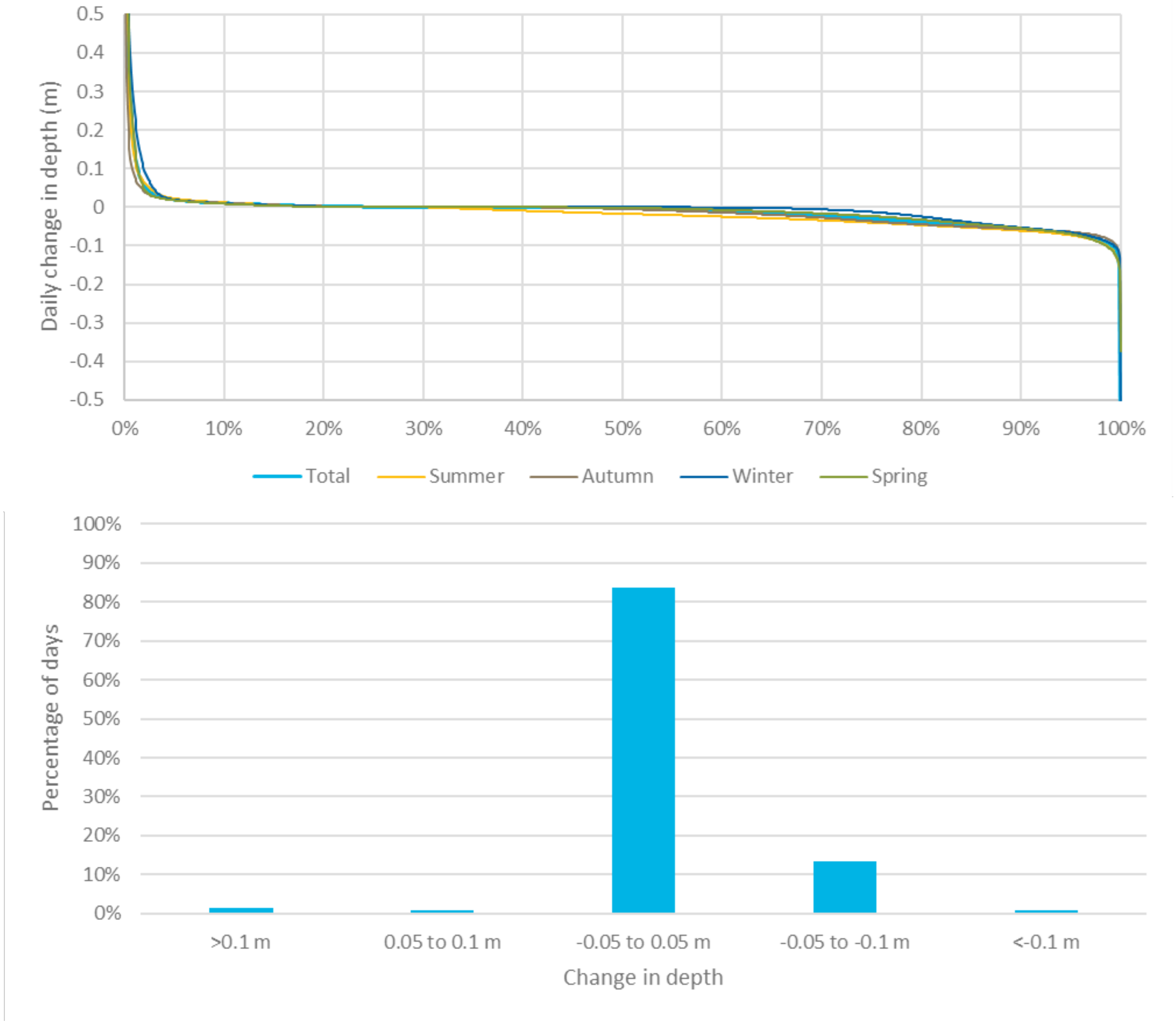


Figure 9.17 Change in daily depth downstream from Chaffey Dam (419045), current climate, current demand

Figure 9.18 shows modelled daily changes to depth at Chaffey Dam (419045) with the project infrastructure, a future wettest climate change scenario or dry climate change scenario and increased demand. Figure 9.18 shows total change in depth and seasonal changes to depth. Modelled changes to depth are similar to the current climate and current demand with a small increase in the number of days of increased flow depth. There is a small seasonal impact of summer flows on the depth observed with modelled reductions of ≥ 1cm of depth expected to occur up to 55 percent of the time under a wet scenario and up to 35 percent of the time under a dry scenario.

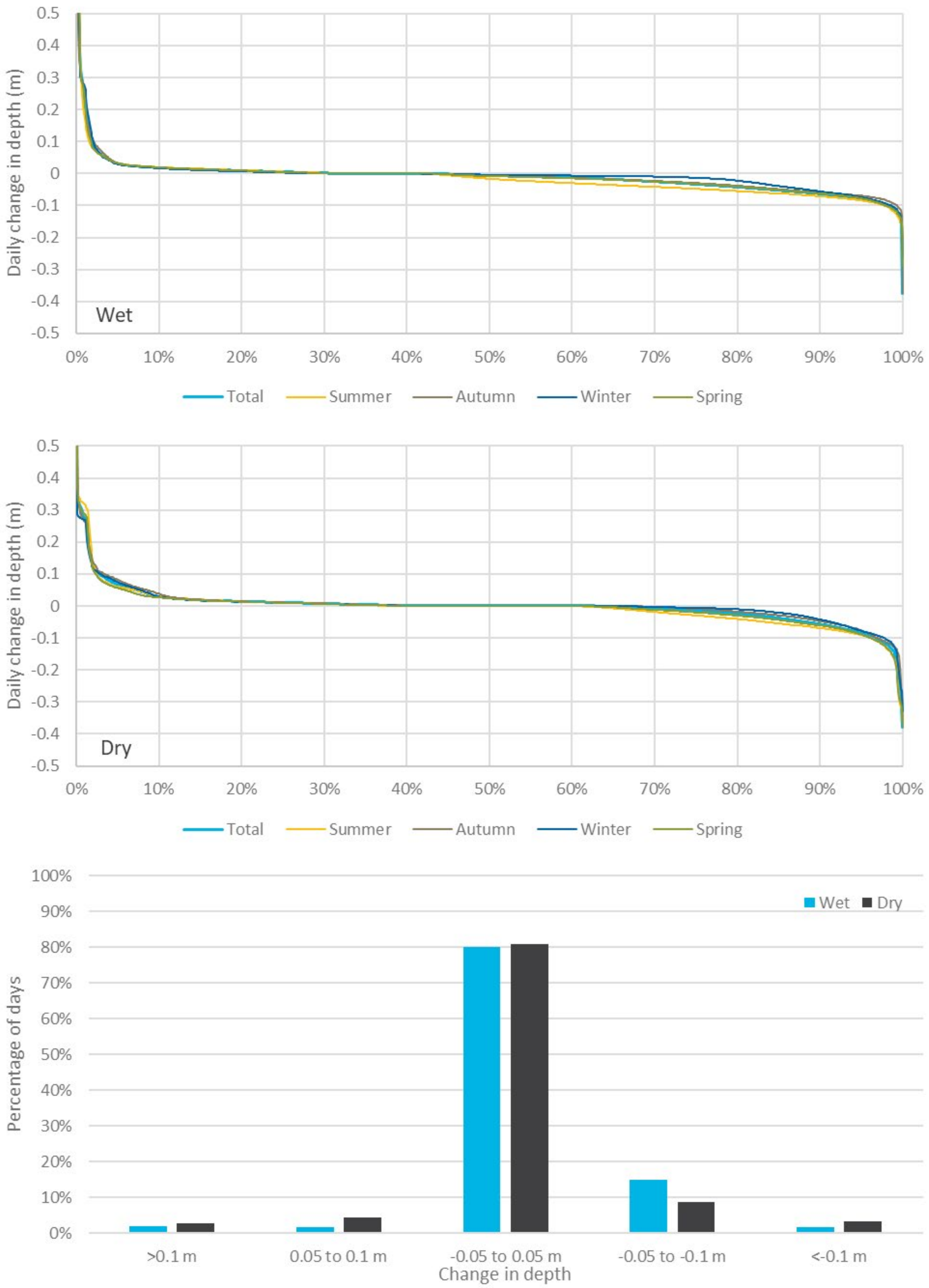


Figure 9.18 Change in daily depth downstream from Chaffey Dam (419045), future climate, +20% demand

ii Piallamore (419015)

Figure 9.19 shows modelled daily changes to depth at Piallamore (419015) with the project infrastructure, the current climate and current demand. Figure 9.19 shows total change in depth and seasonal changes to depth. Total change to depth at Piallamore is similar to that modelled for Chaffey Dam with summer seasonal impacts influencing the depths and modelled to result in reductions of ≥1 cm up to 65 percent of the time.

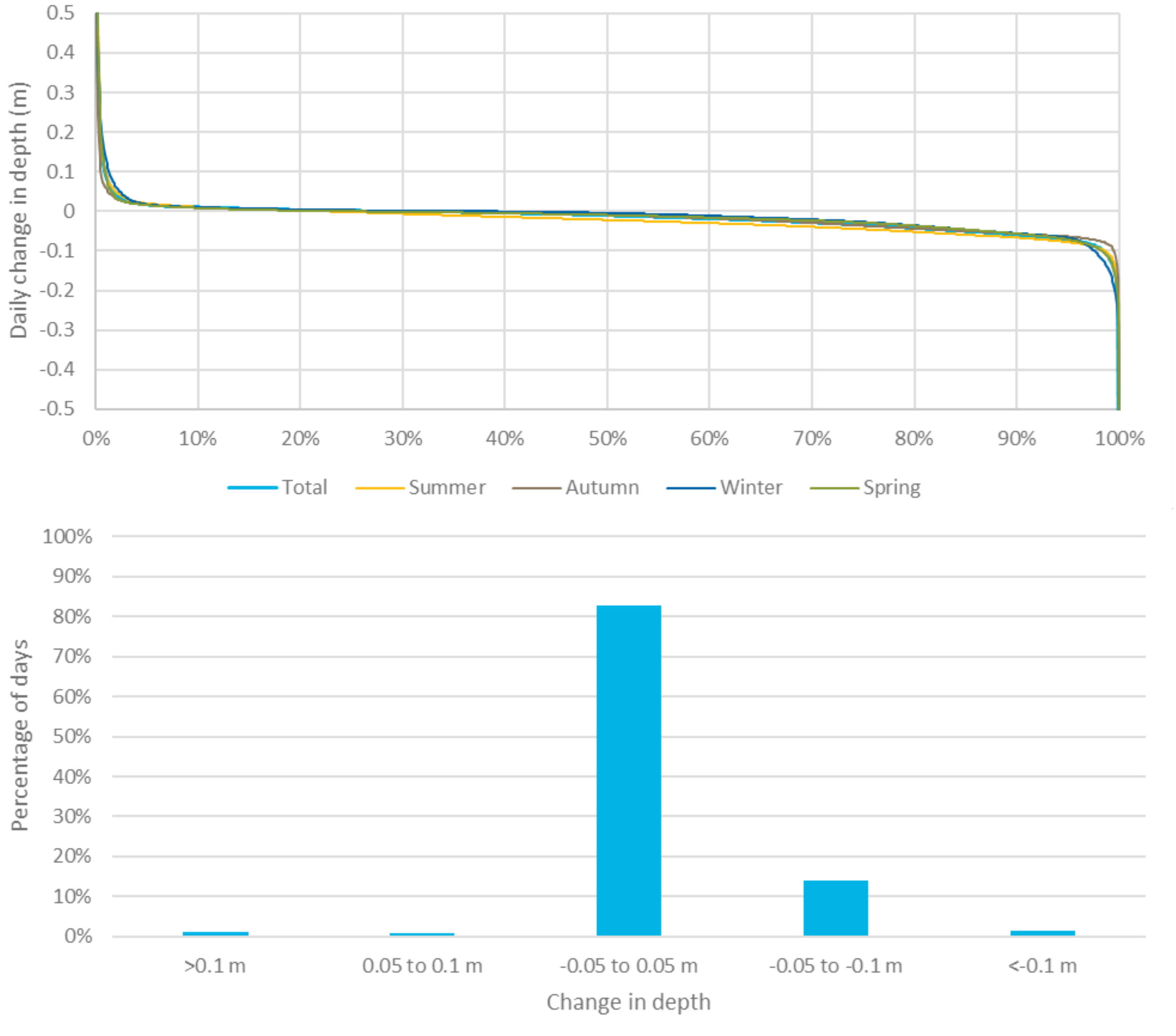


Figure 9.19 Change in daily depth at Piallamore (419015), current climate, current demand

Figure 9.20 shows modelled daily changes to depth at Piallamore (419015) with the project infrastructure, the current climate and current demand. Figure 9.20 shows total change in depth and seasonal changes to depth. With a future wet climate, total change to depth at Piallamore is similar to that modelled for the current climate and current demand scenario with a strong summer seasonal impacts modelled to result in reductions of ≥1 cm up to 55 percent of the time under the wet scenario with seasonal impacts less obvious under the dry scenario.

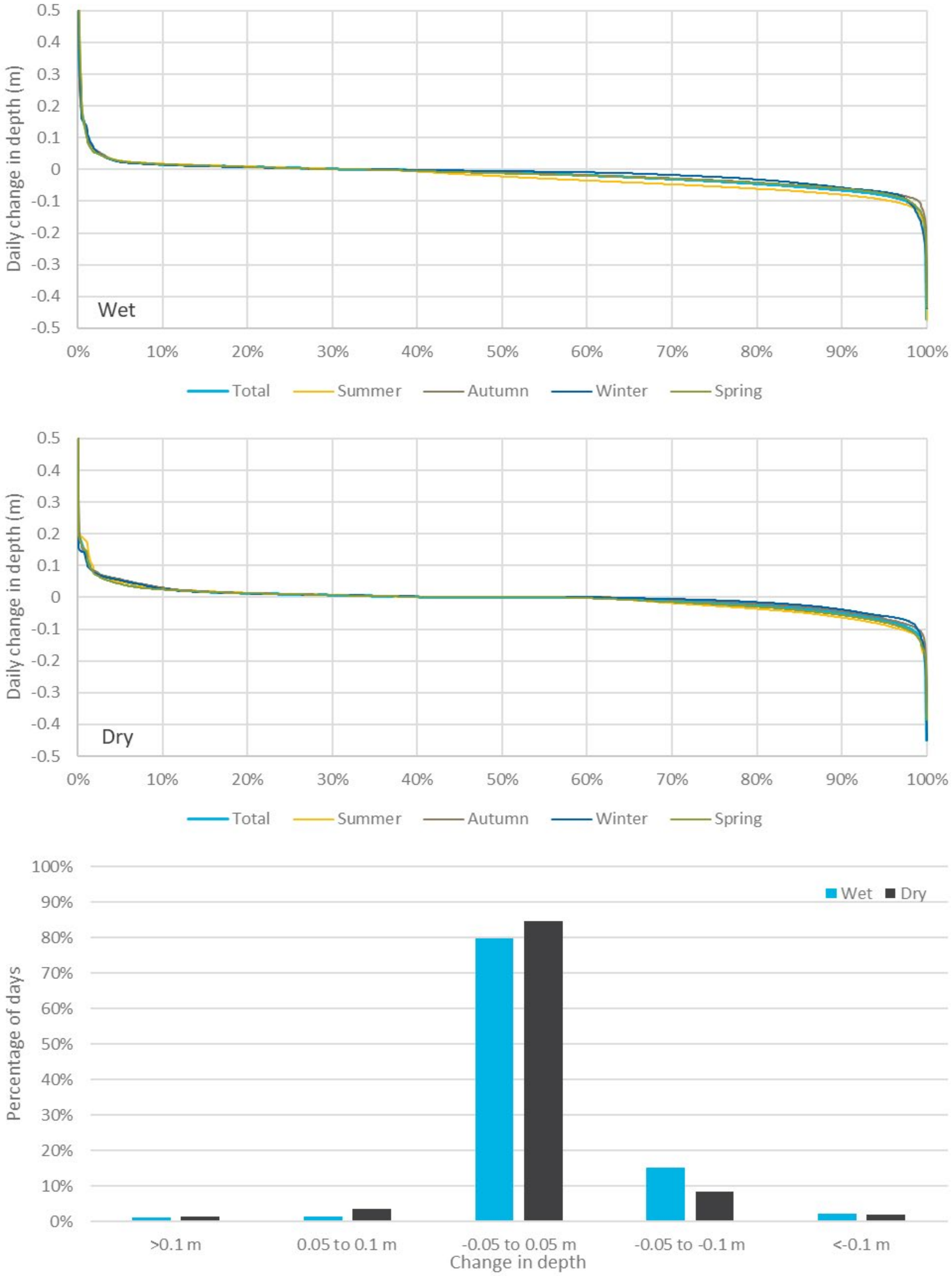


Figure 9.20 Change in daily depth at Piallamore (419015), future climate, +20% demand

iii Paradise weir (419024) – near Tamworth

Figure 9.21 shows modelled daily changes to depth at Paradise weir (419024) with the project infrastructure, the current climate and increased demand. Figure 9.21 shows total change in depth and seasonal changes to depth. Total change to depth is modelled to increase between 1 - 20 cm 10 percent of the time. Changes to depth are then modelled to be nil to negligible 72 percent of the time. Depth is then modelled to decrease by ≥1 cm 18 percent of the time.

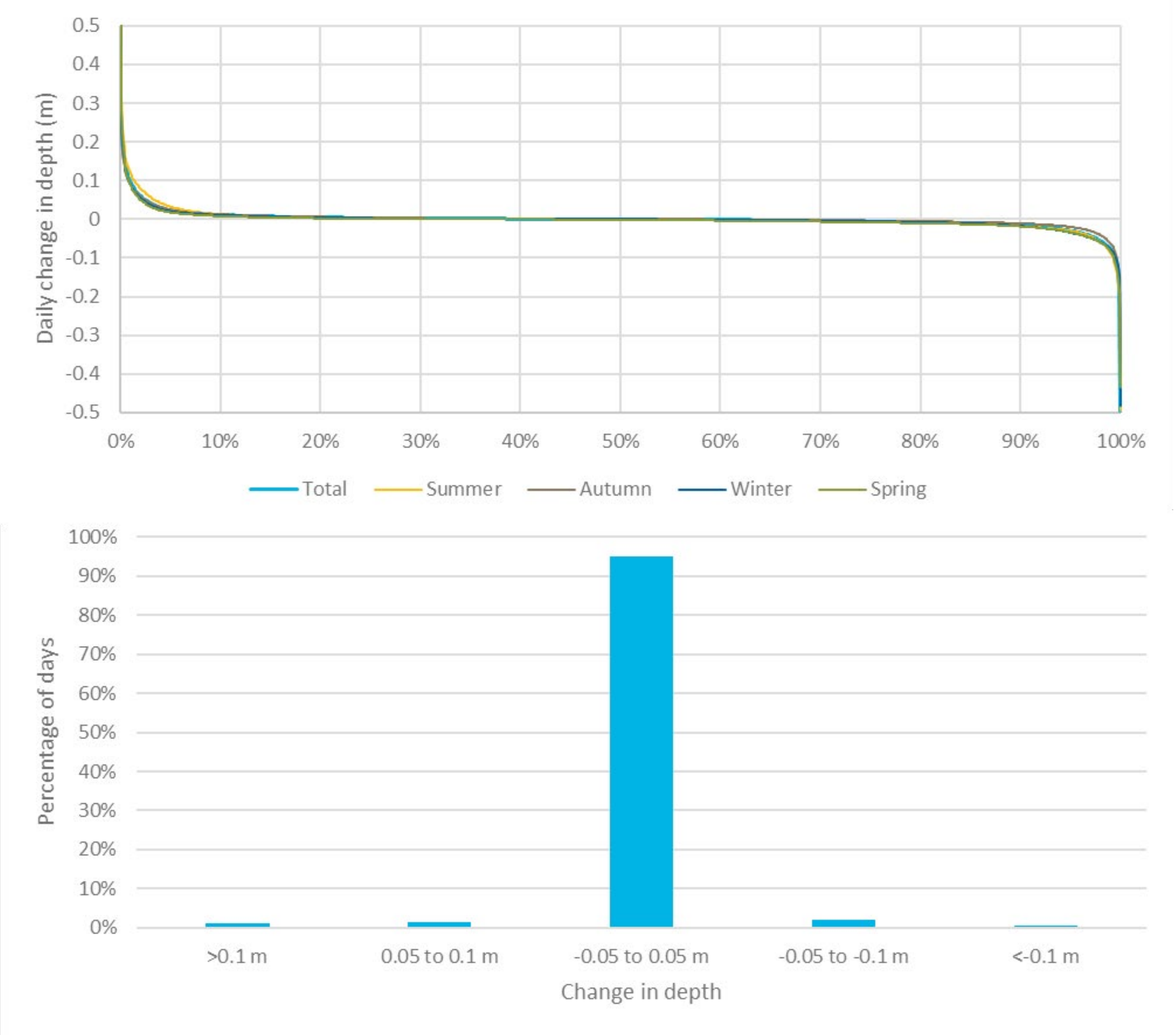


Figure 9.21 Change in daily depth at Paradise Weir (419024), current climate, +20% demand

Figure 9.22 shows modelled daily changes to depth at Paradise Weir (419024), with the project infrastructure, a future wettest climate change scenario or dry climate change scenario and increased demand. Figure 9.22 shows total change in depth and seasonal changes to depth. Modelled changes to depth under the future climate and +20% demand are similar to those for the current climate with +20% demand. The major difference is the seasonal impacts of reduced flow depths under the wet scenario.

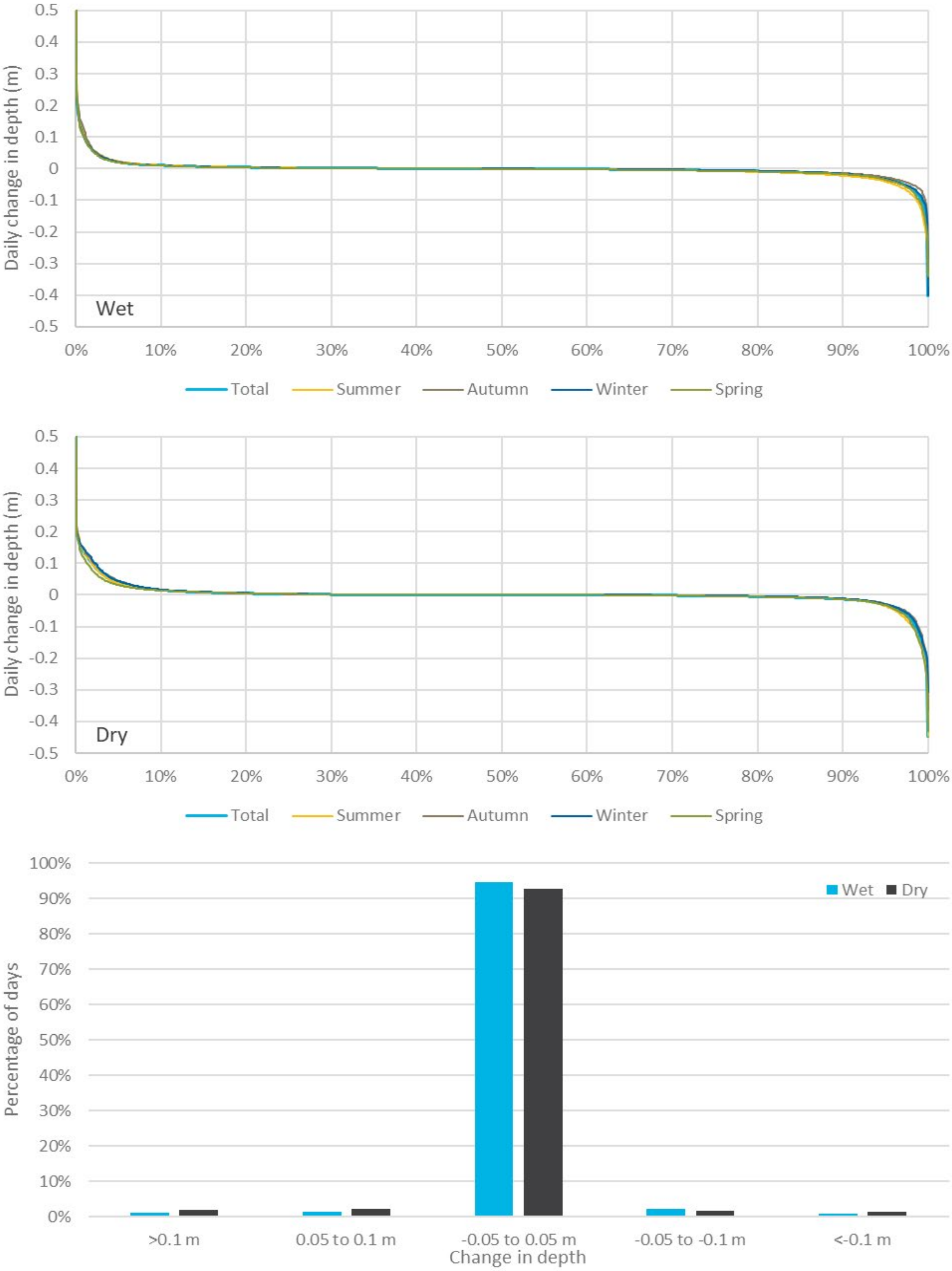


Figure 9.22 Change in daily depth at Paradise Weir (419024), future climate, +20% demand

9.2.3 Environmental Water Requirements for the Peel River

Currently the Environmental Water Requirements (EWR) for the Peel River are not met. The ‘Surface Water Assessment' (EMM, 2022b) details the EWR for the Peel River and shows to what degree water releases currently meet or fail to meet the EWR requirements.

Table 9.1 shows the flow status for each flow component of the Peel River EWR with the current infrastructure in place, and modelled flow status with the project infrastructure in place.

Flow frequency is currently met for all sites for Cease to flow (a) (anytime release) components however, the inter-event duration is not met. Modelled data shows that this will continue to be the case with the project infrastructure in place (Table 9.1).

Flow frequency is currently met for all sites for Cease to flow (b) (anytime release) components however, the inter-event duration is not met. Modelled data shows that this will continue to be the case with the project infrastructure in place.

Flow events are not defined for Cease to flow (c) (anytime release) immediately downstream of Chaffey Dam. Flow frequency is currently met for Cease to flow (c) (anytime release) at Piallamore and Carroll. Modelled data shows this will continue with the project infrastructure in place (Table 9.1).

Flow frequency is currently met immediately downstream of Chaffey Dam and at Piallamore for Very low flow (a). The EWR requirement is not met at Carroll. With the project infrastructure in place, modelled data shows that flow frequency and inter-event duration will both be met immediately downstream of Chaffey Dam and at Piallamore for Very low flow (a) (Table 9.1).

Flow frequency is currently met for Very low flow (b) immediately downstream of Chaffey Dam and at Piallamore however, the inter-event duration is not met. EWR requirements are not met for Carroll. With the project infrastructure in place both flow frequency and the inter-event duration will be met immediately downstream of Chaffey Dam and at Piallamore however, EWR requirements will continue to not be met for Carroll. This pattern is repeated for Very low flow (b) (Table 9.1).

Flow frequency is currently not met immediately downstream of Chaffey Dam and at Piallamore for Base flow 1 (a) however the inter-event duration is met. EWR requirements are not met at Carroll. Flow status for all sites will remain the same for all sites for Base flow 1 (a) with the project infrastructure in place however, modelling indicates that releases will be moving further away from the EWR requirements at Piallamore (Table 9.1). Both flow frequency and inter-event duration are met immediately downstream of Chaffey Dam for Base flow 1 (b) with the current infrastructure in place however, only inter-event duration is met at Piallamore and Carroll. With the project infrastructure in place, flow frequency will not be met at any sites. However inter-event duration will be met for all sites. Modelling shows that releases will be moving further away from the EWR requirements immediately downstream of Chaffey Dam and at Piallamore with the project infrastructure in place.

Currently, both flow frequency and inter-event duration are met for all sites for Base flow 2 (a). Modelling shows this will continue with the project infrastructure in place. Flow status for Base flow 2 (b) repeat what is seen for Base flow 1 (b) and will continue to do so with the project infrastructure (Table 9.1). Both flow frequency and inter-event duration are met for Small fresh 1 (anytime release) immediately downstream of Chaffey Dam with the current infrastructure in place. However, EWR requirements are not met at Piallamore or Carroll. This will continue in the future with the project infrastructure in place.

EWR requirements for Small fresh 1 are not met for all sites with the current infrastructure in place. Modelling shows this will continue with the project infrastructure however, releases will be moving towards the target frequency range immediately downstream of Chaffey Dam (Table 9.1). EWR requirements are currently not met for all sites for Small fresh 2 except at Carroll where flow frequency is currently met. EWR requirements will be unmet at all sites with the project infrastructure in place. However, releases will be moving towards the target frequency range immediately downstream of Chaffey Dam. Both flow frequency and inter-event duration are met immediately downstream of Chaffey Dam for Large fresh 1 (anytime release).

Flow frequency only is met for all other sites. Modelled data shows this will continue with the project infrastructure in place (Table 9.1). EWR requirements are currently unmet at all sites for Large fresh 1. Modelling shows this will continue with the project infrastructure in place. However, releases will be moving towards the target frequency range immediately downstream of Chaffey Dam. EWR requirements are currently not met immediately downstream of Chaffey Dam and at Piallamore for Large fresh 2. Flow frequency is currently met at Carroll, inter-event duration is not. Flow frequency will be met immediately downstream of Chaffey Dam and at Carroll with the project infrastructure in place. EWR requirements will continue to be not met at Piallamore and releases will be moving towards the target frequency range immediately downstream of Chaffey Dam.

EWR requirements are currently not met at all sites for Bankfull 1 through to Bankfull 2 (Table 9.1). Modelling shows this will continue with the project infrastructure in place. Releases will be moving towards the target frequency range immediately downstream of Chaffey Dam for Bankfull 1; immediately downstream of Chaffey Dam and Piallamore for Bankfull 2 (anytime release) and immediately downstream of Chaffey Dam for Bankfull 2 (Table 9.1). Flow frequency is currently met at Piallamore for Overbank 1. However, EWR requirements are not met for all other sites. Modelled data shows this will continue with the project infrastructure in place however, releases will be moving towards the target frequency range immediately downstream of Chaffey Dam. EWR requirements are currently not met for all other flows across all sites with modelling indicating the same with the project infrastructure in place. Releases will be moving towards the target frequency range immediately downstream of Chaffey Dam for Overbank 2 (anytime release).

Table 9.1 Shows flow status for each flow component of the EWR for the Peel River

	Existing Infrastructure			**Proposed Infrastructure**		
Flow Component and Code	**Downstream Chaffey**	**Piallamore**	**Carroll**	**Downstream Chaffey**	**Piallamore**	**Carroll**
Gauge	**419045**	**419015**	**419006**	**419045**	**419015**	**419006**
Cease-to-flow_a_AT	F	F	F	F	F	F
Cease-to-flow_b_AT	F	F	F	F	F	F
Cease-to-flow_c_AT	-	F	F	-	F	F
Very low flow_a	F	F	.	F I	F I	.
Very low flow_b	F	F	.	F I	F I	.
Base flow_1_a	I	I	.	I	I	.
Base flow_1_b	F I	I	I	I	I	I
Base flow_2_a	F I	F I	F I	F I	F I	F I
Base flow_2_b	F I	I	I	I	I	I
Small fresh_1_AT	F I	.	.	F I	.	.
Small fresh_1	.	.	.	.	.	.
Small fresh_2	.	.	F	.	.	.
Large fresh_1_AT	F I	F	F	F I	F	F
Large fresh_1	.	.	.	.	.	.

Table 9.1 Shows flow status for each flow component of the EWR for the Peel River

	Existing Infrastructure			**Proposed Infrastructure**		
Flow Component and Code	**Downstream Chaffey**	**Piallamore**	**Carroll**	**Downstream Chaffey**	**Piallamore**	**Carroll**
Gauge	**419045**	**419015**	**419006**	**419045**	**419015**	**419006**
Large fresh_2	.	.	F	🟩 F	.	F
Bankfull_1	.	.	.	🟩 .	.	.
Bankfull_2_AT	.	.	.	🟩 .	🟩 .	.
Bankfull_2	.	.	.	🟩 .	.	.
Overbank_1	.	F	.	🟩 .	F	.
Overbank_2_AT	.	.	.	🟩 .	.	.
Overbank_2	.	.	.	.	.	.
Overbank_3	.	-	-	.	-	-

Note F indicates that the flow frequency is met; I indicates that the inter-event duration is met. '.' Indicates that the EWR requirement is not met. '-' indicates the event is not defined. Green shading indicates that releases are moving towards the target frequency range. Orange shading indicates that releases are moving away from the target frequency range. 'AT' indicates flow may be released at any time of year.

9.2.4 Cold water pollution

The Surface Water Assessment (EMM, 2022b) reports that CWP effects from the new Dungowan Dam would not extend as far as the Peel River. Run of river transfers from Chaffey Dam would decrease in frequency once the new Dungowan Dam is operational, meaning fewer releases down the Peel River from Chaffey Dam. This suggests a decrease in the frequency of potential CWP events from Chaffey Dam with the new Dungowan Dam operational. The extent of CWP effects from Chaffey Dam will remain the same with the new Dungowan Dam in operation.

9.2.5 Impacts to GDEs

As detailed in (EMM, 2022e), potential impacts to groundwater associated with the Peel River as a result of operating the new Dungowan Dam are as follows:

- Decrease in groundwater levels due to the reduction of run-of-river transfers from Chaffey Dam. Potential to reduce groundwater recharge to the Peel River Alluvium (PRA), potentially resulting in a declining water table limiting groundwater availability. It is possible that the Peel River Alluvial (PRA) groundwater regime may change and GDEs and groundwater users (ie bores) may be affected.

Further details of direct impacts to groundwater as a result of operating the new Dungowan Dam are outlined in the Groundwater Impact Assessment (EMM, 2022e).

9.3 Risk assessment for operation of the new Dungowan Dam

Section 9.1 and Section 9.2 outlines potential impacts associated with the operation of the new Dungowan Dam on the aquatic environments of Dungowan Creek and the Peel River respectively. This section applies a risk matrix to the potential risks and impacts to determine the consequence, likelihood and risk associated with each action for each Listed species. This assessment is based on the data presented in the Surface Water Assessment and Groundwater Impact Assessment, including modelled scenarios for flow, depth and CWP. Whilst some mitigation measures are included within this report a comprehensive CEMP will be prepared based on the risk assessment undertaken in this report. In addition to mitigation measures and management actions to be applied through the comprehensive CEMP potential offsets are to be applied to offset impacts resulting from the proposed action. Offsets are further discussed in section 11.2.

Table 9.2 details the risk matrix and Table 9.3 details the consequence criteria adopted. The operational risk assessment is provided in Table 9.4.

Table 9.2 Risk matrix adopted for the risk assessment for operation

		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

Table 9.3 Consequence criteria adopted for the risk assessment for operation

	Insignificant (IN)	**Minor (MI)**	**Moderate (MO)**	**Major (MA)**	**Catastrophic (CA)**
	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

Table 9.3 Consequence criteria adopted for the risk assessment for operation

	Insignificant (IN)	Minor (MI)	Moderate (MO)	Major (MA)	Catastrophic (CA)
Species Specific Interactions- Aquatic Ecology	No measurable permanent impacts on aquatic ecology values	Minor short term impacts, life cycle may be disrupted but for less than a year. Annual recruitment should still occur. Short and long term viability of individual species not impacted	Medium term (1-2 year) impacts, life cycle disrupted and resulting in no recruitment for a year. Short term viability of individual species impacted recovery within 1 -5 years. Long term viability of species not impacted	Long term (2-5 year) impacts, life cycle significantly disrupted no recruitment for successive years. Short term and long term viability individual species impacted recovery time frame (5-10 years)	Loss of species and population. Minimal possibility of recovery
Surface Water - Water Quality	No measurable change to surface water quality or quality changes are not measurable	Changes to Surface Water quality during the activity, no further changes noted once activity is finished	Changes to Surface Water quality due to activity, recovery up to 1 year	Changes to Surface Water Quality due to activity, recovery 1-2 years	Changes to Surface water quality, where water becomes toxic, or permanent changes to quality, recovery is greater than 2 years
GDE	No detectable change in groundwater levels or quality	Local short term changes in ground water level (>2m change).	Local long term changes in ground water levels (<2m change) or short term regional changes in water level of (>2m change).	Regional long term changes to groundwater levels (>2m change).	Regional long term changes to groundwater levels (<2m change).

Table 9.4 Risk assessment for operational impacts

Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments incl Uncertainty
Species Specific interactions - Aquatic Ecology Dungowan Creek	Impacts to Eel-tailed Catfish	Spawning aborted due to Cold water pollution event as temperatures fail to cue breeding Temperatures of 20 and 24°C is preferable for spawning	Use of multi-level offtake (MLO) during warmer season in addition to ongoing temperature monitoring. Algal blooms within dam mean water must be taken from 10 m below supply level. Consideration of destratification infrastructure during detailed design	MO	PO	M	There is potential for CWP to occur during the spring-summer spawning season. Despite the MLO, the Regional Algal Contingency Plan (Department of Primary Industries, 2020b) states that should algal blooms exceed water quality guidelines water must be drawn from 10 m below supply level in order to minimise algal seeding downstream. There is potential for CWP to occur within 5 km downstream of the new Dungowan Dam. Spawning may be aborted should breeding cues not occur
			Use of multi-level offtake (MLO) during warmer season in addition to ongoing temperature monitoring. No algal blooms	IN	P	L	No CWP pollution so no impact to spawning.
Species Specific interactions - Aquatic Ecology Dungowan Creek	Impacts to Silver Perch	Spawning of Silver Perch occurs when water temperatures reach ~ 23°C. Cold water pollution may impact breeding cue and may result in aborted spawning	Use of multi-level offtake (MLO) during warmer season in addition to ongoing temperature monitoring. Algal blooms within dam mean water must be taken from 10 m below supply level. Consideration of destratification infrastructure during detailed design	MO	PO	M	There is potential for CWP to occur during the spring-summer spawning season. Despite the MLO, the Regional Algal Contingency Plan (Department of Primary Industries, 2020b) states that should algal blooms exceed water quality guidelines water must be drawn from 10 m below supply level in order to minimise algal seeding downstream. There is potential for CWP to occur within 5 km downstream of the new Dungowan Dam. Spawning may be aborted should cues not occur. No evidence of Silver Perch recruitment in Dungowan Creek.
			Use of multi-level offtake (MLO) during warmer season in addition to ongoing temperature monitoring. No algal blooms.	IN	P	L	No CWP pollution so no impact to spawning. No evidence of Silver Perch recruitment in Dungowan Creek.
		A rise in water levels can stimulate untimely aggregation and spawning	Ensure no planned high flow events during spring-summer	MI	P	L	High flow events may occur naturally (eg rain events). Unlikely to occur in the absence of a rain event. Any impact unlikely to be attributed to operation or Dungowan Dam
		Creation of a barrier to migration	Construction of the new Dungowan Dam will create a barrier to migration. Existing Dungowan Dam is a barrier to migration so no new impact occurring	IN	AC	M	The existing Dungowan Dam currently creates a barrier to migration so no new impact occurring. Loss of approximately 6.19 kilometres of habitat due to changed location of fish barrier. Existing weirs to be removed as part of the Offsets agreement. Risk is classified as Medium as a result of risk matrix structure. Is considered a low impact for Silver Perch.
Species Specific interactions - Aquatic Ecology Dungowan Creek	Impacts to Murray Cod Spawning success in Dungowan Creek within 5km of new Dungowan Dam Wall	Spawning occurs in spring-summer in response to rising water temperatures of 16.5 – 23.5°C CWP based on the 10-13ML translucent floe has the potential to disrupt and or delay spawning within 5km of the new dam release point. Assuming water released from dam is 13°C	Use of multi-level offtake (MLO) during warmer season in addition to ongoing temperature monitoring. Algal blooms within dam mean water must be taken from 10 m below supply level. Consideration of destratification infrastructure during detailed design	MO	PO	M	There is potential for CWP to occur during the spring-summer spawning season. Despite the MLO, the Regional Algal Contingency Plan (Department of Primary Industries, 2020b) states that should algal blooms exceed water quality guidelines water must be drawn from 10 m below supply level in order to minimise algal seeding downstream. There is potential for CWP to occur within 5 km downstream of the new Dungowan Dam. Spawning may be aborted should cues not occur.
		Spawning occurs in spring-summer in response to rising water temperatures of 16.5 – 23.5°C Assumes water releases occur from surface level with insignificant impacts to downstream water temperatures.	Use of multi-level offtake (MLO) during warmer season in addition to ongoing temperature monitoring. No algal blooms.	IN	PO	L	No CWP pollution so no impact to spawning.

Table 9.4 Risk assessment for operational impacts

Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments incl Uncertainty
		Hard substrate such as submerged log or rock, or excavations in clay bank used for spawning	Ensure no reduction in flow during spring-summer which may expose potential spawning habitat	MO	R	L	Modelled data indicates flows are unlikely to decrease significantly under the new Dungowan Dam regime compared to the existing flows
		Successful spawning correlated to increased flow or flooding	Ensure no reduction in flow during spring-summer. Translucency flows of 10-13ML/day maintained.	MI	PO	L	Modelled data indicates flows are unlikely to decrease significantly under the new Dungowan Dam regime compared to the existing flows therefore no significant impact anticipated.
		Low flows during spring may limit the dispersal of larvae down stream	Ensure no reduction in flow during spring-summer. Translucency flows of 10-13ML/day maintained.	MI	PO	L	Modelled data indicates flows are unlikely to decrease significantly under the new Dungowan Dam regime compared to the existing flows
		High flows during spring may flush underdeveloped larvae from nests	Ensure no managed high flow events during spring-summer. It is possible that emergency releases may be required during the operation of the dam in response to an extreme weather event.	IN	R	M	High flow events may occur naturally (eg rain events). Unlikely to occur in the absence of a rain event or as a result of operating the new Dungowan Dam. The natural flows would be deemed to have resulted in the same impacts to larvae if emergency releases were required.
		Creation of a barrier to migration	Construction of the new Dungowan Dam may create a barrier to migration. The existing Dungowan Dam currently creates a barrier to migration so no new impact occurring. There is a loss of key fish habitat as a result of the new construction and this has been addressed under dam construction	IN	UN	L	The existing Dungowan Dam currently creates a barrier to migration so no new impact occurring. Existing weirs to be removed as part of the Offsets agreement.
Species Specific interactions - Aquatic Ecology	Impacts to Spawning success in Dungowan Creek greater then 5km from the new Dungowan Dam Wall for all species	Spawning occurs in spring-summer temperature spawning cues not disrupted.	No flows greater than the modelled 13ML translucency flow to occur during spring – summer spawning periods.	IN	PO	L	No CWP pollution impacts to extend more than 5km DS so no impact to spawning.
Species Specific (state or nationally listed species)	Impacts to all listed species as a result of the construction and operation of the new dam and Pipeline	Short term or Long term removal of state and nationally listed species as a result of the project	Impacts to species in the region or state not likely to meet the criteria set out in the consequence matrix.	IN	PO	L	Project construction and operation not expected to result in the removal or loss of listed species from Dungowan Creek or downstream environment.
Species Specific interactions - Aquatic Ecology Dungowan Creek	Southern Purple-spotted Gudgeon	Breeding requires three dimensional complex structure in waters approximately 1 metre deep. Structure combination of vegetation and hard substrate. Inundation may cause breeding to be aborted.	Ensure no high flow events during spring/summer	MO	R	L	High flow events may occur naturally (eg rain events). Unlikely to occur in the absence of a rain event or as a result of operating the new Dungowan Dam
		Breeding requires three dimensional complex structure in waters approximately 1 metre deep. Structure combination of vegetation and hard substrate. Exposure will cause breeding to be aborted.	Ensure no reduction in flow during spring-summer	MO	UN	M	Modelled data indicates flows are unlikely to decrease significantly under the new Dungowan Dam flow regime

Table 9.4 Risk assessment for operational impacts

Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments incl Uncertainty
		CWP has potential to impact spawning cues, 19°C-34°C required to cue spawning	Use of multi-level offtake (MLO) during warmer season in addition to ongoing temperature monitoring. Algal blooms within dam mean water must be taken from 10 m below supply level. Consideration of destratification infrastructure during detailed design	MO	PO	M	Despite the MLO, the Regional Algal Contingency Plan (Department of Primary Industries, 2020b) states that should algal blooms exceed water quality guidelines water must be drawn from 10 m below supply level in order to minimise algal seeding downstream. There is potential for CWP to occur within 5 km downstream of the new Dungowan Dam. Spawning may be aborted should cues not occur.
			Use of multi-level offtake (MLO) during warmer season in addition to ongoing temperature monitoring. No algal blooms	MO	R	L	No CWP pollution so no impact to spawning.
Species Specific interactions - Aquatic Ecology Dungowan Creek	Impacts to Platypus	Reduction in area of feeding habitat due to lowered water levels	Minimise low flow events that will leave water levels lower than they have been historically.	MA	L	H	Modelled data indicates flows are unlikely to decrease significantly under the new Dungowan Dam flow regime. However, the area of riffle habitat that is likely to be impacted is not known. Some impacts to flows are expected however the impacts to the area of riffle habitat that will be impacted is unclear. Due to the lack of data a precautionary approach to habitat availability has been adopted and as such the consequence has been listed as Major. It is likely to occur based on the modelling with some impacts throughout the year to flow volume and depth anticipated. Risk is therefore deemed to be high.
		Loss of aquatic habitat during breeding season due to lowered flows	Ensure no reduction in flow during spring-summer. Translucent flows to be maintained at 10-13ML day	MI	P	L	Modelled data indicates flows are unlikely to decrease significantly under the new Dungowan Dam flow regime on an annual basis.
		Loss of food source (macroinvertebrates) due to temperature change from CWP	Use of multi-level offtake (MLO) during warmer season in addition to ongoing temperature monitoring. Algal blooms within dam mean water must be taken from 10 m below supply level. Consideration of destratification infrastructure during detailed design	MI	P	L	There is potential for CWP to occur during the spring-summer season. This may result in approximately 5 kilometres of habitat that is not suitable for specific species of macroinvertebrate. Should this occur, given sufficient time another species will likely fill the niche resulting in no net loss of macroinvertebrate biomass. The area of impact is not considered critical habitat and is considered relatively small given habitat availability in the broader region.
		Loss of food source (macroinvertebrates) due to temperature change from CWP	Use of multi-level offtake (MLO) during warmer season in addition to ongoing temperature monitoring. No algal blooms.	IN	P	L	No CWP pollution so no impact to food resources.
Species Specific interactions - Aquatic Ecology Dungowan Creek	Impacts to All species	CWP from the new Dungowan Dam will likely reduce the temperature in Dungowan Creek by 2 °C. This temperature change will persist for up to 5 km downstream of the proposed dam. This may result in the extension of the impacts by a further 500m – 1 km relative to current CWP effects as seen at the existing Dungowan Dam	Use of multi-level offtake (MLO) during warmer season in addition to ongoing temperature monitoring.	MO	P	M	Despite the MLO, the Regional Algal Contingency Plan (Department of Primary Industries, 2020b) states that should algal blooms exceed water quality guidelines water must be drawn from 10 m below supply level in order to minimise algal seeding downstream. There is potential for CWP to occur within 5 km downstream of the new Dungowan Dam.

Table 9.4 Risk assessment for operational impacts

Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments incl Uncertainty
		Changes to flow volume and depth with impact to all species as a result of changes to habitat availability along Dungowan Creek. **Flows** = Change in flow of +/-10ML modelled to occur 89% of time greater variations will occur 11% of the time under the current climate and +20% demand. Change in flow of +/-10ML modelled to occur 92% of time greater variations will occur 8% of the time under the future climate and + 20% demand. **Depth** = Change in depth +/- 5cm modelled to occur 91% of the time under current climate with +20% demand. A reduction in depth greater than 5cm is modelled to occur 4% of the time under current climate with +20% demand.	Impacts of the changes in flow to habitat availability cannot be accurately quantified based on the current data. No mitigations currently proposed or considered.	MA	L	H	There are likely to be losses of riffle habitat although this cannot be quantified at this stage. Due to the lack of data a precautionary approach to habitat availability has been adopted and as such the consequence has been listed as Major. It is likely to occur based on the modelling with some impacts throughout the year to flow volume and depth anticipated. Risk is therefore deemed to be high. Changes in flow and depth are modelled but impact to habitat availability particularly riffle habitat cannot be quantified.
		Aquatic Fauna Passage disrupted due to change in flow volume and water depth **Flows** = Change in flow of +/-10ML modelled to occur 89% of time greater variations will occur 11% of the time under the current climate and +20% demand. Change in flow of +/-10ML modelled to occur 92% of time greater variations will occur 8% of the time under the future climate and + 20% demand. **Depth** = Change in depth +/- 5cm modelled to occur 91% of the time under current climate with +20% demand. A reduction in depth greater than 5cm is modelled to occur 4% of the time under current climate with +20% demand.	Impacts of the changes in flow to Fauna passage cannot be accurately quantified based on the current data. No mitigations currently proposed or considered.	MO	L	H	Considered moderate impact based on the potential for disruption to life cycle for 1-2 years. Potential for short term viability of individual species impacted recovery within 1 -5 years. Long term viability of species not impacted Impacts to fauna passage is likely to occur and therefore considered a high risk.
Species Specific interactions - Aquatic Ecology Peel River	Impacts to All species	CWP impacts to all species as a result of the construction and operation of the new Dungowan Dam	Modelling indicates the CWP impacts will not reach the Peel River	IN	R	L	No CWP impacts will reach the Peel River so no impacts.
		Reduction in EWR compliance for Base flows between existing and proposed conditions for Base flow 1_a, Base Flow 2_a and Small Freshes 2.	No additional control measure to increase compliance with EWR for the Peel River.	MO	AC	H	A reduction in base flow compliance is rated as a high risk. Moderate consequence because of potential for disruption of a range of species behaviours, including fish passage.
		Changes to flow volume and depth with impact to all species as a result of changes to habitat availability along Peel River under the new operational guidelines for the Dungowan Pipeline with a reduction in run of river flows from Chaffey Dam to the Tamworth. **Flows** = Reduction in flow modelled to occur at Chaffey Dam and Piallamore ~ 75 % of the time, reductions of ≥10ML modelled to occur ~40% of the time At Tamworth reductions in flow modelled to occur ~25% of the time, reductions of ≥10ML modelled to occur ~10% of the time. Future climate +20% demand has only minor impacts on depths. **Depth** = Change in depth of ≥ 1cm are modelled to occur up to 48 percent of the time at Chaffey Dam and Piallamore with greater modelled impacts over summer under current climate with +20% demand. A Reduction in depth greater than ≥ 1cm is modelled to occur 18% of the time under current climate with +20% demand. Future climate +20% demand has only minor impacts on depths.	Impacts of the changes in flow to habitat availability cannot be accurately quantified based on the current data. No mitigations currently proposed or considered.	MO	L	H	Modelled reduction in flow volume and depth upstream of the confluence of the Cockburn and Peel River for significant periods anticipated. Impacts to reduction in availability of riffle habitat cannot be quantified. Pool and habitat values and likely to be less affected than riffle habitat. Impacts downstream of Tamworth much less pronounced. Considered to be a moderate impact as may impact species at the local level with potential for long term but reversable impacts. Likely to occur based on modelling and deemed a High risk.

Table 9.4 Risk assessment for operational impacts

Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments incl Uncertainty
		Aquatic Fauna Passage disrupted due to change in flows Changes to flow volume and depth with impact to all species as a result of changes to habitat availability along Peel River under the new operational guidelines for the Dungowan Pipeline with a reduction in run of river flows from Chaffey Dam to the Tamworth. **Flows** = Reduction in flow modelled to occur at Chaffey Dam and Piallamore ~ 75 % of the time, reductions of ≥10ML modelled to occur ~40% of the time At Tamworth reductions in flow modelled to occur ~25% of the time, reductions of ≥10ML modelled to occur ~10% of the time. Future climate +20% demand has only minor impacts on flows. **Depth** = Change in depth of ≥ 1cm are modelled to occur up to 48 percent of the time at Chaffey Dam and Piallamore with greater modelled impacts over summer under current climate with +20% demand. A reduction in depth greater than ≥ 1cm is modelled to occur 18% of the time under current climate with +20% demand. Future climate +20% demand has only minor impacts on depths.	Impacts of the changes in flow to Fauna passage cannot be accurately quantified based on the current data. No mitigations currently proposed or considered. Fish passage will be improved as part of the Offset agreement agreed for the project with upgrades to four recognised fish barriers permitting future fish passage.	MO	L	H	Modelled reduction in flow volume and depth upstream of the confluence of the Cockburn and Peel River for significant periods anticipated. Upgrades to recognised fish barriers will improve passage however impact of reduced flow and depth to fish passage over natural barriers (ie riffles) is less certain. Impacts downstream of Tamworth much less pronounced. Considered to be a moderate impact as may impact species at the local level with potential for long term but reversable impacts. Likely to occur based on modelling and deemed a High risk.
Species Specific (state or nationally listed species)	Lower flows to Peel River from Chaffey Dam as a result of operation of Dungowan Dam/pipeline	Risk to Lower Darling EEC as a result of the project changes to river hydrology and impacts on values (species) of the Lower Darling EEC.	Upgrade of fish barrier to facilitate better fish passage at four recognised barriers. Translucent flows from Dungowan Dam 10-13ML/day	MI	AC	M	Reaches significantly impacted are upstream of Tamworth. Area/length of river considered to be less than 1% of the total Lower Darling EEC. Consequence considered minor as impacts less than 1% of area of the state listed EEC, Likelihood is Almost certain as is modelled to occur. Deemed a Moderate risk.
GDE – Peel River	Lower flows to Peel River from Chaffey Dam as a result of operation of Dungowan Dam/pipeline	Lower Run of River flows results is reduced recharge of Peel River Alluvium may result in decreases in ground water levels within the Alluvium. Potential impacts to Stygofauna	No proposed control measures.	MA	L	H	Considered a Major impact because it will be a long term impact and potentially have impacts across the Peel River between Chaffey and Tamworth. Based on the available information it is considered a high risk of an impact to GDE.
GDE – Dungowan Creek	Construction/operation of new dam	The construction of the new Dungowan Dam will result Impoundment of groundwater flow disrupting hydraulic gradients and flow paths	No proposed control measures.	MO	L	H	Considered a Moderate impact because it will be a long term impact and potentially have impacts at the local scale around Dungowan Dam. It is considered a high risk but will not necessarily have a negative impact on localised GDE and stygofauna
Species Specific interactions - Aquatic Ecology	Fish Migration	Migration of fish upstream and downstream of spillway - SEARS 18	Offset strategy in place for loss of fish passage to key fish habitat as a result of the new Dungowan Dam.	C	AC	E	Consequence is considered catastrophic as fish passage is permanently removed from key fish habitat. Likelihood is Almost certain as it will occur. Risk is considered Extreme. Note: Offsets have already been agreed with the modification of 4 fish barriers on the Peel River to facilitate improved fish passage

Table 9.4 Risk assessment for operational impacts

Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments incl Uncertainty
Species Specific interactions - Aquatic Ecology	Trauma from downstream fish passage over the spillway	Fish passage over the spill way can result in death or trauma to fish and aquatic fauna.	No mitigation measures proposed to restrict passage or prevent trauma.	Mi	L	M	Fish do survive passage over spill ways. However many fish are lost as a result of the trauma. Large numbers of fish are not anticipated to be entrained during smaller spilling events however larger spilling events may facility the passage of more and larger fish. Consequence considered minor based on localised impacts. Likely hood is considered likely as the dam is expected to spill, deemed a medium risk.
Species Specific interactions - Aquatic Ecology	Entrapment of fish in the stilling basin	Fish trapped in stilling basin after a dam spilling event	No mitigation measures currently in place	MI	L	M	Fish do survive passage over spill ways. However many fish are lost as a result of the trauma. Large numbers of fish are not anticipated to be entrained during smaller spilling events however larger spilling events may facility the passage of more and larger fish. Some fish will ultimately be trapped in the stilling basin Consequence considered minor based on localised impacts. Likely hood is considered likely as the dam is expected to spill, deemed a medium risk.

10 Cumulative impacts

Cumulative impacts of the project have been assessed assuming the operation of the Chaffey pipeline would occur when the new Dungowan Dam is operational. As the Chaffey pipeline operation would deliver water from Chaffey Dam to Calala through a pipeline instead of via run of river transfers, Dungowan Creek would not be affected by cumulative impacts and is not assessed. The cumulative impacts are therefore focussed on changes to hydrology in the Peel River.

10.1 Changes to flow and EWR compliance

An assessment of the cumulative impacts of the project with the Chaffey pipeline in operation (EMM, 2022b) was assessed using a future increased demand (+ 20% above current demand). As the operation of the Chaffey pipeline is only proposed to occur during drought years when dam levels are low (below 20%), the largest cumulative effects of pipeline operation would likely be the frequency of low flow events during drought years, particularly evident immediately below Chaffey Dam.

Figure 10.1identifies modelling showing the operation of the Chaffey pipeline would reduce the duration of cease-to-flow events and reduce the very low flow inter-event duration, with little effect on baseflow and larger events. This is because the volume of water taken to Calala via the pipeline would be smaller than the volume that would have been released to the river, as transmission losses would be avoided.

Pipeline operation would result in a reduction to the average volume of very low flow events, and more water stored in Chaffey Dam. Due to increased water storage in Chaffey Dam, the pipeline would increase the availability of water, which could be used to prevent cease-to-flow conditions.

As there are no meaningful changes to Peel River hydrology as a result of the Chaffey pipeline (EMM, 2022b), the cumulative impacts to aquatic values resulting from the operation of the new Dungowan Dam and the Chaffey pipeline are considered negligible.

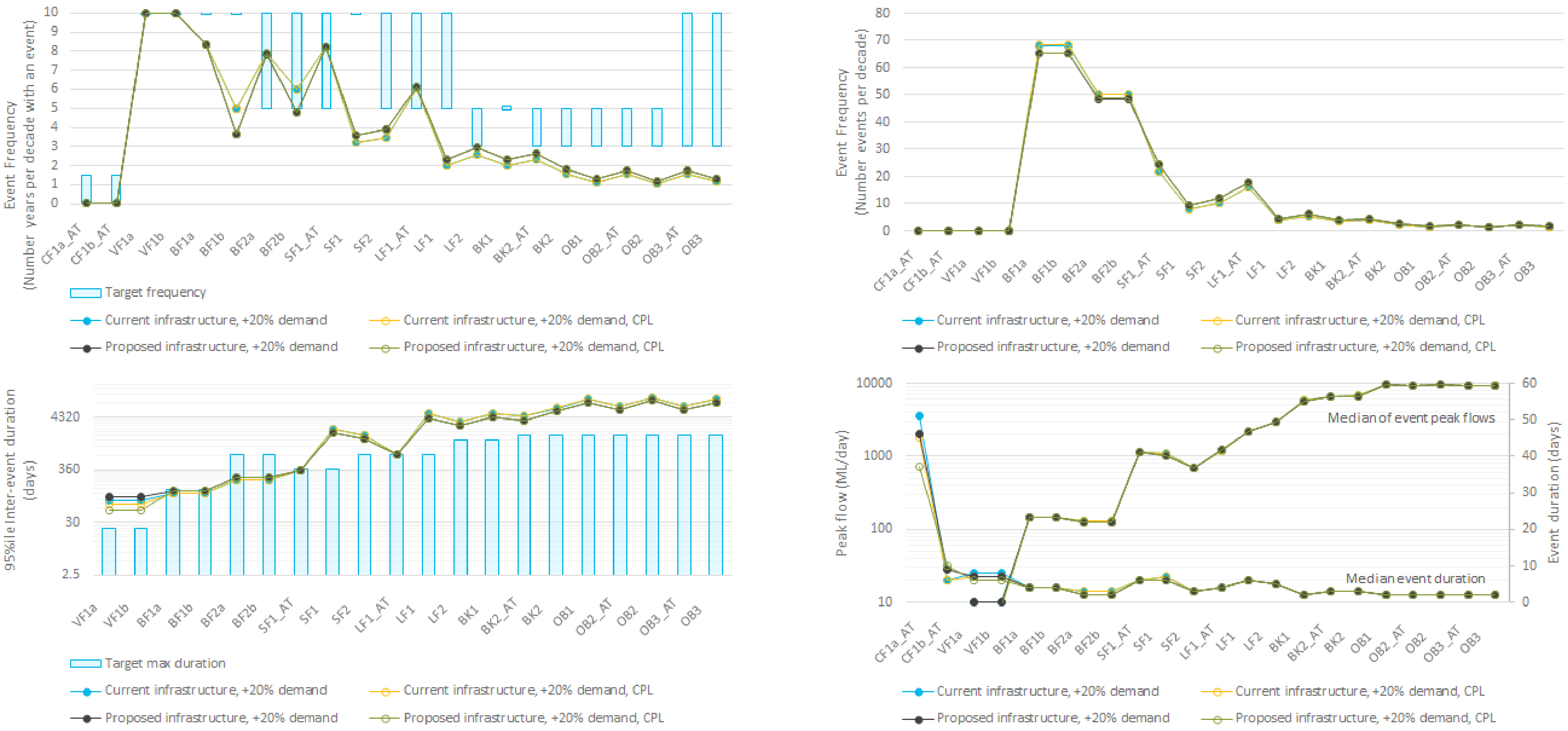


Figure 10.1 Downstream from Chaffey Dam (419045) environmental flow event characteristics, cumulative effects with Chaffey Pipeline operation (CPL)

10.2 Risk assessment for cumulative impacts

Table 10.1 details the risk matrix, Table 10.2 details the consequence criteria adopted and the risk assessment for cumulative impacts is provided in Table 10.3. Whilst some mitigation measures are included within this report a comprehensive CEMP will be prepared based on the risk assessment undertaken in this report. In addition to mitigation measures and management actions to be applied through the comprehensive CEMP potential offsets are to be applied to offset impacts resulting from the proposed action. Offsets are further discussed in Section 11.1.

Table 10.1 Risk matrix adopted for the cumulative impacts 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**

Table 10.2 Consequence Criteria adopted for the Risk assessment for Cumulative Impacts

	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
	Minimal, if any, impact which have an overall negligible net effect	Localised, reversible short term reversible event with minor effects which are contained to an onsite level	Localised long term but reversible event with moderate impacts on a local level	Extensive, long term, but reversible event with high impacts on a regional level	Long term, extensive, irreversible with high level impacts at potential state wide levels
Species Specific (state or nationally listed species)	No detectable permanent impacts on population of a listed species; AND/OR short term removal of >1% of the site population but <1% of the local, regional or state population of a listed species	Permanent removal of >1% of the site population but <1% of the local, regional or state population of a listed species; AND/OR short term removal of >1% of the local population but <1% of the regional or state population of a listed species	Permanent removal of >1% of the local population but <1% of the regional or state population of a listed species; AND/OR short term removal of >1% of the regional population but <1% of the state population of a listed species	Permanent removal of >1% of the regional population but <1% of the state population of a listed species; AND/OR short term removal of >1% of the state or national population of a listed species	Permanent removal of >1% of the state or national population of a listed species

Table 10.2 Consequence Criteria adopted for the Risk assessment for Cumulative Impacts

	Insignificant	Minor	Moderate	Major	Catastrophic
Species Specific Interactions- Aquatic Ecology	No measurable permanent impacts on aquatic ecology values	Minor short term impacts, life cycle may be disrupted but for less than a year. Annual recruitment should still occur. Short and long term viability of individual species not impacted	Medium term (1-2 year) impacts, life cycle disrupted and resulting in no recruitment for a year. Short term viability of individual species impacted recovery within 1 -5 years. Long term viability of species not impacted	Long term (2-5 year) impacts, life cycle significantly disrupted no recruitment for successive years. Short term and long term viability individual species impacted recovery time frame (5-10 years)	Loss of species and population. Minimal possibility of recovery
Surface Water - Water Quality	No measurable change to surface water quality or quality changes are not measurable	Changes to Surface Water quality during the activity, no further changes noted once activity is finished	Changes to Surface Water quality due to activity, recovery up to 1 year	Changes to Surface Water Quality due to activity, recovery 1-2 years	Changes to Surface water quality, where water becomes toxic, or permanent changes to quality, recovery is greater than 2 years
GDE	No detectable change in groundwater levels or quality	Local short term changes in ground water level (>2m change).	Local long term changes in ground water levels (<2m change) or short term regional changes in water level of (>2m change).	Regional long term changes to groundwater levels (>2m change).	Regional long term changes to groundwater levels (<2m change).

Table 10.3 Risk assessment for cumulative impacts

Project Phase	Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments incl Uncertainty
Operation	GDE	Cumulative impacts	Lower flows in Peel River reduce Peel River Alluvial recharge. No impacts expected downstream of Tamworth.	No proposed control measures.	MA	L	H	Stygofauna assemblage and distribution in downstream catchment (Namoi River) still poorly documented. The cumulative impact of the possible impact to the stygofauna community in the Peel River is impossible to quantify. Risk has been retained as for the operational impacts as a precautionary measure.
Operation	Species Specific Interactions- Aquatic Ecology	Fish passage	Cumulative impacts of altered flows on fish passage	Offsets as part of the fish barrier offsets will modify 4 known fish barriers to facilitate better fish passage	MI	AC	M	Consequence is considered Minor as fish passage may be impacted at a local scale (ie upstream of Tamworth). Likelihood is Almost certain as it will occur. Risk is considered Medium. Note: Outcomes for fish passage are likely to improve as a result of the project and the offsets agreements. Over all fish passage likely to improve with a negligible cumulative impact.
Operation	Species Specific Interactions- Aquatic Ecology	Altered flows	Operation of Chaffey pipeline under drought conditions results in lower delivery of water via run of river flows resulting in reduction in flows in Peel River between Chaffey Dam and Tamworth.	No control measures in proposed.	MO	P	M	Altered flows expected under drought conditions with some minor impacts. Considered Moderate consequence due to localised long term but reversable impacts, likelihood is considered possible as will occur under drought conditions which will occur. Risk is deemed moderate.
Operation	Species Specific Interactions- Aquatic Ecology	Compliance with EWR	Operation of the Chaffey Dam Pipeline will result in reduced compliance with the EWR for the Peel River. Only minor impacts to EWR compliance modelled to occur. No impacts downstream of Tamworth anticipated.	No proposed control measures	MI	P	L	
Operation	Species Specific Interactions- Aquatic Ecology	Cumulative Impacts to reproductive and survival success of native fish species.	Project operation could contribute to the long term survival of native fish species via disruption of recruitment or long term survival.	No Proposed control measures	IN	P	L	Silver Perch – no known self-sustaining population in the catchment Purple Spotted Gudgeon – no known population within the area impacted by the project. So no cumulative impacts expected. Murray Cod, Freshwater Catfish – cumulative impacts not expected to be significant. Reproductive success still expected to occur and survival and persistence of species.
Operation	Species Specific (state or nationally listed species)	Cumulative impact of Lower flows to Peel River from Chaffey Dam as a result of operation of Dungowan Dam/pipeline and Chaffey Dam Pipeline	Risk to Lower Darling EEC as a result of the project changes to river hydrology and impacts on values (species) of the Lower Darling EEC.	Upgrade of fish barrier to facilitate better fish passage at four recognised barriers. Translucent flows from Dungowan Dam 10-13ML/day	MI	AC	M	Project consequence, likelihood and risk retained for cumulative impacts in absence of detailed understanding of potential impacts to the broader lower Darling EEC. Reaches significantly impacted are upstream of Tamworth. Area/length of river considered to be less than 1% of the total Lower Darling EEC. Consequence considered minor as impacts less than 1% of area of the state listed EEC, Likelihood is Almost certain as is modelled to occur. Deemed a Moderate risk.
Operation	Species Specific Interactions- Aquatic Ecology	Cumulative Impacts to All species	CWP impacts to all species as a result of the construction and operation of the new Dungowan Dam	Modelling indicates the CWP impacts will not reach the Peel River	IN	R	L	No CWP impacts will reach the Peel River so no impacts.

11 Offsets and mitigation measures

This chapter details the offsets pathway and mitigation measures selected to either offset direct impacts, or reduce the risk of impacts through implementing mitigation measures detailed in this assessment and in other relevant EIS technical assessments.

11.1 Offsets

11.1.1 Fish passage offsets

The existing Dungowan Dam is a current barrier to fish movement. No fish passage infrastructure is included in the design of the new Dungowan Dam and as a result, the new Dungowan Dam will also pose a barrier to fish passage. In essence the barrier to fish movement will be removed from its current location and established 6.19 km (stream length) downstream. This will result in a loss of connectivity to waterways upstream of the new Dungowan Dam, as shown in Table 8.1 and Figure 8.1 .

In discussions with DPI Fisheries, an offsets pathway has been established to offset this loss of connectivity to upstream habitat whereby Water Infrastructure NSW will facilitate the removal, upgrade or bypassing of four existing barriers to fish passage on the Peel River downstream of the new Dungowan Dam. This will facilitate increased connectivity and free movement of fish and platypus between Gunidgera weir and the new Dungowan Dam wall (Figure 11.1).

Whilst details have not been finalised, a draft Fishways Workplan has been prepared and is included in Annexure J. The Fishways Workplan details the timeline for the proposed offset works and shows that four projects would be completed before operation of the new Dungowan Dam commences.

The barriers to be removed, improved or bypassed, and the proposed treatment types, are:

- Calala water gauging station (upgrade)
- Paradise TRC water pipe relocation/upgrade (addition of fishway)
- Jewry Street Causeway remediation/upgrade (addition of fishway)
- Pontibah Causeway remediation/upgrade (box culvert/bridge).

Table 11.1 provides the details associated with the barriers to fish passage to be removed as part of the offsets process, and the increased connectivity that will be gained through the removal of the four barriers. The removal of these barriers to fish passage will enable upstream movement of fish located downstream of the new Dungowan Dam wall.

The removal of the Pontibah causeway will open up access to an additional 24.5 km of 8th order stream; the remediation or upgrade of the Jewry St causeway will open up access to 3.32 km of 8th order stream; the relocation or upgrade of the Paradise TRC supply pipe will open up access to 3.7 km of 8th order stream and 1.9 km of 7th order stream; and the upgrade of the water gauge at Calala (9332) will open up access to 26.5 km of 7th order stream and 37.5 km of 6th order stream. In total, the removal of the four barriers to fish passage will increase connectivity within the Peel River and Dungowan Creek by 97.42 km.

Table 11.1 Fish passage offsets program for new Dungowan Dam and pipeline project. Total length of key fish habitat available with upgraded fish passage to four barriers on the Peel River

Location	Next Upstream Structure	Strahler order stream opened up	km of stream opened up
Pontibah Causeway	Jewry St Causeway (Peel River)	8	24.5
		Total	**24.5**
Jewry St Causeway	Paradise (TRC supply pipe on Peel River)	8	3.32
		Total	**3.32**
Paradise (TRC Supply Pipe)	Water Gauge Calala (Peel River)	7	1.9
		8	3.7
		Total	**5.6**
Water Gauge Calala	Dungowan Dam (Dungowan Creek)	6	37.5
		7	26.5
		Total	**64**
		Total Upstream fish passage (km)	**97.42**

Photograph 11.1 Shows the barrier to fish passage at Pontibah

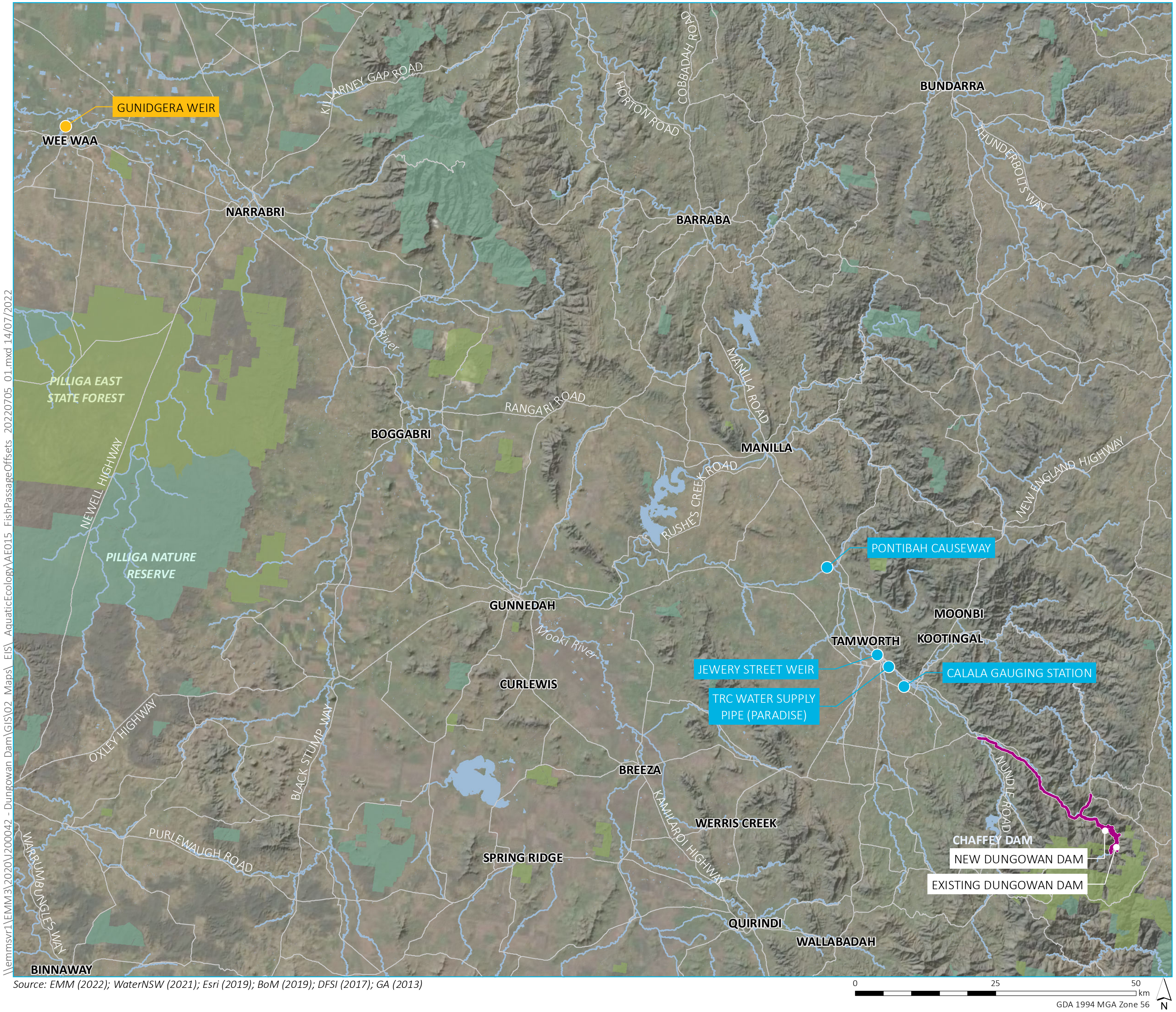
Photograph 11.2 Shows the barrier to fish passage at Jewry Street

Photograph 11.3 Shows the barrier to fish passage at Paradise

Photograph 11.4 Shows the barrier to fish passage at Calala

KEY

- ▭ Project footprint
- ● Fish passage offset location
- ● Gunidgera weir
- — Major road
- — Named watercourse
- ▨ Named waterbody
- ▨ NPWS reserve
- ▨ State forest



Source: EMM (2022); WaterNSW (2021); Esri (2019); BoM (2019); DFSI (2017); GA (2013)

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Location of fish passage offsets for the project (and Gunidgera Weir)

Dungowan Dam and pipeline project
Aquatic ecology assessment
Figure 11.1

creating opportunities

11.1.2 Direct key fish habitat impact offsets

Direct impacts to the total area of key fish habitat as a result of the construction and operation of the New Dungowan Dam cannot be minimised or mitigated. The *NSW Biodiversity Offsets Policy for Major Projects Fact sheet: Aquatic biodiversity* DPI (2014) requires that a minimum 2:1 offset occurs for Type 1 to Type 3 key fish habitats (for streams of Strahler order 1 to 3), to redress both the impacts of development. A cost of $108 per square metre of impact (based on costs outlined within DPI (2014) is required to meet the minimum 2:1 offset ratio (ie $54/m2).

As detailed in Table 8.2, the project will result in the impact to approximately 210,563 m^2key fish habitat of key fish habitat. The final details of the approach to offset this area would be determined in consultation with DPI Fisheries, including:

- the potential to utilise key fish habitat that forms part of the terrestrial biodiversity offset sites as part of the offset package;
- the use of the area of rehabilitation of the existing Dungowan Creek above the existing Dungowan Dam (which will be decommissioned as part of the project) in the offset package; and
- direct offset payment into the Fish Conservation Trust Fund, established under the FM Act.

The timing of the establishment of offsets or payments would be prior to the operation of the project.

11.2 Mitigation measures

A Flora and Fauna Management Plan (FFMP) and a Construction Environment Management Plan (CEMP) will be prepared for the project and include mitigation and management measures identified in this section. Operational management measures will also be adopted in environmental documentation as identified in this section. Further mitigation and management measures identified within this report will also be adopted in relevant management plans for the project.

11.2.1 Water quality

The development of a CEMP and installation of sediment and erosion control measures will mitigate the risks associated with construction activities associated with water quality. These mitigation measures will include:

- Installation of sediment and erosion control measures that 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 will a key monitoring parameter.
- Instream sediment management measures.

11.2.2 Fauna passage and salvage during pipeline construction

A FFMP will be prepared for all aspects of the project including construction. In addition to the CEMP the following specific mitigation measures for fauna will be included:

- Avoid Platypus nesting period of October – March where possible. If construction is to be undertaken at this time, sites inspections are essential.
- Site inspections by a qualified ecologist along the creek banks should be conducted prior to riparian vegetation clearing for platypus burrows.

- Construction periods will be kept to a minimum to limit disruption to aquatic fauna. Construction timing should be scheduled for low flow periods.
- Daily inspections of the works site (Cofferdam/sheet piled work zone) will be completed to check for aquatic fauna that may become entrapped in the works site after overnight foraging.
- It has been assumed that flows will be bypassed around the works site via a pump and appropriate screening will be in place to prevent the entrainment of fauna into the pumps.

11.2.3 Alternative use of additional translucent flow

The proposed translucent flow for the existing Dungowan Dam is 10 ML/day, which is proposed to be increased to 13 ML/day for the new Dungowan Dam. The option to bank the additional 3 ML/day and deliver the banked amount in a pulsed release pattern was modelled and is presented in the Surface Water Assessment (EMM, 2022b).

Comparing Figure 11.2 with Figure 11.3, it can be seen that:

- at the proposed new dam location, the current 15%ile flow is around 40 ML/day (Figure 11.2);
- following construction of the new dam, the 15%ile flow would drop to 13 ML/day (Figure 11.2); and
- with the example mitigation releases, the 15%ile flow would only fall to 30 ML/day (Figure 11.3).

Further downstream in Dungowan Creek the influence of pulse releases would decrease, as unregulated tributaries would continue to contribute flow in response to rainfall runoff.

No changes to Chaffey Dam releases would be expected.

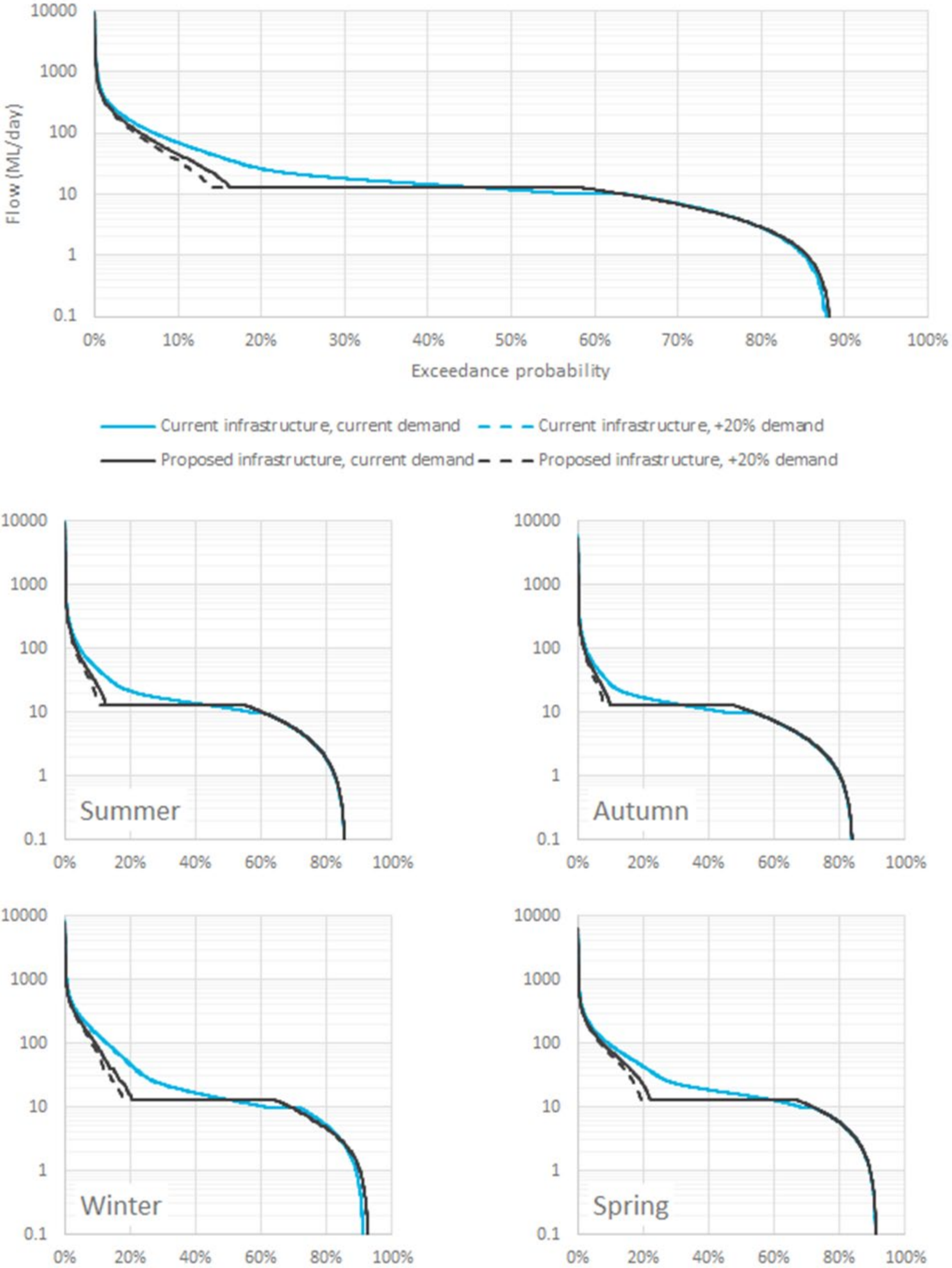

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Figure 11.2 Flow duration curve downstream of new Dungowan Dam location, current climate

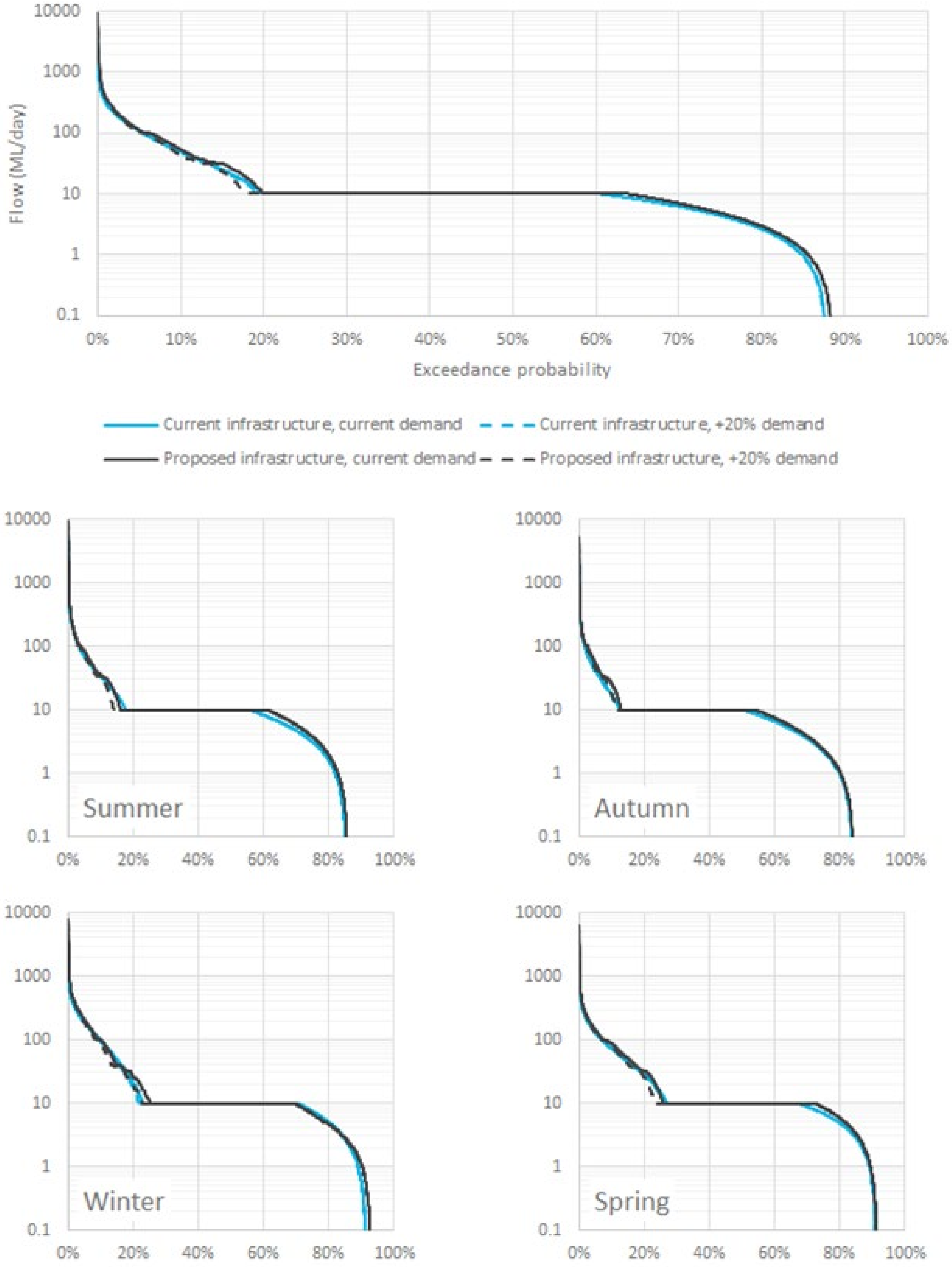

Figure 11.3 Example mitigation applied to 'proposed infrastructure' scenario. Flow duration curve downstream of new Dungowan Dam location, current climate

The development and delivery of environmental water will need to involve the input of a number of stakeholders including but not limited to WaterNSW, DPI Fisheries and the Commonwealth Environmental Water Holder. Consideration for the ecological values and their flow requirements will need to be accounted for in the development and implementation of an environmental watering program for the project.

Consideration of potential impacts from CWP while delivering larger flows, particularly spring - summer flow events will need to carefully consider the species-specific impacts. Monitoring of the environmental flows should be undertaken to ensure that the objectives are being meet and there are no adverse impacts such as CWP further downstream than modelled.

11.2.4 Fish salvage from the spilling basin

Engineering solutions to the entrapment of fish in the spilling basin should be explored as part of the detailed design of the spillway.

In the absence of an engineering solution to the entrapment of fish in the spilling basin, a long term fish salvage protocol/plan should be developed. The plan would address the procedure used to the rescue and translocation of trapped fish to suitable nearby habitat.

11.2.5 Summary of mitigation measures

The proposed mitigation measures to be included in the development of the project environmental management documentation have been summarised below in Table 11.2.

Table 11.2 Safeguards and mitigation measures

Aspect/Impact	Mitigation measure	Responsibility	Timing
Aquatic Ecology			
Fauna Management Plan	A Flora and Fauna Management Plan (FMP) should be prepared prior to construction commencing. The FMP will be included in the CEMP and will detail measures and management actions should terrestrial or aquatic fauna or fauna habitat be disturbed pre-, during, and post-construction.	Contractor	Pre-construction Construction Post-construction
Trenching Dungowan Creek (pipeline construction)	A FMP should be in place prior to commencing trenching of Dungowan Creek. The FMP should detail measures and management actions should terrestrial or aquatic fauna or fauna habitat be disturbed pre-, during, and post-construction.	Contractor	Pre-construction Construction
	A qualified ecologist must be on site during trenching, and pre-trenching construction of Dungowan Creek to relocate any fauna that may be disturbed.		Construction
	The removal of instream habitat structures (eg cobbles, boulders, vegetation, snags) should 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).		
	Minimise the removal of native riparian vegetation during waterway crossing pipeline construction.		
	Trenching methods through waterways should ensure that the original bed level of the waterway is reinstated upon completion of works, such that the final bed profile does not obstruct the passage of fish.		

Table 11.2 Safeguards and mitigation measures

Aspect/Impact	Mitigation measure	Responsibility	Timing
	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 Post-construction
Sedimentation	Sedimentation management protocols should be installed and utilised at each trenching site in accordance with the endorsed CEMP.	Contractor	Pre-construction Construction
Installing the bore under the Peel River	Sedimentation management protocols should be installed and utilised at each side of the Peel River in accordance with the endorsed CEMP.	Contractor	Pre-construction Construction
Water Quality	Downstream water quality at each trenching site should 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 (eg turbidity, dissolved oxygen, salinity, metals).	Contractor	Construction
	Installation of instream silt curtains to reduce downstream transport of sediment.		
	Silt fencing and sediment controls to be installed to mitigate the risk of turbid water being generated from the pipeline corridor and entering the waterway.		
	Install control measures to reduce potential for generation of turbidity during bypass of creek flows around the crossing. Measures could include infrastructure to ensure water is not pumped from the bed or banks of the creek.		
	Any dewatering activities to meet regulatory requirements for discharge water quality		
Groundwater			
Administrative controls	A groundwater management plan (GWMP) will be developed for the project to support construction activities. The GWMP will be a sub-plan of the environmental management system. The GWMP will document the proposed mitigation and management measures for the project, 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. 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 GWMP to assist in early identification of water quality trends. The monitoring program will be prepared in accordance with the approved project's environment protection licence (EPL), once enacted.	Contractor	Construction
Flow mitigations			
Flow Recommendations	Prepare flow recommendations to utilise possible savings of 3ML/day about the existing translucent flows of 10ML/day for use as environmental flows.	Operator	Operation

Table 11.2 Safeguards and mitigation measures

Aspect/Impact	Mitigation measure	Responsibility	Timing
Summer Flows	Environmental flows recommendations to consider CWP and ensure that flows do not result in CWP particularly during spring and summer. Release of flows that result in CWP to downstream environments of Dungowan Creek may be required but consideration to the timing and impacts should be undertaken.	Operator	Operation
Fish Entrapment			
Fish salvage option - engineering	Explore engineering solutions to prevent entrapment of fish in the spilling basin.	Contractor and Operator Design Phase	Operation
Fish Salvage plan	Develop a salvage plan to be implemented after spilling events.	Operator	Operation

Abbreviations

AHD	Australian Height Datum
AEP	Annual Exceedance probability
CBP	concrete batching plant
CPOM	coarse particulate organic matter
CSSI	critical State significant infrastructure
CWP	Cold-Water Pollution
DCCEEW (previously DAWE)	Department of Climate Change, Energy, the Environment and Water (previously Department of Agriculture, Water and the Environment (DAWE))
DGV	default guideline values
DO	Dissolved oxygen
DPI	Department of Primary Industries
DPIE	Department of Planning, Industry and Environment
EEC	Endangered Ecological Community
EIS	Environmental impact statement
EPT	Ephemoptera, Plecoptera, Trichoptera
FM Act	NSW *Fisheries Management Act 1994*
FSL	full supply level
GDE	Groundwater Dependant Ecosystems
GL	Giga litre
HDPE	high density polyethylene
LGA	local government area
ML	Mega litre
NSW	New South Wales
PMF	Probable maximum flood
PMST	Protected Matters Search Tool
SEAR’s	Secretary’s Environmental Assessment Requirements
WM Act	*Water Management Act 2000*
WTP	Water treatment plant

References

Manaaki Whenua Landcare Research. (2022). *Oedogonium (Oedogoniaceae) - Manaaki Whenua Landcare Research*. Retrieved 2022, from https://www.landcareresearch.co.nz/tools-and-resources/identification/freshwater-algae/identifications-guide/filamentous/filaments-microscopic/filaments-are-unbranched/chloroplasts-visible-inside-cells-are-green-or-yellow-green/oedogonium-oedogoniaceae/

Alam, K., Rolfe, J., & Windle, J. (2004). *The importance of riparian vegetation in improving water quality (Establishing the Potential for Offset Trading in the Lower Fitzroy River Research Report No. 2).* Emerald: Central Queensland University.

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

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

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

Bestland, E., George, A., Green, G., Olifent, V., Mackay, D., & Whalen, M. (2017). Groundwater dependent pools in seasonal and permanent streams in the Clare Valley of South Australia. *Journal of Hydrology: Regional Studies, 9*, 216-235.

Bethge, P., Munks, S., Otley, H., & Nicol, S. (2003). Diving behaviour, dive cycles and aerobic dive limit in the Platypus Ornithorhynchus anatinus. *Comparative Biochemistry and Physiology Part A. Molecular and Integrative Physiology, 136*, 799-809.

Bino, G., Kingsford, R. T., Archer, M., Connolly, J. H., Day, J., Dias, K., . . . Whittington, C. (2019). The platypus: evolutionary history, biology, and an uncertain future. *Journal of Mammalogy*, Volume 100, Issue 2, pp 308–327.

Bureau of Meteorology. (2022a, November). *Monthly rainfall - Ogunbil (Amaroo)*. Retrieved from Climate Data Online: http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=139&p_display_type=dataFile&p_startYear=&p_c=&p_stn_num=055262

Bureau of Meteorology. (2022b). *Groundwater Dependent Ecosystems Atlas*. Retrieved from http://www.bom.gov.au/water/groundwater/gde/map.shtml

Cadwallader, P., & Backhouse, G. N. (1983). *A Guide to the Freshwater Fish of Victoria.* Melbourne: Government Printe.

Chessman, B. C. (2003). New sensitivity grades for Australian river macroinvertebrates. *Marine and Freshwater Research, 54*, 95-103.

Dadheech, P. K., Selmeczy, G. B., Vasas, G. V., Padisak, J., Arp, W., Tapolczai, K., . . . Krienitz, L. (2014). Presence of Potential Toxin-Producing Cyanobacteria in an Oligo-Mesotrophic Lake in Baltic Lake District, Germany: An Ecological, Genetic and Toxicological Survey. *Toxins (Basel), 6*(10), 2912-2931.

Davies, P., Harris, J., Hillman, T., & Walker, K. (2008). *Report 1: A Report on the Ecological Health of Rivers in th eMurray-Dalring Basin, 2004-2007. Prepared by the Independent Sustainable Rivers Audit Group for the Murray-Darling Basin Ministerial Council.* Canberra: Murray–Darling Basin Commission.

Department of Agriculture, Water and the Environment. (2001, June 14). *A Directory of Important Wetlands in Australia*. Retrieved from Directory of Important Wetlands in Australia - Information sheet Goran Lake - NSW005: https://www.awe.gov.au/sites/default/files/documents/directory.pdf

Department of Agriculture, Water and the Environment. (2020). *Wildlife and threatened species bushfire recovery research and resources*. Retrieved from Provisional list of animals requiring urgent management intervention: https://www.environment.gov.au/biodiversity/bushfire-recovery/research-and-resources

Department of Agriculture, Water and the Environment. (2020). *Wildlife and threatened species bushfire recovery research and resources*. Retrieved from Provisional list of animals requiring urgent management intervention: https://www.environment.gov.au/biodiversity/bushfire-recovery/research-and-resources

Department of Agriculture, Water and the Environment. (2022a). *Maccullochella peelii — Murray Cod*. Retrieved from Species Profile and Threats Database: https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=66633

Department of Agriculture, Water and the Environment. (2022c). *Bidyanus bidyanus in Species Profile and Threats Database*. Retrieved March 16, 2022, from https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=76155

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

Department of Planning, Industry and Environment. (2016, April 16). *Biodiversity Reform*. Retrieved from Nandewar Biioregion: https://www.environment.nsw.gov.au/bioregions/NandewarBioregion.htm

Department of Planning, Industry and Environment. (2020). *Namoi Long-Term Water Plan Part B: Namoi planning units.* Sydney: NSW Government.

Department of Primary Industries. (2005). *PrimeFact 11: Removal of large woody debris from NSW rivers and streams.* Sydney: NSW Department of Primary Industries.

Department of Primary Industries. (2006). *Silver Perch Bidyanus bidyanus: NSW Recovery Plan.* Nelson Bay: Department of Primary Industries.

Department of Primary Industries. (2007a). *PrimeFact 173: Lowland Darling River aquatic ecological community.* Nelson Bay: NSW Department of Primary Industries.

Department of Primary Industries. (2007a). *Primefacts - Lowland Darling River aquatic ecological community.* Retrieved from NSW Department of Primary Industires: https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/634557/Lowland-Darling-River-aquatic-ecological-community.pdf

Department of Primary Industries. (2007b). *Primefacts.* Retrieved from Lowland Darling River aquatic ecological community: https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/634557/Lowland-Darling-River-aquatic-ecological-community.pdf

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

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

Department of Primary Industries. (2012). *Risk assessment guidelines for groundwater dependent ecosystems: Volume 1 – The conceptual framework.* Sydney: NSW Department of Primary Industries, Office of Water.

Department of Primary Industries. (2013a). *Policy and guidelines for fish habitat conservation and management.* Sydney: NSW Department of Primary Industries.

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

Department of Primary Industries. (2015, December). *PrimeFact: Eel-Tailed Catfish population in the Murray-Darling Basin, Tandanus tandanus.* Retrieved from https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/635918/primefact-eel-tailed-catfish-population-in-the-murray-darling-basin.pdf

Department of Primary Industries. (2017). *Eastern Freshwater Cod*. Retrieved from https://www.dpi.nsw.gov.au/fishing/threatened-species/what-current/endangered-species2/eastern-freshwater-cod

Department of Primary Industries. (2018b, December). *PrimeFact: Southern Purple Spotted Gudgeon – Mogurnda adspersa.* Retrieved from https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/635290/Primefact-1275-Southern-Purple-Spotted-Gudgeon-Mogurnda-adspersa.pdf

Department of Primary Industries. (2019). *WeedWise*. Retrieved from Alligator weed (Alternanthera philoxeroides): https://weeds.dpi.nsw.gov.au/Weeds/AlligatorWeed

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

Department of Primary Industries. (2020a). *Peel River habitat mapping and prioristisation report.* Dubbo.

Department of Primary Industries. (2020b). *Cudgegong River: Habitat Mapping - Inundation heights for key habitat features and management recommendations.* Dubbo: Department of Industries.

Department of Primary Industries. (2022a). *NSW DPI Spatial Data Portal*. Retrieved from https://webmap.industry.nsw.gov.au/Html5Viewer/index.html?viewer=Fisheries_Data_Portal

Department of Primary Industries. (2022b). *Fish stocking*. Retrieved from Recreational Fishing: https://www.dpi.nsw.gov.au/fishing/recreational/resources/stocking

Department of Primary Industries. (2022c). *Freshwater threatened species distribution maps*. Retrieved from https://www.dpi.nsw.gov.au/fishing/species-protection/threatened-species-distributions-in-nsw/freshwater-threatened-species-distribution-maps

Department of Primary Industries. (2022d). *Priorities Action Statement - Action for Murray-Darling population of Eel-tailed Catfish*. Retrieved 2022, from https://www.dpi.nsw.gov.au/fishing/threatened-species/what-current/endangered-populations2/eel-tailed-catfish/priorities-action-statement-actions-for-murray-darling-population-of-eel-tailed-catfish

Department of Primary Industries. (2022e). *Priorities Action Statement - Actions for the Southern-purple Spotted Gudgeon*. Retrieved from https://www.dpi.nsw.gov.au/fishing/threatened-species/what-current/endangered-species2/purple-spotted-gudgeon/priorities-action-statement-actions-for-the-purple-spotted-gudgeon

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

Department of the Environment. (2013). *Matters of National Environmental Significance: Significant Impact Guidelines 1.1.* Retrieved 2022, from https://www.dcceew.gov.au/environment/epbc/publications/significant-impact-guidelines-11-matters-national-environmental-significance

Department of the Environment. (2016). *Draft EPBC Act referral guidelines for the vulnerable Murray cod (Maccullochella peelii).* Retrieved from Map 1: The natural distribution of the Murray Cod (Maccullochella peelii): https://www.environment.gov.au/system/files/resources/7a17c9a0-bd7c-4bea-ab6c-965059223aa9/files/draft-referral-guidelines-vulnerable-murray-cod-map.pdf

Department of the Environment. (2016). *Draft EPBC Act referral guidelines for the vulnerable Murray cod (Maccullochella peelii)*. Retrieved 2022, from https://www.dcceew.gov.au/environment/biodiversity/threatened/publications/epbc-act-referral-guidelines-murray-cod-draft

DPM Envirosciences. (2021). *Peel River critical needs ecological monitoring - Platypus survey.*

Ellam, B. A., Bryant, A., & O'Connor, A. (1998). Statistical modelling of platypus, Ornithorhynchus anatinus, habitat preferences using generalised linear modelling. *Australian Mammology*.

EMM. (2022a). *Detailed Project Description: Dungowan Dam and Pipline Project.* Unpublished report for Water Infrastructure NSW.

EMM. (2022b). *Streamflow analysis - Surface Water Assessment - Annexure A.* Unpublished report for Water Infrastructure NSW.

EMM. (2022c). *Dungowan Creek Temperature Model (HEC-RAS) surface water assessment-Annexure.* Unpublished report prepare for Water Infrastructure NSW.

EMM. (2022d). *Dungowan Dam & Pipeline Project: Biodiversity Development Assessment Report.* Unpublished report for WaterNSW.

EMM. (2022e). *Dungowan Dam & Pipeline Project: Groundwater Impact Assessment.* Sydney: Unpublished report for WaterNSW.

EMM. (2022f). *Aboriginal Cultural Heritage Assessment.* Unpublished Report Prepared Water Infrastructure NSW.

Entwisle, T. J., Sonneman, J. A., & Lewis, S. H. (1997). *Freshwater Algae in Australia. A Guide to Conspicuous Genera.* NSW: Sainty and Associates Pty Ltd.

EnviroDNA. (2021a). *Investigating fish biodiversity, platypus and Booroolong frog occurence in the Peel River using environmental DNA.*

EnviroDNA. (2021b). *Detecting platypus (Ornithorhynchus anatinus) in the Peel River using environmental DNA.*

Fish Base. (2022a). *Tandanus tandanus*. Retrieved from fishbase.org: http://www.fishbase.org/summary/Tandanus-tandanus.html

Fish Base. (2022b). *Mogurnda adspersa*. Retrieved from fishbase.org: https://www.fishbase.de/summary/10714

Fisheries Scientific Committee. (2007). *Aquatic Ecological Community in the Natural Drainage System of the Lowland Catchment of the Darling River.* Sydney: DPI Fisheries.

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

GHD. (2019). *WaterNSW Peel River Drought Protection Works Stage 1 Temporary Works at Dungowan - Review of Environmental Factors.* Sydney: Unpublished report for WaterNSW.

GHD. (2021a). *WaterNSW Peel River drought protection works baseline monitoring 2020-2021.*

GHD. (2021b). *WaterNSW Peel River Drought Protection Works Operation Monitoring April.*

GHD. (2021c). *WaterNSW Peel River Drought Protection Works Operation monitoring May 2021.*

GHD. (2021d). *WaterNSW Peel River Drought Protection Works Operation Monitoring June 2021.*

Grant, T. (2004). Depth and substrate selection by Platypuses, Ornithorhynchus anatinus, in the lower Hastings River, New South Wales. *Proceedings of the Linnean Society of New South Wales*.

Grant, T. R. (1992). Historical and current distribution of the platypus, Ornithorhynchus anatinus, In Australia. *Platypus and Echidnas*, 232-254.

Grant, T. R., & Temple-Smith, P. D. (1998). Field biology of the platypus (Ornithorynchus anatinus): Historical and current perspectives. *Philosophical Transactions of the Royal Society of London B: Biological Sciences, 353*, 1081-1091.

Grant, T. R., & Temple-Smith, P. D. (2003). Conservation of the Platypus, Ornithorhynchus anatinus: Threats and challenges. *Aquatic Ecosystem Health and Management, 6*, 5-18.

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

Griffiths, J., Kelly, T., & Weeks, A. (2014). *Impacts of high flows on platypus movement and habitat use in an urban stream.* Parkville.

Guiry, M. D., & Guiry, G. M. (2012). *Navicula Bory de Saint-Vincent*. Retrieved from http://www.algaebase.org/search/genus/detail/?genus_id=43698

Gust, N., & Handasyde, K. (1995). Seasonal Variation in the Ranging Behaviour in platypus (Ornithorhynchus anatinus) on the Goulburn River, Victoria. *Australian Journal of Zoology, 43*, 193-208.

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

Hazelton, P., & Murphy, B. (2007). *Interpreting Soil Test Results. What do all the numbers mean.* Collingwood: CSIRO Publishing.

Holland, N., & Jackson, S. M. (2002). Reproductive behaviour and food consumption associated with the captive breeding of platypus (Ornithorhynchus anatinus). *Journal of Zoology*.

Hotzel, G., & Croome, R. (1999). *A phytoplankton methods manual for Australian rivers. LWRRDC Occasional Paper 22/99.* Canberra: Land and Water Resources Research and Development Corporation.

Ingleton, T., Kobayashi, T., Sanderson, B., Patra, R., Macinnis-Ng, C. M., Hindmarsh, B., & Bowling, L. (2008). Investigations of the Temporal Variation of Cyanobacterial and Other Phytoplanktonic Cells at the Offtake of a Large Reservoir, and Their Survival Following Passage Through It. *Hydrobiologia, 603*, 221-240.

John, J. (1983). *The diatom flora of the Swan River estuary.* Perth: Bibliotheca Phycologia.

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

Kelly, T., Griffiths, J., & Weeks, A. (2012). *Development of a novel tracking technique for Platypuses using acoustic telemetry.* Parkville: CESAR.

Koehn, J., Doeg, T. J., Harrington, D. J., & Milledge, G. A. (1995). *The effects of Dartmouth Dam on the Aquatic Fauna of the Mitta Mitta River.*

Komarek, J. (2003). COCCOID AND COLONIAL CYANOBACTERIA. In J. D. Wehr, & R. G. Sheath (Eds.), *Freshwater Algae of North America.* Elsevier Inc.

Korbel, K., Lim, R., & Hose, G. (2013). An inter-catchment comparison of groundwater biota in the cotton-growing region of north-western New South Wales. *Crop and Pasture Science, 12*(64), 1195-1208.

Krueger, B., Hunter, S., & Serena, M. (1992). Husbandry, diet and behaviour of Platypus Ornithorhynchus anatinus at Healsville Sanctuary. *International Zoo Yearbook*.

Kyle, M., Anderson, T., Haande, S., & Rohrlack, T. (2015). Historical Planktothrix diversity across seven Norwegian lakes implies environmentally driven niche differentiation. *Ecology Evolution*.

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

Lugg, A., & Copeland, C. (2014). Review of Cold Water Pollution in the Murray-Darling Basin and the Impacts on Fish Communities. *Ecological Management and Restoration, 15*(1).

Margulis, L., & Chapman, M. J. (2009). *Kingdoms and Domains: An illustrated Guide to the Phyla of Life on Earth.* Academic Press.

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

Merrick, J. R., & Schmida, G. E. (1984). *Australian Freshwater Fishes - Biology and Management.* South Australia: Griffin Press Ltd.

Mitrovic, S., & Bowling, L. (2013). Identification and Management of Freshwater Algae. In *Workbook for Managing Urban Wetlands in Australia* (WET eBook ed.).

Murray–Darling Basin Authority. (2010). *Sustainable Rivers Audit 2: The ecological health of rivers in the Murray–Darling Basin at the end of the Millennium Drought (2008–2010): Volume 1.* Canberra: The Sustainable Rivers Audit Program.

Murray-Darling Basin Authority. (2019, March 26). *Catchments*. Retrieved from Namoi: https://www.mdba.gov.au/discover-basin/catchments/namoi

National Murray Cod Recovery Team. (2010). *National Recovery Plan for the Murray Cod Maccullochella peelii peelii.* Melbourne: Department of Sustainability and Environment.

Natural Resources Commission. (2010). *Final report: Review of the Water Sharing Plan for the Peel Valley Regulated, Unregulated, Alluvium and Fractured Rock Water Sources 2010.* Sydney: NSW Government.

NGH Environmental. (2012). *Chaffey Dam Augmentation And Safety Upgrade: Terrestrial And Aquatic Flora And Fauna Impact Assessment.* Bega: Unpublished report for WaterNSW.

NSW Department of Planning and Environment. (2022). *BioNet*. Retrieved from NSW BioNet: https://www.environment.nsw.gov.au/atlaspublicapp/ui_modules/atlas_/atlassearch.aspx

NSW Department of Planning, Industry and Environment. (2021). *Nandewar Bioregion - climate*. Retrieved from Bioregion overviews: https://www.environment.nsw.gov.au/bioregions/Nandewar-Climate.htm

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

NSW Office of Environment and Heritage. (2018). *Western Swashelled Turtle, Bell's Turtle - profile.* Retrieved 4 7, 2022, from https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10266

NSW Office of Environment and Heritage. (2019, 4 7). *Manning River Helmeted Turtle, Purvis' Turtle - profile.* Retrieved 4 7, 2022, from https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=20326

NSW Office of Water. (2010). *Water Sharing Plan for the Peel Valley regulated, unregulated, alluvial and fractured rock water sources: background document.* NSW Office of Water. Sydney: NSW Office of Water. Retrieved from http://www.water.nsw.gov.au/__data/assets/pdf_file/0008/548045/wsp_peel_valley_background.pdf

Otley, H. M., Munks, S. A., & Hindell, M. A. (2000). Activity patterns, movements and burrows of Platypuses (Ornithorhynchus anatinus) in a sub-alpine Tasmanian lake. *Australian Journal of Zoology, 48*, 701-713.

Reid, M., Thoms, M., Chilcott, S., & Fitzsimmons, K. (2016). Sedimentation in Dryland River Waterholes: A threat to aquatic refugia? *Journal of Marine and Freshwater Research, 68*(4), 668-685.

Rousso, B. Z., Bertone, E., Stewart, R. A., Hughes, S. P., Hobson, P., & Hamilton, D. P. (2022). Cyanobacteria species dominance and diversity in three Australian drinking water reservoirs. *Hydrobiologia, 849*, 1453-1469.

Royal Botanic Gardens Victoria. (2020). *Freshwater Algae of Australia*. Retrieved from https://algae.rbg.vic.gov.au/

Serena, M. (1998). Use of time and space by Platypus (Ornithorhynchus anatinus: Monotremata) along a Victorian stream. *Journal of Zoology, 232*, 117 - 131.

Serena, M., Thomas, J. L., & Williams, G. A. (1998). *Status and habitat relationships of Platypus in the Dandenong Creek Catchment: II. Results of surveys and radio-tracking studies, September 1997 - March 1998.* Whittlesea: Australian Platypus Conservancy.

Serena, M., Williams, G. A., Weeks, A. R., & Griffiths, J. (2014). Variation in Platypus (Ornithorhynchus anatinus) life-history attributes and population trajectories in urban streams. *Australian Journal of Zoology, 62*, 223-234.

Serena, M., Worley, M., Swinnerton, M., & Williams, G. A. (2001). Effect of food availability and habitat on the distribution of Platypuses (Ornithorhynchus anatinus) foraging activity. *Australian Journal of Zoology, 49*, 263-277.

Serov, P. A., & Kuginis, L. (2017). A groundwater ecosystem classification - the next steps. *International Journal of Water, 11*(4), 328-362.

Sherman, B., Ford, P., Grey, L., Maher, B., Hatton, P., Whittington, J., . . . Beckett, R. (2001). *Chaffey Dam Project - CRCFE projects B.202 and B.203 / MDFRC project M/03/5066.* Canberra: Murray-Darling Freshwater Research Centre.

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

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

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

Taukulis, F. (2007). *Diatom communities in lakes and streams of varying salinity from south-west Western Australia: distribution and predictability.* Curtin University of Technology: Doctoral Thesis.

Temple-Smith, P. D., & Grant, T. R. (2003). Conservation of the Platypus, Ornithorhynchus anatinus : Threats and Challenges. *Aquatic Ecosystem Health & Management*, 6(1):5-18.

Thackway, R., & Cresswell, I. D. (1995). *An Interim Biogeographic Regionalisation for Australia.* Canberra: Australian Nature Conservation Agency.

Thoms, M., Norris, R., Harris, J., Williams, D., & Cottingham, P. (1999). *Environmental Scan of the Namoi River Valley.* Canberra: Unpublished report for the Department of Land and Water Conservation and the Namoi River Management Committee.

Tomlinson, M., Boulton, A. J., Hancock, P. J., & Cook, P. G. (2007). Deliberate omission or unfortunate oversight: Should stygofaunal surveys be included in routine groundwater monitoring programs? *Hydrogeology Journal, 15*, 1317-1320.

Turak, E., Waddell, N., & Johnstone, G. (2004). *New South Wales (NSW) Australian Rivers Assessment Systen (AUSRIVAS) Sampling and processing manual.*

Vyverman, W., Muylaert, K., Verleyen, E., & Sabbe, K. (2007). Ecology of Non-Marine Algae: Lakes and Large Rivers. In *Algae of Australia* (pp. 459-475). Melbourne: CSIRO Publishing.

WA Department of Biodiversity, Conservation and Attractions. (2022a). *Florabase*. Retrieved from https://florabase.dpaw.wa.gov.au/

WA Department of Biodiversity, Conservation and Attractions. (2022b). *Florabase*. Retrieved from https://florabase.dpaw.wa.gov.au/browse/profile/109

WA Department of Biodiversity, Conservation and Attractions. (2022c). *Florabase*. Retrieved from https://florabase.dpaw.wa.gov.au/browse/profile/555

Water Infrastructure NSW. (2022). *Community and Stakeholder Engagement Report.*

Water infrastructure NSW. (2022). *New Dungowan dam and pipeline project fishway offsets.* Unpublishing timeline.

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

WaterNSW. (2021). *Chaffey Dam to Dungowan Pipeline Operation: Environmental Baseline and Monthly Water Quality Monitoring Report. December 2020 - January 2021.*

Woinarski, J. C., Burbidge, A. A., & Harrison, P. L. (2014). *The action plan for Australian mammals 2012.* Collingwood: CSIRO Publishing.

Woinarski, J., & Burbidge, A. A. (2016). Ornithorhynchus anatinus. The IUCN Red List of Threatened Species.

Worley, M., & Serena, M. (2000). *Ecology and conservation of Platypuses in the Wimmera River catchment. IV. Results of habitat studies.* Whittlesea: Australian Platypus Conservancy.

Annexure A

Database search summary

Table A.1 BioNet database search results (Namoi River catchment)

Family	Vernacular	Species	# Records
Fish			
Cyprinidae	*Common Carp	*Cyprinus carpio*	1
Mammal			
Ornithorhynchidae	Platypus	*Ornithorhynchus anatinus*	123
Reptile			
Chelidae	Broad-shelled River Turtle	*Chelodina expansa*	9
Chelidae	Eastern Long-necked Turtle	*Chelodina longicollis*	606
Chelidae	Macquarie River Turtle	*Emydura macquarii*	84
Chelidae	Western Sawshelled Turtle	*Myuchelys bellii* (also: *Wollumbinia belli*)	1,331

Table A.2 PMST database search results

Family	Common Name	Scientific Name	Conservation status: EBPC Act	Potential distribution
Habitats				
-	Hunter Estuary	-	Wetlands of International Importance	At least 150km upstream from the project
-	Banrock station wetland complex	-	Wetlands of International Importance	At least 1,100km from the project
-	Riverland	-	Wetlands of International Importance	At least 1,100km from the project
-	The Coorong, Lake Alexandrina, Albert Wetland	-	Wetlands of International Importance	At least 1,300km from the project
Threatened Ecological Communities				
-	Upland wetlands of the New England Tablelands and the Monaro Plateau	-	Endangered	North-northeast of project
Fish				
Percichthyidae	Murray Cod	*Maccullochella peelii*	V	Species or species habitat known to occur within area

Table A.2 PMST database search results

Family	Common Name	Scientific Name	Conservation status: EBPC Act	Potential distribution
Reptile				
Chelidae	Western Sawshelled Turtle	*Wollumbinia belli* (also: *Myuchelys bellii*)	E	Species or species habitat may occur within area

Table A.3 DPI Fisheries database search results – listed species

Listed Species
Fish
Eleotridae
Southern Purple-spotted Gudgeon (*Mogurnda adspersa*)
Plotosidae
Eel-tailed Catfish (*Tandanus tandanus*)

Annexure B

Literature review summary

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

Reference	Report title	General	Impacts	Aquatic Flora & Riparian Vegetation	Aquatic Invertebrates	Aquatic Vertebrates (non-threatened)	Threatened species^	Aquifer Geology & Water Quality	Stygofauna Taxa
Aquatic ecology									
(Department of Planning, Industry and Environment, 2020)	Namoi Long Term Water Plan Part A: Namoi Catchment	This Namoi LTWP contains ecological objectives and targets for priority environmental assets and ecosystem functions in the Namoi catchment. The objectives and targets have been identified for native fish, native vegetation, waterbirds, river connectivity and ecosystem functions.	Key impact is river regulation to meet the needs of irrigators, stock and domestic users, and town water supplies.	Remnant water dependent native vegetation in the catchment is diverse and varies from east to west. It includes river red gum woodland and forests, river oak woodlands, coolibah woodlands, tea-tree sedgelands, river coolibah swamp wetlands and lignum shrubland wetlands. EECs found in the catchment	-	Native - Australian Smelt, Golden Perch, River Blackfish, Bony Herring, Darling River Hardyhead, Murray River Rainbowfish, Spangled Perch, Unspecked Hardyhead, Western Carp Gudgeon, Mountain galaxias, Obscure galaxias	Murray Cod, Silver Perch, Southern Purple-spotted Gudgeon, Eel-tailed Catfish, Olive perchlet	-	-

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

Reference	Report title	General	Impacts	Aquatic Flora & Riparian Vegetation	Aquatic Invertebrates	Aquatic Vertebrates (non-threatened)	Threatened species^	Aquifer Geology & Water Quality	Stygofauna Taxa
				include coolibah-black box woodland, brigalow communities, marsh club-rush sedgeland, myall woodland, Pilliga outwash ephemeral wetlands and swamp oak floodplain forest					

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

Reference	Report title	General	Impacts	Aquatic Flora & Riparian Vegetation	Aquatic Invertebrates	Aquatic Vertebrates (non-threatened)	Threatened species^	Aquifer Geology & Water Quality	Stygofauna Taxa
(Green, et al., 2011)	Water resource and management overview: Namoi Catchment	The Namoi catchment has a total area of approximately 42,000 km^2	-	Riverine vegetation is dominated by river oaks and willows, with river red gums occurring along the major streams such as the Peel.	-	-	River snail, Silver Perch, Purple spotted gudgeon, Olive perchlet	The high-yielding aquifers of the Namoi catchment are managed as two groundwater resources – the Lower Namoi Groundwater Source and the Upper Namoi Groundwater Source, both of which are managed under a water sharing plan	-

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

Reference	Report title	General	Impacts	Aquatic Flora & Riparian Vegetation	Aquatic Invertebrates	Aquatic Vertebrates (non-threatened)	Threatened species^	Aquifer Geology & Water Quality	Stygofauna Taxa
(Lintermans, 2017)	Fishes of the Murray-Darling Basin: An introductory guide	-	-	-	-	Native - Australian Smelt, Golden Perch, River Blackfish, Bony Herring, Darling River Hardyhead, Murray River Rainbowfish, Spangled Perch, Unspecked Hardyhead, Western Carp Gudgeon, Mountain galaxias, Obscure galaxias	Murray Cod, Silver Perch, Southern Purple-spotted Gudgeon, Eel-tailed Catfish, Olive perchlet	-	-
Murray Darling Basin Authority, 2010	Sustainable Rivers Audit 2: The ecological health of rivers in the Murray–Darling Basin at the end of the Millennium Drought (2008–2010): Volume 1	Namoi catchment considered in “good” hydrological condition, “moderate” physical form condition, and 'poor’ in terms of ecosystem health	Habitat modification, degradation and fragmentation of aquatic and riparian habitat.	Vegetation condition within the Namoi catchment is considered to be “poor”	Namoi Valley catchment is considered to be ‘moderate’ in terms of the macroinvertebrate community	Exotic – Common Carp, Eastern mosquito fish, Goldfish, Redfin perch, brown and rainbow trout	Murray Cod, Silver Perch and Eel-tailed Catfish	-	-

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

Reference	Report title	General	Impacts	Aquatic Flora & Riparian Vegetation	Aquatic Invertebrates	Aquatic Vertebrates (non-threatened)	Threatened species^	Aquifer Geology & Water Quality	Stygofauna Taxa
(WaterNSW, 2021)	Chaffey Dam to Dungowan Pipeline Operation, Environmental Baseline and Monthly Water Quality Monitoring Report	Riparian condition typically poor. Dissolved oxygen occasionally very low. 33 macroinvertebrate taxa collected during sampling	Low dissolved oxygen resulted in a fish kill	Riparian condition typically poor.	33 Macroinvertebrate taxa recorded during surveys	-	-	-	
(EnviroDNA, 2021a)	Investigating fish biodiversity, platypus and Booroolong frog occurrence in the Peel River using environmental DNA	Wide range of native fish species and platypus detected in the Peel River between Chaffey Dam and Tamworth	-	-	-	Native - Australian Short finned Eel, Australian long-finned Eel, Australian Smelt, Golden Perch, River Blackfish, Bony Herring, Darling River Hardyhead, Murray River Rainbowfish, Spangled Perch, Unspecked Hardyhead, Western Carp Gudgeon, Flathead	Silver Perch, Murray Cod, Macquarie Perch, Eel-tailed Catfish	-	-

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

Reference	Report title	General	Impacts	Aquatic Flora & Riparian Vegetation	Aquatic Invertebrates	Aquatic Vertebrates (non-threatened)	Threatened species^	Aquifer Geology & Water Quality	Stygofauna Taxa
						gudgeon, Dwarf flathead gudgeon, Mountain galaxias, Obscure galaxias, Estuary Perch Exotic – Goldfish, Common Carp, Eastern Mosquitofish			
(EnviroDNA, 2021b)	Detecting platypus (*Ornithorhynchus anatinus*) in the Peel River using environmental DNA	Platypus present within the Peel River	-	-	-	Platypus	-	-	-

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

Reference	Report title	General	Impacts	Aquatic Flora & Riparian Vegetation	Aquatic Invertebrates	Aquatic Vertebrates (non-threatened)	Threatened species^	Aquifer Geology & Water Quality	Stygofauna Taxa
(DPM Envirosciences, 2021)	Peel River critical needs ecological monitoring – platypus survey	Platypus and Rakali present within the Peel River	-	-	-	Native - Platypus, Rakali, Unspecked Hardyhead, Western Carp Gudgeon, Australian Smelt, Murray River Rainbowfish Exotic - Common Carp, Eastern Mosquitofish	Eel-tailed Catfish	-	-
(Department of Primary Industries, 2020a)	Peel River Habitat Mapping: Habitat mapping and prioritisation report	Sections of riparian habitat remain. Fish habitat present in the form of large woody habitat, root balls. Drought refugia present.	Erosion, stock access, barriers to fish passage, pump sites, cold water pollution	Sections of riparian zone intact. Some areas support macrophytes	-	Mountain galaxias, Unspecked Hardyhead, Western Carp Gudgeon, Australian Smelt, Murray River Rainbowfish, Bony Herring, Golden Perch, River Blackfish, Darling River Hardyhead	Eel-tailed Catfish, Silver Perch, Murray Cod, Southern Purple-spotted Gudgeon	-	-

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

Reference	Report title	General	Impacts	Aquatic Flora & Riparian Vegetation	Aquatic Invertebrates	Aquatic Vertebrates (non-threatened)	Threatened species^	Aquifer Geology & Water Quality	Stygofauna Taxa
(GHD, 2021a)	WaterNSW Peel River Drought Protection Works Baseline monitoring 2020-2021	Riparian condition 'very poor'	Drought, erosion	Riparian condition 'very poor'	Community condition 'generally good'	-	-	-	-
(GHD, 2021b)	WaterNSW Peel River Drought Protection Works Operation Monitoring April 2021	Riparian condition 'very poor'	Drought, erosion	Riparian condition 'very poor'	-	platypus	-	-	-
(GHD, 2021c)	WaterNSW Peel River Drought Protection Works Operation Monitoring May 2021	Riparian condition 'very poor'	Drought, erosion	Riparian condition 'very poor'	-	platypus	-	-	-
(GHD, 2021d)	WaterNSW Peel River Drought Protection Works Operation Monitoring June 2021	Riparian condition 'very poor'	Drought, erosion	Riparian condition 'very poor'	Community condition 'generally good'	platypus	-	-	-

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

Reference	Report title	General	Impacts	Aquatic Flora & Riparian Vegetation	Aquatic Invertebrates	Aquatic Vertebrates (non-threatened)	Threatened species^	Aquifer Geology & Water Quality	Stygofauna Taxa
Subterranean ecology									
(Korbel, et al., 2013)	An inter-catchment comparison of groundwater biota in the cotton-growing region of north-western New South Wales.	-	-	-	-	-	-	With particular regard to the Namoi catchments, 14 taxa were observed	Ostracoda, Copepoda, Syncarida, Malacostraca, Oligochaeta, Acarina

Annexure C

Likelihood of occurrence

creating opportunities

Table C.1 Likelihood of occurrence assessment for the project (Namoi River catchment)

Family	Common Name	Scientific Name	Data source			Conservation status			Likelihood of Occurrence (LoO)	Rationale for likelihood ranking	Species Info
			DPI	BioNet	PMST	FM Act	WM Act	EBPC Act			
Habitats											
-	Lowland Darling River aquatic ecological community	-	✓	-	-	E	-	-	Known	DPI Fisheries: EEC located within Dumaresq River and Macintyre River.	The EEC listing includes all native fish and aquatic invertebrates within all associated waterways within the Darling River catchment, including the Dumaresq River downstream of the confluence with the Mole River, and the Macintyre River downstream of the Graman Weir.
Fish											
Terapontidae	Silver Perch	*Bidyanus bidyanus*	✓^	-	-	V	-	CE	Low	Species confirmed during surveys. Literature: The species was recorded within the Peel River (NGH Environmental, 2012)	Silver Perch are endemic to the Murray-Darling system (including all states and sub-basins). Hatchery-bred Silver Perch are also stocked out of their range in a number of impoundments on east coast river systems, where they seemingly fail to reproduce. However, a self-sustaining population of Silver Perch occurs in Cataract Dam in the Hawkesbury/Nepean system.

Table C.1 Likelihood of occurrence assessment for the project (Namoi River catchment)

Family	Common Name	Scientific Name	Data source			Conservation status			Likelihood of Occurrence (LoO)	Rationale for likelihood ranking	Species Info
			DPI	BioNet	PMST	FM Act	WM Act	EBPC Act			
Percichthyidae	Murray Cod	*Maccullochella peelii*	✓^	-	✓	-	-	V	Recorded	Species confirmed during surveys.	The Murray Cod's natural distribution extends throughout the Murray-Darling basin ranging west of the divide from south east Qld, through NSW into Victoria and South Australia. It is found in the waterways of the Murray–Darling Basin in a wide range of warm water habitats that range from clear, rocky streams to slow flowing turbid rivers, billabongs and large deep holes. Murray Cod is entirely a freshwater species and will not tolerate high salinity levels.
Eleotridae	Southern Purple-spotted Gudgeon	*Mogurnda adspersa*	✓	-	-	E	-	-	Known	DPI Fisheries: Database records indicate that the species is found within the Peel river, Dungowan Creek and Terrible Billy Creek.	The Southern Purple-spotted Gudgeon is a benthic species associated with aquatic vegetation cover. It is found in still or slow-moving water of creeks, rivers, wetlands and billabongs with a preference for deeper habitats. The species occurs in inland drainages of the Murray-Darling basin as well as coastal drainages of northern NSW and Qld. The species was previously widespread in the Murray, Murrumbidgee and Lachlan River systems and tributaries of the Darling but has experienced a significant decline in recent times. The Southern Purple-spotted Gudgeon is now extremely rare in inland NSW, having been recorded from this area only once since 1983.

Table C.1 Likelihood of occurrence assessment for the project (Namoi River catchment)

Family	Common Name	Scientific Name	Data source			Conservation status			Likelihood of Occurrence (LoO)	Rationale for likelihood ranking	Species Info
			DPI	BioNet	PMST	FM Act	WM Act	EBPC Act			
Plotosidae	Murray-Darling Basin population of Eel-tailed Catfish	*Tandanus tandanus*	✓	-	-	EP	-	-	Recorded	Species confirmed during surveys.	Eel-tailed Catfish are naturally distributed throughout the Murray-Darling Basin and in the Eastern drainages NSW north of Newcastle. Eel-tailed Catfish numbers in the Murray-Darling Basin have declined due to a range of impacts including invasive species, habitat degradation, cold water pollution and fishing pressures and are now virtually absent from the Murray River, Murrumbidgee River and Lachlan River, and associated catchments.
Mammal											
Ornithorhynchidae	Platypus	*Ornithorhynchus anatinus*	-	✓	-	-	-	PL	Recorded	Species confirmed during surveys.	Platypus' commonly live in the rivers, streams and lakes of eastern Australia, from the Annan River in northern Qld to the far south of Victoria and Tasmania. They are found in the major permanent river systems in the south of NSW, west of the Great Dividing Range, and occasionally in South Australia.
Invertebrates											
-	Subterranean fauna	-	-	-	-	-	✓	-	Moderate	Literature: Surveys undertaken with the Namoi catchment indicate that	Representatives of the following groups were recorded: Ostracoda, Copepoda, Syncarida, Malacostraca, Oligochaeta, Acarina .

Table C.1 Likelihood of occurrence assessment for the project (Namoi River catchment)

Family	Common Name	Scientific Name	Data source			Conservation status			Likelihood of Occurrence (LoO)	Rationale for likelihood ranking	Species Info
			DPI	BioNet	PMST	FM Act	WM Act	EBPC Act			
										stygofauna occurred in aquifers ranging from fresh to saline, with 14 taxa recorded.	
Reptiles											
Chelidae	Western Sawshelled Turtle	Myuchelys bellii		✓	-	E	-	V	Moderate	Bionet: 1 331 records within the Namoi Catchment. Multiple records to the north within the Cobrabald and McDonald rivers.	In NSW the species is found in four disjunct populations in the upper reaches of the Namoi, Gwydir and Border river systems, and on the escarpment of the North West Slopes. Frequents shallow to deep pools in upper reaches or small tributaries of major rivers in granite country.

Note ^indicates DPI Fisheries fish stocking data.

Annexure D

Site photographs, August 2020 and February-March 2022

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Annexure D

Site photographs, August 2020 and February-March 2022

Photograph D.1 **Site photographs taken during the August 2020 field survey showing upstream, downstream, riverbed and riverbank profiles**

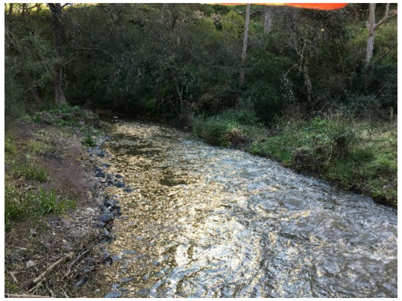
Photograph D.1 Site photographs taken during the August 2020 field survey showing upstream, downstream, riverbed and riverbank profiles

Site	Upstream	Downstream	Bed	Banks
BOC01				
DC01				
DC02				

Photograph D.1 Site photographs taken during the August 2020 field survey showing upstream, downstream, riverbed and riverbank profiles

Site	Upstream	Downstream	Bed	Banks
DC03				
DC04				
DC05				

Photograph D.1 Site photographs taken during the August 2020 field survey showing upstream, downstream, riverbed and riverbank profiles

Site	Upstream	Downstream	Bed	Banks
DC06				
DC07				
HHG01				

Photograph D.1 Site photographs taken during the August 2020 field survey showing upstream, downstream, riverbed and riverbank profiles

Site	Upstream	Downstream	Bed	Banks
JC01				
JOC01				
OC01				

Photograph D.1 Site photographs taken during the August 2020 field survey showing upstream, downstream, riverbed and riverbank profiles

Site	Upstream	Downstream	Bed	Banks
PC01				
PR01				
TBC01				

Photograph D.1 **Site photographs taken during the August 2020 field survey showing upstream, downstream, riverbed and riverbank profiles**

Site	Upstream	Downstream	Bed	Banks
UN01				
UN02				
UN03				

Photograph D.1 Site photographs taken during the August 2020 field survey showing upstream, downstream, riverbed and riverbank profiles

Site	Upstream	Downstream	Bed	Banks
UN04				
UN05				
UN06				

Photograph D.1 Site photographs taken during the August 2020 field survey showing upstream, downstream, riverbed and riverbank profiles

Site	Upstream	Downstream	Bed	Banks
UN07				
UN08				
UN10				

Photograph D.1 Site photographs taken during the August 2020 field survey showing upstream, downstream, riverbed and riverbank profiles

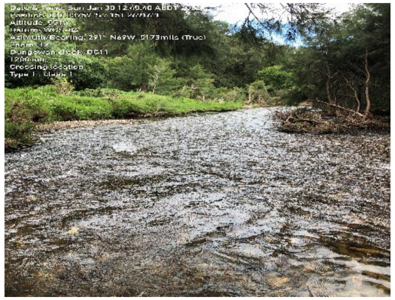
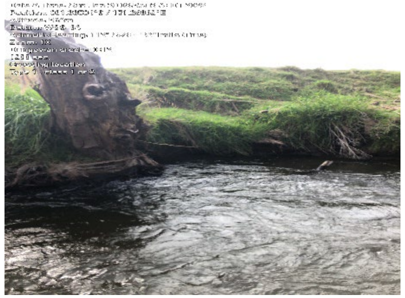
Site	Upstream	Downstream	Bed	Banks
UN11				
UN12				

Photograph D.2 Site photographs taken during the February-March 2022 field survey showing upstream, downstream, riverbed and riverbank profiles

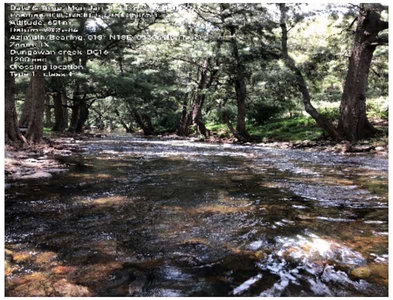
Photograph D.2 Site photographs taken during the February-March 2022 field survey showing upstream, downstream, riverbed and riverbank profiles

Site	Upstream	Downstream	Bed	Banks
DC08				
DC09				
DC10				

Photograph D.2 Site photographs taken during the February-March 2022 field survey showing upstream, downstream, riverbed and riverbank profiles

Site	Upstream	Downstream	Bed	Banks
DC11				
DC12				
DC13				

Photograph D.2 Site photographs taken during the February-March 2022 field survey showing upstream, downstream, riverbed and riverbank profiles

Site	Upstream	Downstream	Bed	Banks
DC14				
DC15				
DC16				

Photograph D.2 Site photographs taken during the February-March 2022 field survey showing upstream, downstream, riverbed and riverbank profiles

Site	Upstream	Downstream	Bed	Banks
PR02				
PR03				
OC02				

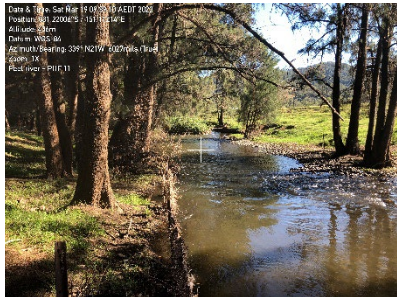
Photograph D.2 Site photographs taken during the February-March 2022 field survey showing upstream, downstream, riverbed and riverbank profiles

Site	Upstream	Downstream	Bed	Banks
UN13				
PHF 01				
PHF 04				

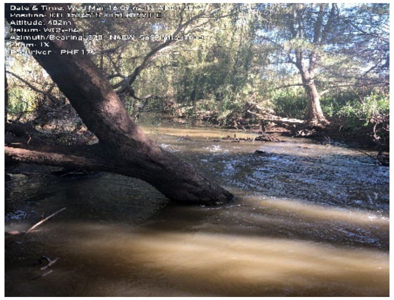
Photograph D.2 **Site photographs taken during the February-March 2022 field survey showing upstream, downstream, riverbed and riverbank profiles**

Site	Upstream	Downstream	Bed	Banks
PHF 06				
PHF 08				
PHF 09				

Photograph D.2 Site photographs taken during the February-March 2022 field survey showing upstream, downstream, riverbed and riverbank profiles

Site	Upstream	Downstream	Bed	Banks
PHF 11				
PHF 12				
PHF 13				

Photograph D.2 Site photographs taken during the February-March 2022 field survey showing upstream, downstream, riverbed and riverbank profiles

Site	Upstream	Downstream	Bed	Banks
PHF 14				
PHF 15				
PHF 17				

Photograph D.2 Site photographs taken during the February-March 2022 field survey showing upstream, downstream, riverbed and riverbank profiles

Site	Upstream	Downstream	Bed	Banks
PHF 19				
PHF 23A				
PHF 23AB				

Annexure E

DPI Fisheries Key Fish Habitat assessment proforma

Table E.1 Key fish habitat – waterway type assessment

Component	Present?	Component	Present?	Component	Present?
Type 1 - Highly sensitive key fish habitat		**Type 2 – Moderately sensitive key fish habitat**		**Type 3 – Minimally sensitive key fish habitat**	
Posidonia australis (a seagrass)		*Zostera*, *Heterozostera*, *Halophila* and *Ruppia* species of seagrass beds <5m^2 in area		Unstable or unvegetated sand or mud substrate, coastal and estuarine sandy beaches with minimal or no in-fauna	
*Zostera/*Heterozostera/*Halophila/Ruppia* species of seagrass beds >5m^2 in area		Mangroves		Coastal and freshwater habitats not included in TYPES 1 or 2	
Coastal saltmarsh >5m^2 in area		Coastal saltmarsh <5m^2 in area		Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	
Coral communities		Marine macroalgae such as *Ecklonia* and *Sargassum* species		Notes: For the purposes of these policy and guidelines the following are not considered key fish habitat:	
Coastal lakes and lagoons that have a natural opening and closing regime (ie 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 (eg managed in line with an entrance management plan)		Farm dams on first and second order streams or unmapped gullies	

Table E.1 **Key fish habitat – waterway type assessment**

Component	Present?	Component	Present?	Component	Present?
Type 1 - Highly sensitive key fish habitat		**Type 2 – Moderately sensitive key fish habitat**		**Type 3 – Minimally sensitive key fish habitat**	
SEPP 14 coastal wetlands, wetlands recognised under international agreements (eg 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 (eg evaporation basins, aquaculture ponds)	
Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act		Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1		Sections of stream that have been concrete-lined or piped (not including a waterway crossing)	
Mound springs		Weir pools and dams up to full supply level where the weir or dam is across a natural waterway		Canal estates	

Table E.2 Key fish habitat – waterway class assessment

Classification	Characteristics of waterway class	Present?
Class 1 – major key fish habitat	Marine or estuarine waterway or permanently flowing or flooded freshwater waterway (eg 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 (eg 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 (eg dry gullies, shallow floodplain depressions with no aquatic flora).	

Annexure F

In situ water quality, August 2020 and February-March 2022

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Table F.1 *In situ* water quality parameters from the August 2020 field surveys

Project component	Waterway	Site	pH	Salinity (ppt)	EC (uS/cm)	Dissolved oxygen (%)	Redox	Turbidity (NTU)	Temperature (ºC)	Water depth (m)
FSL	Jones Oaky Creek	JOC01		0.1	302	72	-9.8	1	8.1	0.09
FSL	Paradise Creek	PC01	8.06	0.05	172	104.5	119.6	3	9.7	0.06
FSL	Terrible Billy Creek	TBC01	8.13	0.03	81	104.3	41.9	1.2	6.14	0.1
FSL	Unknown Creek	UN01	-	-	-	-	-	-	-	0
FSL	Unknown Creek	UN02	-	-	-	-	-	-	-	0
Downstream	Big Oaky Creek	BOC01		0.06	193	88.5	28.6	0.5	10.1	0.15
Downstream	Dungowan Creek	DC01	7.71	0.05	141	106	45.4	30.9	7.18	0.2
Downstream	Dungowan Creek	DC02	9.89	0.05	140	98.1	87.7	5.1	10	0.2
Downstream	Dungowan Creek	DC03	10.42	0.05	146	101.2	53.4	6.2	10.9	0.3
Downstream	Dungowan Creek	DC04		0.05	160	110		0	10.7	0.5
Downstream	Dungowan Creek	DC05	-	-	-	-	-	-	-	0.5
Downstream*	Peel River	PR01		0.1	309	96.5		16.6	8.9	0.9
Pipeline	Dungowan Creek	DC06	8.15	0.05	151	104.2	10.3	32.6	10.6	0.17
Pipeline	Dungowan Creek	DC07	8.26	0.05	143	105.1	13.6	9.3	10.5	0.15
Pipeline	Hell Hole Gully	HHG01	-	-	-	-	-	-	-	0
Pipeline	Johnston Oaky Creek	JC01	7.62	0.04	132	110.4	142.5	1.6	10.9	0.07
Pipeline	Oaky Creek	OC01	-	-	-	-	-	-	-	0
Pipeline	Unknown Creek	UN03	-	-	-	-	-	-	-	0

Table F.1 *In situ* water quality parameters from the August 2020 field surveys

Project component	Waterway	Site	pH	Salinity (ppt)	EC (uS/cm)	Dissolved oxygen (%)	Redox	Turbidity (NTU)	Temperature (°C)	Water depth (m)
Pipeline	Unknown Creek	UN04	-	-	-	-	-	-	-	0
Pipeline	Unknown Creek	UN05	-	-	-	-	-	-	-	0.1
Pipeline	Unknown Creek	UN06	-	-	-	-	-	-	-	0
Pipeline	Unknown Creek	UN07		0.1	302	101.8		2.4	11.6	0.17
Pipeline	Unknown Creek	UN08	-	-	-	-	-	-	-	0
Pipeline	Unknown Creek	UN10	-	-	-	-	-	-	-	0
Pipeline	Unknown Creek	UN11	-	-	-	-	-	-	-	0
Pipeline	Unknown Creek	UN12	-	-	-	-	-	-	-	0

Note * indicates the site is used as a "baseline" for both the new Dungowan Dam and the proposed pipeline.

Table F.2 In situ water quality parameters from the February-March 2022 field survey

Project component	Waterway	Site	pH	EC (uS/cm)	SPC (uS/cm at 25°c)	Dissolved oxygen (%)	Dissolved oxygen (mg/L)	Turbidity (NTU)	Temperature (°C)
Pipeline	Dungowan Creek	DC08	7.49	74.9	82.2	56.7	5.12	2.23	20.3
Pipeline	Dungowan Creek	DC09	7.76	73.8	82	48.3	4.41	7.36	19.8
Pipeline	Dungowan Creek	DC10	7.44	72.7	83.1	52.5	4.94	5.16	18.5
Pipeline	Dungowan Creek	DC11	6.89	113.5	117.8	50	4.28	5.94	23
Pipeline	Dungowan Creek	DC12	7.32	107.3	117.4	49.2	4.42	5.82	20.5
Pipeline	Dungowan Creek	DC13	-	-	-	-	-	-	-

Project component	Waterway	Site	pH	EC (uS/cm)	SPC (uS/cm at 25°c)	Dissolved oxygen (%)	Dissolved oxygen (mg/L)	Turbidity (NTU)	Temperature (°C)
Pipeline	Dungowan Creek	DC14	7.48	102.7	113.5	50.6	4.6	13	19.9
Pipeline	Dungowan Creek	DC15	7.48	146.8	156	46.5	4.08	7.13	21.9
Pipeline	Dungowan Creek	DC16	7.11	74.5	79.3	51.9	4.55	2.34	21.9
Pipeline	Peel River	PR02	7.29	384.7	395.4	42.9	3.64	8.14	23.6
Pipeline	Peel River	PR03	7.21	250.9	270.1	50.6	4.49	23.7	21.3
Pipeline	Oaky Creek	OC01	-	-	-	-	-	-	-
Pipeline	Unknown Creek	UN03	-	-	-	-	-	-	-
Chaffey Dam	Peel River	PHF01	8.21	593	638	86.2	7.13	7.11	21.3
Chaffey Dam	Peel River	PHF04	7.93	346.3	398.2	65.4	6.16	5.22	18.2
Chaffey Dam	Peel River	PHF06	7.91	636	674	82.1	6.77	5.79	22.1
Chaffey Dam	Peel River	PHF08	7.93	609	672	78.7	6.82	7.34	20.1
Chaffey Dam	Peel River	PHF09	5.61	642	697	82.1	7.02	8.52	20.8
Chaffey Dam	Peel River	PHF11	7.62	634	706	75.9	6.5	8.78	19.7
Chaffey Dam	Peel River	PHF12	7.95	480	518	102	8.67	-	21.2
Chaffey Dam	Peel River	PHF13	4.74	485.7	523.7	101.6	8.64	-	21.2
Chaffey Dam	Peel River	PHF14	7.99	483	553	85.9	7.51	-	20
Chaffey Dam	Peel River	PHF15	8.0	515	560	92.8	7.98	-	20.8
Chaffey Dam	Peel River	PHF17	8.5	501	561	86.7	7.72	-	19.3
Chaffey Dam	Peel River	PHF19	7.81	308	346	87.4	6.44	16	19.3

Table F.3 In situ water quality parameters collected at deep water sites (PHF22A/B) during the March 2022 field surveys

Water quality parameters	Chaffey Dam Peel River					
Depth (m)	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**
Temperature (°c)	20.4	22.4	20.66	20.4	20.4	20.4
Dissolved Oxygen (%)	81.2	83.3	83.4	83.1	83	81.4
Dissolved Oxygen (mg/L)	7	7.27	7.3	7.28	7.27	7.19
Electrical conductivity (µS/cm)	780	781	781	780	780	781
Specific electrical conductivity (µS/cm@25°C)	856	856	856	856	856	856
pH (unit)	7.72	7.63	7.67	7.65	7.69	7.68

Annexure G

Electrofisher settings, August 2020

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Table G.1 Electrofisher settings from the August 2020 field survey

Project component	Waterway	Site	Volts	Frequency (Hz)	Duty cycle (%)	Seconds on time
FSL	Jones Oaky Creek	JC01	500	120	12	558
FSL	Paradise Creek	PC01	500	120	12	689
FSL	Terrible Billy Creek	TBC01	500	120	12	795
Downstream	Dungowan Creek	DC01	500	120	12	487
Downstream	Dungowan Creek	DC02	500	120	12	621
Downstream	Dungowan Creek	DC03	500	120	12	701
Downstream	Dungowan Creek	DC04	500	120	12	628
Downstream*	Peel River	PR01	300	60	12	1,240

Note * indicates the site is used as a "baseline" for both the new Dungowan Dam and the proposed pipeline.

Table G.2 Electrofisher settings from the February-March 2022 field survey

Project component	Waterway	Site	Volts	Frequency (Hz)	Duty cycle (%)	Seconds on time
Proposed Pipeline	Dungowan Creek	DC08	500	30	15	1200
Proposed Pipeline	Dungowan Creek	DC09	500	30	15	1200
Proposed Pipeline	Dungowan Creek	DC10	500	30	15	1200
Proposed Pipeline	Dungowan Creek	DC11	500	30	15	1080
Proposed Pipeline	Dungowan Creek	DC12	500	30	15	1200
Proposed Pipeline	Dungowan Creek	DC13	500	30	15	1200
Proposed Pipeline	Dungowan Creek	DC14	500	30	15	1200
Proposed Pipeline	Dungowan Creek	DC15	-	-	-	-
Proposed Pipeline	Dungowan Creek	DC16	500	30	15	1200
Proposed Pipeline	Peel River	PR02	-	-	-	-
Proposed Pipeline	Peel River	PR03	500	30	15	600
Proposed Pipeline	Oaky Creek	OC02	-	-	-	-
Proposed Pipeline	Unnamed waterway	UN13 (dry)	-	-	-	-
Chaffey Dam	Peel River	PHF01	-	-	-	1200
Chaffey Dam	Peel River	PHF04	-	-	-	1200
Chaffey Dam	Peel River	PHF06	220	30	12	1200
Chaffey Dam	Peel River	PHF08	220	30	12	1200
Chaffey Dam	Peel River	PHF09	240	30	12	1200

Table G.2 Electrofisher settings from the February-March 2022 field survey

Project component	Waterway	Site	Volts	Frequency (Hz)	Duty cycle (%)	Seconds on time
Chaffey Dam	Peel River	PHF11	230	30	12	1200
Chaffey Dam	Peel River	PHF12	220	30	12	1200
Chaffey Dam	Peel River	PHF13	350	30	12	1050
Chaffey Dam	Peel River	PHF14	220	30	12	450
Chaffey Dam	Peel River	PHF15	180	30	12	1200
Chaffey Dam	Peel River	PHF17	220	30	12	1200
Chaffey Dam	Peel River	PHF19	-	-	-	-
Chaffey Dam	Peel River	PHF22A/B	-	-	-	2160

Annexure H

FM Act significant impact assessments

Table H.1 Significant impact criteria (threatened ecological community) – Lowland Darling River EEC

Criteria	Discussion
(a) in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,	Not applicable
(b) in the case of an endangered population, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,	Not applicable
(c) in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity-- **(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**	The proposed project will not adversely affect the extent of the ecological community such that its occurrence is likely to be placed at risk of extinction, given that: • the Lowland Darling River EEC directly impacted by the current Dungowan Dam project in the reach of Dungowan Creek between Dungowan Dam and the confluence of the Peel River and the Peel River between Chaffey Dam and Tamworth accounts for only ≤1% of the Lower Darling EEC. • The impacts to the ecological community is not likely to be placed at risk of extinction from the project.
(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,	The proposed project will not substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction, given that: • The species present as part of the ecological community is expected to persist and reproduce successfully under the proposed operating requirements.
(d) in relation to the habitat of a threatened species, population or ecological community-- **(i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and**	The proposed project will not result in removal of habitat of the ecological community but may modify but not to the extent that its local occurrence is likely to be placed at risk of extinction, given that: • Some impacts to habitat availability as a result of reduced flows and flow depth are expected. • The species present as part of the ecological community is expected to persist and reproduce successfully under the proposed operating requirements.

Table H.1 Significant impact criteria (threatened ecological community) – Lowland Darling River EEC

Criteria	Discussion
(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,	The proposed project are not 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 given that: • The species present as part of the ecological community is expected to persist and reproduce successfully under the proposed operating requirements.
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the threatened species, population or ecological community in the locality,	The proposed project will result in modified modify habitat of the ecological community but not to the extent that its local occurrence is likely to be placed at risk of extinction, given that: • Some impacts to habitat availability as a result of reduced flows and flow depth are expected. • The species present as part of the ecological community is expected to persist and reproduce successfully under the proposed operating requirements. • The species present as part of the ecological community is expected to persist and reproduce successfully under the proposed operating requirements.
(e) whether the proposed development or activity is likely to have an adverse effect on any critical habitat (either directly or indirectly),	The project is expected to have an impact on flow volume and flow depths and may have an adverse effect on any critical habitat (either directly or indirectly) particularly riffle habitat, given that: • Modelling indicates that the flows will be reduced compared to the current conditions at Chaffey Dam and Piallamore ~ 75 % of the time, reductions of ≥10ML modelled to occur ~40% of the time (reduction of 1 – 10ML/day modelled to occur 35% of the time). At Tamworth reductions in flow modelled to occur ~25% of the time, reductions of ≥10ML modelled to occur ~10% of the time. • Change in depth of ≥ 1cm are modelled to occur up to 48 percent of the time at Chaffey Dam and Piallamore with greater modelled impacts over summer under current climate with +20% demand. A reduction in depth ≥ 5cm is modelled to occur 15% of the time under current climate with +20% demand.
(f) whether the proposed development or activity is consistent with a Priorities Action Statement,	The projectand possible impacts will align with the PAS for the Lower Darling EEC by; • Improving fish passage to 4 recognised fish barriers as part of the agreed offsets strategy for the project. The project and possible impacts do not align with the PAS for the Lower Darling EEC by; • Contributing to directly to the key threatening processes of altered flow regime in the reach between Chaffey dam and Tamworth • Contributing to indirectly to the key threatening processes of altered flow regime in the reach downstream of Tamworth, although impacts significantly reduced compared to the upstream reach.
(g) whether the proposed development constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.	Key threatening processes relevant to the Lower Darling EEC is the regulation of river flows which are already present in the impact area between Chaffey Dam and Tamworth on the Peel River. The proposed project will impact flows and depth as a result and will increase the impacts of river regulation to this reach. Impacts downstream of Tamworth significantly reduced with increase tributary inputs.

Table H.1 Significant impact criteria (threatened ecological community) – Lowland Darling River EEC

Criteria	Discussion
Conclusion	Implementation of the project will have a direct impact and indirect impact on the Lowland Darling River EEC as: • A direct impact to the reach between Chaffey Dam and Tamworth as a result of altered flows; • Indirect impacts to the reach downstream of Tamworth as a result of altered flows although indirect impacts downstream are likely to be reduced based on the modelling and tributary inflows. Species of the Lowland Darling River EEC present within the area are expected to persist and successfully reproduce and maintain a presence in the directly and indirectly impacted reaches of the Peel River.

Table H.2 Significant impact criteria (endangered populations) – Murray-Darling Basin population of Eel-tailed Catfish

Criteria	Discussion
(a) in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,	Not applicable
(b) in the case of an endangered population, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,	The Eel-tailed Catfish builds a nest within macrophytes for egg laying, hence its preference for slower moving waterways including lakes and ponds with fringing vegetation. As a result of these preferences, fluctuations in water volume/flow (affecting water level) as a result of the project may result in a retraction of permanent pools and effectively increase the distance between the waterbody and the fringing vegetation. A decrease in water level may also lead to exposure of nests, causing them to be abandoned, and sufficient water is needed just prior to breeding to ensure sufficient depth for nest building. Eel tailed catfish and evidence of recruitment (young of year collected) was detected in the Peel River and Dungowan Creek. Habitat in the Peel River is more typical of preferred Catfish habitat with Dungowan Creek containing more riffle and cobble bed sections of stream. With regard to water volume and flow in Dungowan Creek minor impact to flow have been modelled and can are summarised below, • With a change in flow of +/-10ML modelled to occur 89% of time and greater variations will occur 11% of the time under the current climate and +20% demand scenario. A change in flow of +/-10ML modelled to occur 92% of time greater variations will occur 8% of the time under the future climate and + 20% demand. • With a change in depth +/- 5cm modelled to occur 91% of the time under current climate with +20% demand. A Reduction in depth greater than 5cm is modelled to occur 4% of the time under current climate with +20% demand. Frequency analysis for each flow type prepared for Dungowan Creek indicates that there will be little change to the current compliance levels between the existing and proposed operating requirements. The major difference is a change in the event frequency of cease to flow periods from 6 to 7 years every decade. Translucent flows of between 10 -13ML/day will be maintained (10ML/translucent flows are currently in place) in Dungowan Creek with options to retain 3ML/day to be banked and used as and environmental flow to further minimise flow changes from the current conditions. CWP will potential extend 5km downstream of the new Dungowan Dam wall. With regard to water volume and flow in the Peel River larger impacts to flow have been modelled and can are summarised below, • Modelling indicates that the flows will be reduced compared to the current conditions at Chaffey Dam and Piallamore ~ 75 % of the time, reductions of ≥10ML modelled to occur ~40% of the time (reduction of 1 – 10ML/day modelled to occur 35% of the time). At

Table H.2 Significant impact criteria (endangered populations) – Murray-Darling Basin population of Eel-tailed Catfish

Criteria	Discussion
	Tamworth reductions in flow modelled to occur ~25% of the time, reductions of ≥10ML modelled to occur ~10% of the time. • Change in depth of ≥ 1cm are modelled to occur up to 48 percent of the time at Chaffey Dam and Piallamore with greater modelled impacts over summer under current climate with +20% demand. A reduction in depth ≥ 5cm is modelled to occur 15% of the time under current climate with +20% demand. EWR compliance will be reduced slightly under the proposed operation requirements with a reduction in compliance for base flows (components 1_B and 2_B). No additional environmental water is proposed for the reach between Chaffey Dam and Tamworth. Potential for banked flows and environmental water discharges to Dungowan Creek to further minimise flow changes from the current conditions.
(c) in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity-- **(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,**	Not applicable
(d) in relation to the habitat of a threatened species, population or ecological community-- **(i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and**	Habitat is unlikely to be directly removed. Some modification of habitat is expected as a result of the project. It is possible that impacts to the Murray-Darling Basin population of Eel tailed Catfish may occur, particularly as a result of sedimentation and erosion during construction. Management plans will also be implemented to ensure that construction impacts are mitigated as far as reasonably practicable. It is likely that there will be some local modifications to habitat availability although these changes are not expected to preclude the successful recruitment and persistence of the species in Dungowan Creek and the Peel River.
(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,	Not applicable

Table H.2 Significant impact criteria (endangered populations) – Murray-Darling Basin population of Eel-tailed Catfish

Criteria	Discussion
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the threatened species, population or ecological community in the locality,	key fish habitat in Dungowan Creek will be removed as a results of the new dam construction occurring 6.2 km downstream of the existing dam. The 26.5km of type 1 key fish habitat will be lost including 6.2km on Dungowan Creek. Construction of the new Dungowan Dam has the potential to create a fragmented population upstream of the new Dungowan Dam. Some habitats will be temporarily removed in Dungowan Creek as a result of the installation of the pipeline and trenched crossings on Dungowan Creek. Long term of the species survival or the species or population in the not expected as a result of the loss of key fish habitat in Dungowan Creek and the associated tributaries.
(e) whether the proposed development or activity is likely to have an adverse effect on any critical habitat (either directly or indirectly),	There is no declared critical habitat listed under the FM Act for the Murray-Darling Basin population of Eel-tailed Catfish.
(f) whether the proposed development or activity is consistent with a Priorities Action Statement,	There are a number of recovery actions stipulated for the Murray-Darling Basin population of Eel-tailed Catfish, with two potentially being of relevance to the project: • Allocate and manage environmental water flows in regulated rivers to restore natural seasonal flow patterns, and to reduce the impact of cold water downstream of dams (High priority) – Flow changes have been described above and the impacts of CWP could extend up to 5km downstream in a worst case scenario. Operation of the Multi level offtake and mixing strategies for the dam should minimise the potential for CWP. Risk of CWP are greater in summer when there is a potential for blue green algal blooms and a need to take water from cooler lower water levels. – CWP impacts are not anticipated to change downstream of Chaffe Dam • Work with community groups, relevant natural resource management agencies, local councils, landholders etc. to identify, restore and protect known and potential Eel-Tailed Catfish habitats and address key threats such as habitat degradation and water quality decline from expanding development (High priority). – Implementation of the project is likely to contribute to habitat modification based on modelled flows and flow depths. Water quality degradation (excluding CWP) are not expected to generally occur. Changes in water quality during cease to flow events will remain the same under the current and proposed operation regulations. – Habitat modification to the 4 crossing locations on Dungowan Creek will occur but these are considered temporary and habitat restoration at the crossing locations will be implemented. – No habitat modification will occur in the Peel River. – It is acknowledged that habitat may be isolated as a result of a decrease in water volume/flow, and depth as described above. It is likely that there will be some local modifications to habitat availability although these changes are not expected to

Table H.2 Significant impact criteria (endangered populations) – Murray-Darling Basin population of Eel-tailed Catfish

Criteria	Discussion
	preclude the successful reproduction and persistence of the species in Dungowan Creek and the Peel River. The project will be implemented in a manner that does not contradict relevant Priorities Action Statements, as far as practicable.
(g) whether the proposed development constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.	Of the key threatening processes listed under the FM Act, three may be relevant to the project with regard to the Murray-Darling Basin population of Eel-tailed Catfish: • *Degradation of native riparian vegetation along New South Wales water courses;* – Installation of the pipeline will require the clearing of riparian vegetation at the 4 crossing locations on Dungowan Creek. The Peel River crossing will be under bored and no impacts are expected to riparian vegetation. Post construction restoration will be undertaken and the riparian zone replanted. The changes in flow will have impacts on both Dungowan Creek and the Peel River as described above. Flow related impacts are not expected to impact riparian vegetation (EMM, 2022e) – Vegetation clearing for the pipeline at the crossing locations will be minimised as much as much as practicable. • *Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams*; and – Details of the expected changes to flows are described above. Regulation of both Dungowan Creek and the Peel River already occur. The proposed impacts to the flows have been outlined above (criteria b). The proposed project will impact flows and depth as a result and will increase the impacts of river regulation to the Peel River and Dungowan Creek upstream of the Tamworth. Impacts downstream of Tamworth significantly reduced with increase tributary inputs. The project will be implemented in a manner that does not contradict key threatening processes, as far as practicable.
Conclusion	Construction and operation of the project is unlikely to significantly impact on the Murray-Darling Basin population of Eel-tailed Catfish, given that: • Self-sustaining populations of Eel-tailed catfish are known to occur in both the Peel River and Dungowan Creek. • Changes to flow and depth will result in some changes in habitat availability in both the Peel River and Dungowan Creek with some potential for optimising flows in Dungowan Creek via the translucent flows to mitigate some of the impacts; • Compliance with EWR in the in the Peel River will be marginally impacted with some impacts to base flow compliance. • Changes in habitat availability as a result of the changed flows and depths are not expected to preclude the successful recruitment and persistence of the species in Dungowan Creek and the Peel River. • exotic fish species known to impact the Eel tailed Catfish are already widespread throughout the local catchment.

Table H.2 Significant impact criteria (endangered populations) – Murray-Darling Basin population of Eel-tailed Catfish

Criteria	Discussion
	It is not anticipated that the proposed project will result in significant impacts to the Murray-Darling Basin population of Eel-tailed Catfish. Translucent flows of between 10 -13ML/day will be maintained (10ML/translucent flows are currently in place) in Dungowan Creek with options to retain 3ML/day to be banked and used as environmental flow to further minimise flow changes from the current conditions.

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

Criteria	Discussion
(a) in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,	The Southern Purple-spotted Gudgeon is currently considered to be extremely rare in inland NSW with limited populations known. In addition, no individuals have been recorded during recent aquatic monitoring survey along Dungowan Creek or the Peel River. However, DPI Fisheries habitat mapping indicates it is possible that it is present within the vicinity of the project. Overall, it is unlikely that the project will have an adverse effect on the life cycle of the Southern Purple-spotted Gudgeon such that a viable local population of the species is likely to be placed at risk of extinction, because a viable local population is likely absent from the Peel River and Dungowan Creek.
(b) in the case of an endangered population, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,	Not applicable
(c) in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity-- **(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,**	Not applicable
(d) in relation to the habitat of a threatened species, population or ecological community-- **(i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and**	With regard to water volume and flow in Dungowan Creek minor impact to flow have been modelled and can are summarised below, • With a change in flow of +/-10ML modelled to occur 89% of time and greater variations will occur 11% of the time under the current climate and +20% demand scenario. A change in flow of +/-10ML modelled to occur 92% of time greater variations will occur 8% of the time under the future climate and + 20% demand. • With a change in depth +/- 5cm modelled to occur 91% of the time under current climate with +20% demand. A Reduction in depth greater than 5cm is modelled to occur 4% of the time under current climate with +20% demand.

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

Criteria	Discussion
	Frequency analysis for each flow type prepared for Dungowan Creek indicates that there will be little change to the current compliance levels between the existing and proposed operating requirements. The major difference is a change in the event frequency of cease to flow periods from 6 to 7 years every decade. Translucent flows of between 10 -13ML/day will be maintained (10ML/translucent flows are currently in place) in Dungowan Creek with options to retain 3ML/day to be banked and used as an environmental flow to further minimise flow changes from the current conditions. CWP will potential extend 5km downstream of the new Dungowan Dam wall. With regard to water volume and flow in the Peel River larger impacts to flow have been modelled and can are summarised below, • Modelling indicates that the flows will be reduced compared to the current conditions at Chaffey Dam and Piallamore ~ 75 % of the time, reductions of ≥10ML modelled to occur ~40% of the time (reduction of 1 – 10ML/day modelled to occur 35% of the time). At Tamworth reductions in flow modelled to occur ~25% of the time, reductions of ≥10ML modelled to occur ~10% of the time. • Change in depth of ≥ 1cm are modelled to occur up to 48 percent of the time at Chaffey Dam and Piallamore with greater modelled impacts over summer under current climate with +20% demand. A reduction in depth ≥ 5cm is modelled to occur 15% of the time under current climate with +20% demand. EWR compliance will be reduced slightly under the proposed operation requirements with a reduction in compliance for base flows (components 1_B and 2_B). No additional environmental water is proposed for the reach between Chaffey Dam and Tamworth. Potential for banked flows and environmental water discharges to Dungowan Creek to further minimise flow changes from the current conditions. Habitat may be isolated as a result of a decrease in water volume/flow, and it is acknowledged that the potential exits for downstream impacts to threatened aquatic fauna to occur. These impacts would not occur the majority of the time, as reflected via the flow duration curves but would potentially be more noticeable during periods of low flow within the Dungowan Creek and the Peel River. However, it is not anticipated that a negligible change in water volume or flow will result in significant impacts to Southern Purple-spotted Gudgeon. Southern Purple-spotted Gudgeon may be able to survive in shallower water by comparison to the other species and can tolerate lower water level and no flow conditions.
(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,	Not applicable
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the threatened species,	With regard to the Southern Purple-spotted Gudgeon, the species prefers slow-flowing or still water with a substantial amount of macrophyte coverage and/or a rocky benthos.

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

Criteria	Discussion
population or ecological community in the locality,	Habitat in Dungowan Creek and the Peel River is generally lacking the habitat complexity preferred by the species although their presence is not precluded. Overall, it is unlikely that Dungowan Creek and the Peel River is considered to be "important habitat" in its current condition, and therefore any potential impacts to water level are unlikely to affect Southern Purple-spotted Gudgeon.
(e) whether the proposed development or activity is likely to have an adverse effect on any critical habitat (either directly or indirectly),	There is no declared critical habitat listed under the FM Act for Southern Purple-spotted Gudgeon.
(f) whether the proposed development or activity is consistent with a Priorities Action Statement,	There are a number of recovery actions stipulated for the Southern Purple-spotted Gudgeon, with three potentially being of relevance to the project: • *Allocate and manage environmental water flows in regulated rivers to restore natural seasonal flow patterns, and to reduce the impact of cold water downstream of dams (High priority)* – It is acknowledged that the potential exits for downstream impacts to threatened aquatic fauna to occur. These impacts would not occur the majority of the time, as reflected via the flow duration curves and modelling that indicates flow impacts downstream of Tamworth will be negligible as tributary inflows have a greater influence. It is not anticipated that the modelled impacts to water volume or flow will result in significant impacts to Southern Purple-spotted Gudgeon if present. – Flow changes have been described above and the impacts of CWP could extend up to 5km downstream in a worst case scenario. Operation of the Multi level offtake and mixing strategies for the dam should minimise the potential for CWP. Risk of CWP are greater in summer when there is a potential for blue green algal blooms and a need to take water from cooler lower water levels. – No changes CWP impacts anticipated in the Peel River. • *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).* – Implementation of the project is likely to contribute to habitat modification based on modelled flows and flow depths. Water quality degradation (excluding CWP) are not expected to generally occur. Changes in water quality during cease to flow events will remain the same under the current and proposed operation regulations. – Habitat modification to the 4 crossing locations on Dungowan Creek will occur but these are considered temporary and habitat restoration at the crossing locations will be implemented. – No habitat modification will occur in the Peel River. – It is acknowledged that habitat may be isolated as a result of a decrease in water volume/flow, and depth as described above. It is likely that there will be some local modifications to habitat availability although these changes are not expected to preclude the successful reproduction and persistence of the species in Dungowan Creek and the Peel River.

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

Criteria	Discussion
	The project will be implemented in a manner that does not contradict relevant Priorities Action Statements, as far as practicable.
(g) whether the proposed development constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.	Of the key threatening processes listed under the FM Act, three may be relevant to the project with regard to Southern Purple-spotted Gudgeon: • *Degradation of native riparian vegetation along New South Wales water courses;* – Installation of the pipeline will require the clearing of riparian vegetation at the 4 crossing locations on Dungowan Creek. The Peel River crossing will be under bored and no impacts are expected to riparian vegetation. Post construction restoration will be undertaken and the riparian zone replanted. The changes in flow will have impacts on both Dungowan Creek and the Peel River as described above. The extent that the altered flows will impact riparian vegetation is not known (EMM, 2022d). – Vegetation clearing for the pipeline at the crossing locations will be minimised as much as much as practicable. • *Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams;* and – Details of the expected changes to flows are described above. Regulation of both Dungowan Creek and the Peel River already occur. The proposed impacts to the flows have been outlined above (criteria b). The proposed project will impact flows and depth as a result and will increase the impacts of river regulation to the Peel River and Dungowan Creek upstream of the Tamworth. Impacts downstream of Tamworth significantly reduced with increase tributary inputs. The project will be implemented in a manner that does not contradict key threatening processes, as far as practicable. The project will be implemented in a manner that does not contradict key threatening processes, as far as practicable.
Conclusion	Construction and operation of the project is unlikely to significantly impact on Southern Purple Spotted Gudgeon given: • optimal habitat is not present in Dungowan Creek or the Peel River but the habitat could still support Southern Purple-spotted Gudgeon which may occur within the project area; • the Southern Purple-spotted Gudgeon has not been recorded from the project vicinity during the current surveys; and • exotic fish species are known to impact Southern Purple-spotted Gudgeon and are already widespread throughout the local catchment. It is not anticipated that the proposed changes to the operation regulations will result in significant impacts to the Murray-Darling Basin population of Eel-tailed Catfish. Translucent flows of between 10 -13ML/day will be maintained (10ML/translucent flows are currently in place) in Dungowan Creek with options to retain 3ML/day to be banked and used as an environmental flow to further minimise flow changes from the current conditions.

Annexure I

EPBC Act significant impact assessments

creating opportunities

Table I.1 Significant impact criteria – Critically endangered species – Silver Perch

Species assessed	Silver Perch
Criteria	**Discussions**
Lead to a long-term decrease in the size of a population	The Silver Perch is known from the Peel River, with an individual capture at Tamworth and via eDNA surveys at Piallamore during the current surveys in 2022. The individual collected was a mature adult and no known self sustaining population is thought to exist in Dungowan Creek or the Peel River in the reach upstream of Tamworth. NSW fisheries mapping does not include the Peel River and the nearest mapped habitat is at the confluence of the Peel and Namoi Rivers. Silver Perch is known to be stocked in Chaffey Dam and it is likely that the fish encountered were stocked fish. The species is prevented from upstream migrations past the existing Dungowan Dam and Chaffey Dam. Knowledge of self-sustaining populations of Silver Perch are limited but are known to occur within Cataract Dam in the Hawkesbury Nepean catchment, within the Mid Murray and some tributaries (ie Wakool River). Therefore, it is unlikely that the project will lead to a long-term decrease in the size of a population because a viable local population is likely absent from the Peel River and Dungowan Creek.
Reduce the area of occupancy for of the species	Silver Perch is known to be stocked within Chaffey Dam and no known self sustaining population is thought to exist in Dungowan Creek or the Peel River in the reach upstream of Tamworth. NSW fisheries mapping does not include the Peel River and the nearest mapped habitat is at the confluence of the Peel and Namoi Rivers. While minimally suitable habitat occurs for the species within the Peel River it is unlikely that a viable, self sustaining population occurs within the study area. The new Dungowan Dam is to be constructed 6.13 km downstream of the existing Dungowan Dam resulting in a loss of connectivity to upstream reaches of key fish habitat. Additional impacts include relatively minor CWP effects and alterations to flow due to operation of the new Dungowan Dam. Overall, while the available area of occupancy may decrease as a result of the project, it is unlikely that a viable, self sustaining population of Silver Perch occurs within the study area and are therefore there will be no reduction in the area of occupancy for the species.
Fragment an existing population into two or more populations	It is unlikely that a viable, self sustaining population of Silver Perch occurs in the vicinity of the project and therefore the project is unlikely to result in the fragmentation of a population into two or more populations.
Adversely affect habitat critical to the survival of a species	As of 2006, no critical habitat had been declared for Silver Perch and there is limited information available on their habitat requirements and preferences for particular habitat components. It is thought that they prefer fast flowing conditions; however, other data indicates this is not as important. Their dependence on large woody debris and snags is also unclear. It is possible that the project area contains some suitable habitat for the Silver Perch, particularly during periods of high flow. However, it is unlikely that local conditions in their current state comprise suitable habitat. Overall, it is considered unlikely that the reaches of the Peel River between Tamworth and the Chaffey Dam, or Dungowan Creek contain habitat critical to the survival of the species, therefore it is unlikely that implementation of the project will impact upon survival of the species.

Table I.1 Significant impact criteria – Critically endangered species – Silver Perch

Species assessed	**Silver Perch**
Criteria	**Discussions**
Disrupt the breeding cycle of a population	It is unlikely that viable, breeding populations of the Silver Perch occur in the vicinity of the project and therefore the project is unlikely to result in the disruption of the breeding cycle of a population of either species.
Modify, destroy, remove, isolate or decrease the availability habitat to the extent that the species is likely to decline	It is acknowledged that the potential exists for downstream impacts to threatened aquatic fauna to occur. These impacts would not occur the majority of the time, as reflected via the modelled changes to daily flow and changes to daily depth (section 9.1 and 9.2) but would potentially be more noticeable during periods of low flow within the Peel River and Dungowan Creek. However, it is not anticipated that the modelled changes in water volume, flow or depth will result in significant impacts to the Silver Perch. As there is uncertainty around habitat preferences for the Silver Perch, it is possible that the species could be impacted; however, current conditions, particularly during times of low rainfall and inflow, are unlikely to be conducive to supporting the species in the first place, therefore the reduction in water availability and potential contraction of surface water pools would be unlikely to lead to a decline in the species. There is potential for habitat characteristics such as LWD to be modified at eight discrete locations on Dungowan Creek as a result of trenching activity however all LWD is to be replaced immediately after trenching is completed. is highly unlikely that habitat will be permanently modified, destroyed or removed as a result of the project; however, management plans will be implemented to ensure that construction impacts are mitigated as far as reasonably practicable. It is also considered unlikely that a viable, self sustaining population of Silver Perch occurs within the vicinity of the project. As such, given minimal impacts to habitat and the lack of a sustainable population it is considered unlikely that the proposed action will modify, destroy, remove, isolate or decrease the availability of habitat to the extent that the species is likely to decline
Result in invasive species that are harmful to a critically endangered species becoming established in the critically endangered species' habitat	Aquatic surveys revealed that exotic species including Goldfish, Common Carp, Eastern mosquitofish, Rainbow Trout and Brown Trout already occur within the Peel River and Dungowan Creek although Eastern mosquitofish and Goldfish were not recorded within Dungowan Creek. Therefore, while it is possible that Eastern mosquitofish larvae could be transferred from the Peel River to Dungowan Creek, it is highly unlikely that water would be transferred from the Peel River to Dungowan Creek as Dungowan Creek itself is a ready water source. In addition, this species is already widespread throughout the local catchment. Overall, the project will not result in new invasive species that are harmful to a critically endangered species becoming established in the critically endangered species' habitat.

Table I.1 Significant impact criteria – Critically endangered species – Silver Perch

Species assessed	Silver Perch
Criteria	**Discussions**
Introduce disease that may cause the species to decline	While not considered to be introduced diseases, the cyanobacteria *Anabaena* sp. was recorded within the Peel River and Dungowan Creek in low abundances. *Dolichospermum circinale* and *Planktothrix* sp. Were also recorded within the Peel River. These genera contain either anatoxin or microcystin and thus have the potential to be toxic to aquatic biota when blooming. It is possible that cyanobacteria could be transferred from the Peel River to Dungowan Creek; however, it is highly unlikely that water would be taken from the Peel River to be used at Dungowan Creek given Dungowan Creek is its own ready water source. In addition, it is highly likely that both *Dolichospermum circinale* and *Planktothrix* sp. already occur within Dungowan Creek and were simply not recorded at the time of sampling. Overall, it is considered unlikely that the proposed action will facilitate the transfer of cyanobacteria or disease that may cause the species to decline into the study area.
Interfere substantially with the recovery of the species	As it is unlikely that viable, self sustaining populations of the Silver Perch occur in the vicinity of the project and are more likely to be limited to occasional, stocked individuals, it is unlikely that the project will interfere sustainably with the recovery of the species.
Conclusion	The construction and operation of the project is unlikely to result in a significant impact to the Silver Perch as it is unlikely that viable, self sustaining populations of the species occur in the vicinity of the project and are more likely to be limited to occasional stocked individuals. In addition, local conditions are not considered to contain sufficient high quality habitat for the species. It is acknowledged that the potential exists for downstream impacts to threatened aquatic fauna to occur. These impacts would not occur the majority of the time, as reflected via the modelled changes to daily flow and changes to daily depth (section 9.1 and 9.2) but would potentially be more noticeable during periods of low flow within the Peel River and Dungowan Creek. However, it is not anticipated that the modelled changes in water volume, flow or depth will result in significant impacts to the Silver Perch.

Table I.2 Significant impact criteria – Vulnerable species – Murray Cod

Species assessed	Murray Cod
Criteria	**Discussions**
Lead to a long-term decrease in the size of an important population	The Murray Cod has been recorded within Dungowan Creek and the Peel River prior to this project commencing. Aquatic surveys undertaken as part of this EIS confirmed that both Dungowan Creek and the Peel River support viable, self sustaining populations of Murray Cod. Murray Cod access to habitat is to be reduced due to loss of key fish habitat due to construction of the proposed Dam wall, inundation of the new dam area upstream of the dam wall and CWP extending to less than five kilometres downstream of the proposed dam wall. Whilst all these impacts are likely to negatively effect Murray Cod habitat the impact area is relatively small compared to the current distribution/ area of occupancy. As such it is considered that the proposed action is unlikely to lead to a long-term decrease in the size of an important population.
Reduce the area of occupancy for an important population	The new Dungowan Dam is to be constructed 6.13 km downstream of the existing Dungowan Dam resulting in a loss of connectivity to upstream reaches of key fish habitat. Additional impacts include relatively minor CWP effects extending less than five kilometres downstream of the site of the proposed dam wall and alterations to flow due to operation of the new Dungowan Dam. The Namoi River population of Murray Cod is considered an ‘important’ population (Department of the Environment, 2016). Given the connectivity between the Namoi River and the study area, in addition to the fact that the local population of Murray Cod is self sustaining it should be considered an ‘important’ population. There will be a reduction in connectivity due to the construction of the new Dungowan Dam and the local population of Murray Cod is considered an ‘important’ population. Should the project proceed there will be an increase in connectivity due to the removal or bypassing of four barriers to fish passage within the Peel River which will result in an overall INCREASE in connectivity. Given the area of loss is relatively small compared to the current distribution of Murray Cod and the increased connectivity associated with the project it has been determined that the proposed action will not result in a reduction in the area of occupancy for an important population.
Fragment an existing important population into two or more populations	The existing Dungowan Dam creates a barrier to fish passage on Dungowan Creek and likely fragmented an existing important population into two populations upon construction. The construction of a new dam 6.13 km downstream and decommissioning of the old Dam will not further fragment an existing important population into two or more populations.

Table I.2 Significant impact criteria – Vulnerable species – Murray Cod

Species assessed	Murray Cod
Criteria	**Discussions**
Adversely affect habitat critical to the survival of a species	High quality breeding habitat for Murray Cod exists within the Peel River and Dungowan Creek in the form of LWD, undercut banks, and areas of deeper, slow flowing waters. Substantial dietary resources also occur within both waterways. Habitat is likely to be adversely affected primarily due to loss of key fish habitat as a result of the construction of the proposed dam wall and subsequent inundation of the dam area. Additional impacts to habitat are likely to occur as a result of trenching during construction of the proposed pipeline however mitigation measures and replacement of LWD will minimise these impacts. Modelled changes to flow and depth as a result of operating the proposed dam are not considered likely to significantly impact Murray Cod habitat however CWP has the potential to occur and is modelled to extend less than five kilometres downstream of the proposed dam. CWP has the potential to result in a loss of spawning habitat should water temperatures drop below 16.5°C during spring-summer. Whilst the impacted habitat is considered high value the area of impact is small relative to the current distribution of Murray Cod and the proportion of the overall population to be impacted is not considered 'significant'. As such the habitat to be impacted is not considered 'critical' to the survival of the species. Overall the proposed action will not adversely affect habitat critical to the survival of a species.
Disrupt the breeding cycle of an important population	Construction of the dam and pipeline will occur across multiple years and will continue through the Murray Cod breeding season of spring/summer likely disrupting the breeding cycle of an 'important' population. Modelled changes to temperature within Dungowan Creek as a result of CWP may inhibit spawning cues for Murray Cod up to less than five kilometres downstream of the proposed dam wall. Field assessments confirmed that the upper reaches of Dungowan creek approaching the proposed site for the new Dungowan Dam is predominantly riffle habitat and supports few characteristics associated with Murray Cod breeding habitat. Breeding may occur within this area however it is unlikely to occur on a large scale such as would be seen in higher value breeding habitat such as areas of deep pools that support hard substrate such as LWD. The proposed action may disrupt the breeding cycle of an important population during construction and may continue to disrupt the breeding cycle of an important population beyond the construction period however the area of impact is small relative to the current distribution of Murray Cod and the proportion of the overall population to be impacted is not considered 'significant'. As such, it has been determined that the disruption to the breeding cycle of an important population should not be considered a significant impact.

Table I.2 Significant impact criteria – Vulnerable species – Murray Cod

Species assessed	Murray Cod
Criteria	**Discussions**
Modify, destroy, remove, isolate or decrease the availability habitat to the extent that the species is likely to decline	High quality breeding habitat for Murray Cod exists within the Peel River and Dungowan Creek in the form of LWD, undercut banks, and areas of deeper, slow flowing waters. Substantial dietary resources also occur within both waterways. Removal of habitat will occur due to the construction of the proposed dam wall and subsequent inundation of the dam area. The area of impact is considered small relative to the overall distribution of the Murray Cod. Additionally, four barriers to fish passage are to be removed from the Peel River as part of the offsets pathway chosen to offset the loss of connectivity that will occur as a result of constructing the proposed dam wall. The removal of the four barriers to fish passage will substantially increase connectivity within the Peel River and Dungowan Creek increasing access to suitable habitat for Murray Cod. Whilst access to habitat upstream of the proposed dam will be removed, access to downstream habitat will significantly increase. It is considered unlikely that the species will decline due to a loss of habitat.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Aquatic surveys revealed that exotic species including Goldfish, Common Carp, Eastern mosquitofish, Rainbow Trout and Brown Trout already occur within the Peel River and Dungowan Creek although Eastern mosquitofish and Goldfish were not recorded within Dungowan Creek. Therefore, while it is possible that Eastern mosquitofish larvae could be transferred from the Peel River to Dungowan Creek, it is highly unlikely that water would be transferred from the Peel River to Dungowan Creek as Dungowan Creek itself is a ready water source. In addition, this species is already widespread throughout the local catchment. Overall, the project will not result in new invasive species that are harmful to a critically endangered species becoming established in the critically endangered species' habitat.
Introduce disease that may cause the species to decline	While not considered to be introduced diseases, the cyanobacteria *Anabaena* sp. was recorded within the Peel River and Dungowan Creek in low abundances. *Dolichospermum circinale* and *Planktothrix* sp. Were also recorded within the Peel River. These genera contain either anatoxin or microcystin and thus have the potential to be toxic to aquatic biota when blooming. It is possible that cyanobacteria could be transferred from the Peel River to Dungowan Creek; however, it is highly unlikely that water would be taken from the Peel River to be used at Dungowan Creek given Dungowan Creek is its own ready water source. In addition, it is highly likely that both *Dolichospermum circinale* and *Planktothrix* sp. already occur within Dungowan Creek and were simply not recorded at the time of sampling. Overall, it is considered unlikely that the proposed action will facilitate the transfer of cyanobacteria or disease that may cause the species to decline into the study area.
Interfere substantially with the recovery of the species	Given the area of impact is small relative to the current distribution of the Murray Cod and the fact that the species is unlikely to decline as a result of the proposed action it is considered unlikely that the proposed action will interfere substantially with the recovery of the species.

Table I.2 Significant impact criteria – Vulnerable species – Murray Cod

Species assessed	**Murray Cod**
Criteria	**Discussions**
Conclusion	The construction and operation of the project will not result in a significant impact to an important population of Murray Cod. Despite a reduction in connectivity due to the construction of the new Dungowan Dam and the status of the local population as an 'important' population the small area of impact and increased connectivity resulting from the removal or bypass of four barriers to fish passage on the Peel River it has been determined that the proposed action will not result in a decrease in the area of occupancy for an important population It is considered likely that the proposed action will adversely affect high value habitat associated with Murray Cod however the area of impact is small relative to the current distribution of Murray Cod and the habitat to be impacted is not considered critical to the survival of a species. The proposed action will disrupt the breeding cycle of an important population during construction and may continue to disrupt the breeding cycle of an important population beyond the construction period. The proportion of the population to be impacted is not considered to be a significant proportion of the overall population and is not considered a significant impact. It is considered unlikely that the proposed action will interfere substantially with the recovery of the species.

Table I.3 Significant impact criteria – Vulnerable species - Platypus

Species assessed	**Platypus**
Criteria	**Discussions**
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 Agriculture, Water and the Environment, 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 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 platypus no populations of platypus are formally recognised as ‘important’ populations. As such the proposed action will not lead to the fragment of an existing ‘important’ population into two or more populations.
Adversely affect habitat critical to the survival of a species	High value habitat for platypus is known to occur within both the Peel River and Dungowan Creek. Monitoring programs initiated prior to this project confirmed that platypus is prevalent within the study area and aquatic surveys undertaken as part of this EIS confirmed these findings. High value habitat is likely to be adversely affected primarily due to loss of key fish habitat as a result of the construction of the proposed dam wall and subsequent inundation of the dam area however this habitat is not considered critical to the survival of the species. Additional impacts to habitat are likely to occur as a result of trenching during construction of the proposed pipeline however mitigation measures and replacement of key habitat characteristics will minimise these impacts. Modelled data indicates flows are unlikely to decrease significantly under the new Dungowan Dam flow regime, however it is likely that riffle habitat associated with foraging and feeding behaviour will be negatively impacted. Due to a lack of data it is not possible to quantify the loss of riffle habitat that is likely to occur. A precautionary approach has been adopted and it has been assumed that modelled changes to depth will adversely affect feeding habitat between the site of the new Dungowan Dam and Tamworth. It is not possible to determine to what degree riffle habitat between the proposed dam and Tamworth will be impacted from the available data. Regardless, the proportion of the overall platypus population that is likely to be impacted is not considered to be ‘significant’. The proposed action is unlikely adversely affect habitat critical to the survival of a species.
Disrupt the breeding cycle of an important population	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 disrupt the breeding cycle of an ‘important’ population.

Table I.3 Significant impact criteria – Vulnerable species - Platypus

Species assessed	Platypus
Criteria	**Discussions**
Modify, destroy, remove, isolate or decrease the availability habitat to the extent that the species is likely to decline	High quality habitat for platypus exists within the Peel River and Dungowan Creek in the form of steep clay banks for burrowing, undercut banks, and areas of riffle habitat which support macroinvertebrates, the primary dietary source for platypus. Removal of habitat will occur due to the construction of the proposed dam wall and subsequent inundation of the dam area. Operation of the proposed dam may impact riffle habitat downstream of the dam however with the available data it is not possible to quantify riffle habitat loss. As such the precautionary principle must be applied and it must be assumed that all riffle habitat downstream of the new Dungowan Dam to Tamworth will be impacted although it is not possible to determine to what degree it will be impacted. Regardless, the overall area of impact is considered small relative to the current distribution of the platypus across Australia. The proportion of the overall population to be impacted is not considered a 'significant' proportion of the overall population. Four barriers to fish passage are to be removed from the Peel River as part of the offsets pathway chosen to offset the loss of connectivity that will occur as a result of constructing the proposed dam wall. The removal of the four barriers to fish passage will substantially increase connectivity within the Peel River and Dungowan Creek increasing access to suitable habitat for platypus. Whilst access to habitat upstream of the proposed dam will be removed, access to downstream habitat will significantly increase. It is considered unlikely that the species will decline due to a loss of habitat.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Aquatic surveys revealed that exotic species known to compete with platypus for dietary resources, including Goldfish, Common Carp, Eastern mosquitofish, Rainbow Trout and Brown Trout already occur within the Peel River and Dungowan Creek although Eastern mosquitofish and Goldfish were not recorded within Dungowan Creek. Therefore, while it is possible that Eastern mosquitofish larvae could be transferred from the Peel River to Dungowan Creek, it is highly unlikely that water would be transferred from the Peel River to Dungowan Creek as Dungowan Creek itself is a ready water source. In addition, this species is already widespread throughout the local catchment. The proposed action is unlikely to increase the prevalence of foxes or feral cats which are known to prey upon platypus. Overall, the project will not result in new invasive species that are harmful to a critically endangered species becoming established in the critically endangered species' habitat.
Introduce disease that may cause the species to decline	While not considered to be introduced diseases, the cyanobacteria *Anabaena* sp. was recorded within the Peel River and Dungowan Creek in low abundances. *Dolichospermum circinale* and *Planktothrix* sp. Were also recorded within the Peel River. These genera contain either anatoxin or microcystin and thus have the potential to be toxic to aquatic biota when blooming. It is possible that cyanobacteria could be transferred from the Peel River to Dungowan Creek; however, it is highly unlikely that water would be taken from the Peel River to be used at Dungowan Creek given Dungowan Creek is its own ready water source. In addition, it is highly likely that both *Dolichospermum circinale* and *Planktothrix* sp. already occur within Dungowan Creek and were simply not recorded at the time of sampling. Overall, it is considered unlikely that the proposed action will facilitate the transfer of cyanobacteria or disease that may cause the species to decline into the study area.

Table I.3 Significant impact criteria – Vulnerable species - Platypus

Species assessed	Platypus
Criteria	**Discussions**
Interfere substantially with the recovery of the species	While platypus habitat is predicted to be impacted by the proposed action the proportion of the overall platypus population to be impacted is not considered significant. It is considered unlikely that the proposed action will interfere substantially with the recovery of the species.
Conclusion	The construction and operation of the project is unlikely to result in a significant impact to platypus. Whilst platypus habitat will be impacted as a result of the proposed action the proportion of the overall population to be impacted is not considered significant.

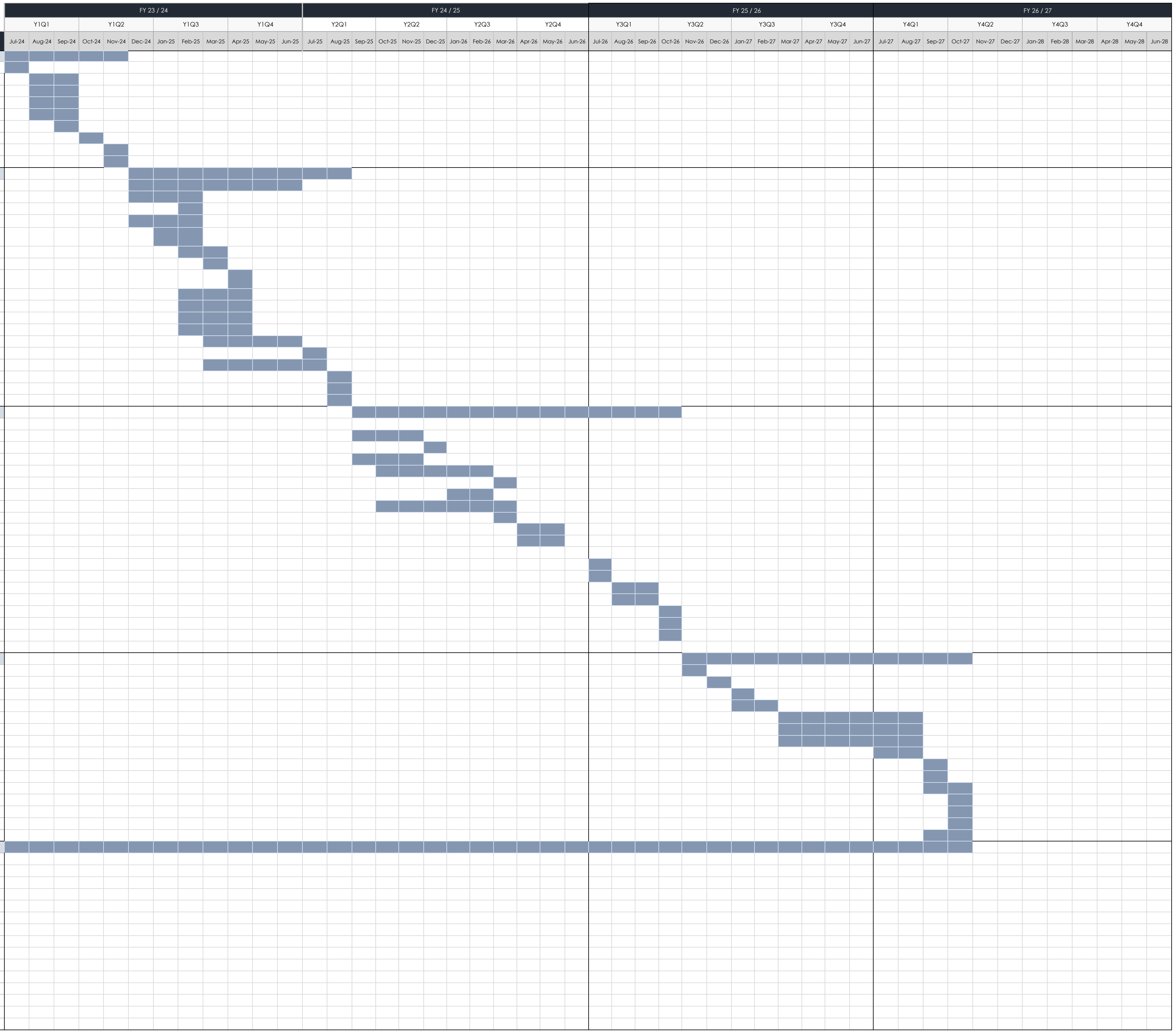
Annexure J

Fish passage offset – Site workplans

New Dungowan Dam and Pipeline Project Fishway Offsets

PROJECT TITLE	START DATE	PROJECT DURATION (DAYS)	
Ponitbah Causeway Upgrade	Jul-24		
PROJECT MANAGER	END DATE		
Water Infrastructure NSW	Oct-27	1188	

TASK NO.	TASK NAME	STATUS	RESPONSIBLE	START DATE	END DATE	PROGRESS
1	**PROJECT DEVELOPMENT**			Jul-24	Nov-24	0%
1.1	Engage Project Manager			Jul-24	Jul-24	0%
1.2	Prepare Project Management Plan			Aug-24	Sep-24	0%
1.3	Prepare Risk and Project Registers			Aug-24	Sep-24	0%
1.4	Prepare Stakeholder Communications Plan			Aug-24	Sep-24	0%
1.5	Prepare Budget and Resourcing Plan			Aug-24	Sep-24	0%
1.6	Preparation of Principal Design Consultant (PDC) brief & agreement			Sep-24	Sep-24	0%
1.7	Tender for PDC			Oct-24	Oct-24	0%
1.8	Engage PDC			Nov-24	Nov-24	0%
1.90	Prepare Progress Report			Nov-24	Nov-24	0%
2	**CONCEPT DESIGN**			Dec-24	Aug-25	0%
2.1	Water level sensor deployment			Dec-24	Jun-25	
2.2	Collation of site information and identification of knowledge gaps			Dec-24	Feb-25	0%
2.3	Inception meeting with key stakeholders, site visit			Feb-25	Feb-25	0%
2.4	Hydrologic assessment & modelling (as required)			Dec-24	Feb-25	0%
2.5	Development of design criteria - ecological, hydrologic, structural			Jan-25	Feb-25	0%
2.6	Development of Feasibility Options			Feb-25	Mar-25	0%
2.7	Complete asset condition assessment			Mar-25	Mar-25	0%
2.8	Review of Feasibility Options and selection of Concept Design Option(s)			Apr-25	Apr-25	0%
2.9	Complete site survey (mAHD)			Feb-25	Apr-25	0%
2.10	Complete geotechnical assessments			Feb-25	Apr-25	0%
2.11	Complete flora / fauna assessments			Feb-25	Apr-25	0%
2.12	Complete cultural heritage assessment			Feb-25	Apr-25	0%
2.13	Obtain Aboriginal Heritage Impact Permit			Mar-25	Jun-25	0%
2.14	Finalise hydrologic assessment with water level sensor data			Jul-25	Jul-25	0%
2.14	Development of Concept Designs including cost estimates			Mar-25	Jul-25	0%
2.16	Review of Concept Designs			Aug-25	Aug-25	0%
2.17	Review cost estimates via Quantity Surveyor			Aug-25	Aug-25	0%
2.18	Prepare Progress Report			Aug-25	Aug-25	0%
3	**DETAILED DESIGN**			Sep-25	Oct-26	0%
3.1	Physical Modelling - tender hydraulic laboratory			Sec-25	Nov-25	0%
3.2	Physical Modelling - Options Assessment			Sep-25	Nov-25	0%
3.3	Physical Modelling - Report review and finalise			Dec-25	Dec-25	0%
3.4	Complete hydraulic CFD modelling (as required)			Sep-25	Nov-25	0%
3.5	Develop Detailed Designs & Costings (50% stage)			Oct-25	Feb-26	0%
3.6	Review Detailed Designs & Costings (50% stage)			Mar-26	Mar-26	0%
3.7	Develop MER Plan			Jan-26	Feb-26	0%
3.8	Develop Project Approval Documentation (e.g. REF)			Oct-25	Mar-26	0%
3.9	Submit Project Approval Documentation			Mar-26	Mar-26	0%
3.10	Develop Draft Operational & Maintenance Plan			Apr-26	May-26	0%
3.11	Develop asset owner agreements			Apr-26	May-26	0%
3.12	Develop Detailed Designs & Costings (90% stage)			Ap-26	Jun-26	0%
3.13	Review Detailed Designs & Costings (90% stage)			Jul-26	Jul-26	0%
3.14	Review cost estimates via Quantity Surveyor			Jul-26	Jul-26	0%
3.15	Finalise Detailed Designs & Costings			Aug-26	Sep-26	0%
3.16	Finalise Operational & Maintenance Plan			Aug-26	Sep-26	0%
3.17	DPI Fisheries fishway "suitability" signoff			Oct-26	Oct-26	0%
3.18	Finalise asset owner agreements			Oct-26	Oct-26	0%
3.19	Finalise Project Approval			Oct-26	Oct-26	0%
3.20	Prepare Progress Report			Oct-26	Oct-26	0%
4	**CONSTRUCTION**			Nov-26	Oct-27	0%
4.1	Develop procurement documentation			Nov-26	Nov-26	0%
4.2	Tender project			Dec-26	Dec-26	0%
4.3	Award & sign contract w/ preferred contractor			Jan-27	Jan-27	0%
4.4	Finalise Project Approval documentation (e.g. CEMP)			Jan-27	Feb-27	0%
4.5	Construct causeway upgrade			Mar-27	Aug-27	0%
4.6	Safety Audits			Mar-27	Aug-27	0%
4.7	Site survey (as required)			Mar-27	Aug-27	0%
4.8	Defects inspections & notification			Jul-27	Aug-27	0%
4.9	Fishway commissioning			Sep-27	Sep-27	0%
4.10	Initiate post-works monitoring			Sep-27	Sep-27	0%
4.11	Finalise contract with variation claims			Sep-27	Oct-27	0%
4.12	Stakeholder Engagement finalised			Oct-27	Oct-27	0%
4.13	Communications campaign finalised			Oct-27	Oct-27	0%
4.14	Prepare Final Report			Oct-27	Oct-27	0%
4.15	Commissioning / Handover			Sep-27	Oct-27	0%
5	**PM & CONTRACT ADMIN**			Jul-24	Oct-27	0%
5.1	General Contract Administration					0%
5.2	Prepare monthly PCG report					0%
5.3	Organise, chair & minute PCG meetings					0%
5.4	Organise, chair & minute GC21 meetings					0%
5.5	Review the Contractor's WHS, EM, Aboriginal plans					0%
5.6	Review Contractor's insurances, long service levy etc					0%
5.7	Organise, chair & minute monthly contract meetings					0%
5.8	Site inspections (fortnightly)					0%
5.9	Asses variation claims and EOT claims					0%
5.10	Review of conformance documentation etc.					0%
5.11	Monitor Contractor's WHS management on site					0%
5.12	Carry out / organise consultants defects inspections					0%
5.13	Review of Contractor's operational maintenance documents					0%
5.14	Organize handover activities, training of users					0%
5.15	Prepare progress & final reports					0%



STATUS
Not Commenced
In Progress
Complete
On Hold

New Dungowan Dam and Pipeline Project Fishway Offsets

PROJECT TITLE: Jewry Street Causeway Upgrade

START DATE: Jul-24

PROJECT MANAGER: Water Infrastructure NSW

END DATE: Oct-27

PROJECT DURATION (DAYS): 1188

TASK NO.	TASK NAME	STATUS	RESPONSIBLE	START DATE	END DATE	PROGRESS
1	**PROJECT DEVELOPMENT**			Jul-24	Nov-24	0%
1.1	Engage Project Manager			Jul-24	Jul-24	0%
1.2	Prepare Project Management Plan			Aug-24	Sep-24	0%
1.3	Prepare Risk and Project Registers			Aug-24	Sep-24	0%
1.4	Prepare Stakeholder Communications Plan			Aug-24	Sep-24	0%
1.5	Prepare Budget and Resourcing Plan			Aug-24	Sep-24	0%
1.6	Preparation of Principal Design Consultant (PDC) brief & agreement			Sep-24	Sep-24	0%
1.7	Tender for PDC			Oct-24	Oct-24	0%
1.8	Engage PDC			Nov-24	Nov-24	0%
1.90	Prepare Progress Report			Nov-24	Nov-24	0%
2	**CONCEPT DESIGN**			Dec-24	Aug-25	0%
2.1	Water level sensor deployment			Dec-24	Jun-25	
2.2	Collation of site information and identification of knowledge gaps			Dec-24	Feb-25	0%
2.3	Inception meeting with key stakeholders, site visit			Feb-25	Feb-25	0%
2.4	Hydrologic assessment & modelling (as required)			Dec-24	Feb-25	0%
2.5	Development of design criteria - ecological, hydrologic, structural			Jan-25	Feb-25	0%
2.6	Development of Feasibility Options			Feb-25	Mar-25	0%
2.7	Complete asset condition assessment			Mar-25	Mar-25	0%
2.8	Review of Feasibility Options and selection of Concept Design Option(s)			Apr-25	Apr-25	0%
2.9	Complete site survey (mAHD)			Feb-25	Apr-25	0%
2.10	Complete geotechnical assessments			Feb-25	Apr-25	0%
2.11	Complete flora / fauna assessments			Feb-25	Apr-25	0%
2.12	Complete cultural heritage assessment			Feb-25	Apr-25	0%
2.13	Obtain Aboriginal Heritage Impact Permit			Mar-25	Jun-25	0%
2.14	Finalise hydrologic assessment with water level sensor data			Jul-25	Jul-25	0%
2.14	Development of Concept Designs including cost estimates			Mar-25	Jul-25	0%
2.16	Review of Concept Designs			Aug-25	Aug-25	0%
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2.18	Prepare Progress Report			Aug-25	Aug-25	0%
3	**DETAILED DESIGN**			Sep-25	Oct-26	0%
3.1	Physical Modelling - tender hydraulic laboratory			Sec-25	Nov-25	0%
3.2	Physical Modelling - Options Assessment			Sep-25	Nov-25	0%
3.3	Physical Modelling - Report review and finalise			Dec-25	Dec-25	0%
3.4	Complete hydraulic CFD modelling (as required)			Sep-25	Nov-25	0%
3.5	Develop Detailed Designs & Costings (50% stage)			Oct-25	Feb-26	0%
3.6	Review Detailed Designs & Costings (50% stage)			Mar-26	Mar-26	0%
3.7	Develop MER Plan			Jan-26	Feb-26	0%
3.8	Develop Project Approval Documentation (e.g. REF)			Oct-25	Mar-26	0%
3.9	Submit Project Approval Documentation			Mar-26	Mar-26	0%
3.10	Develop Draft Operational & Maintenance Plan			Apr-26	May-26	0%
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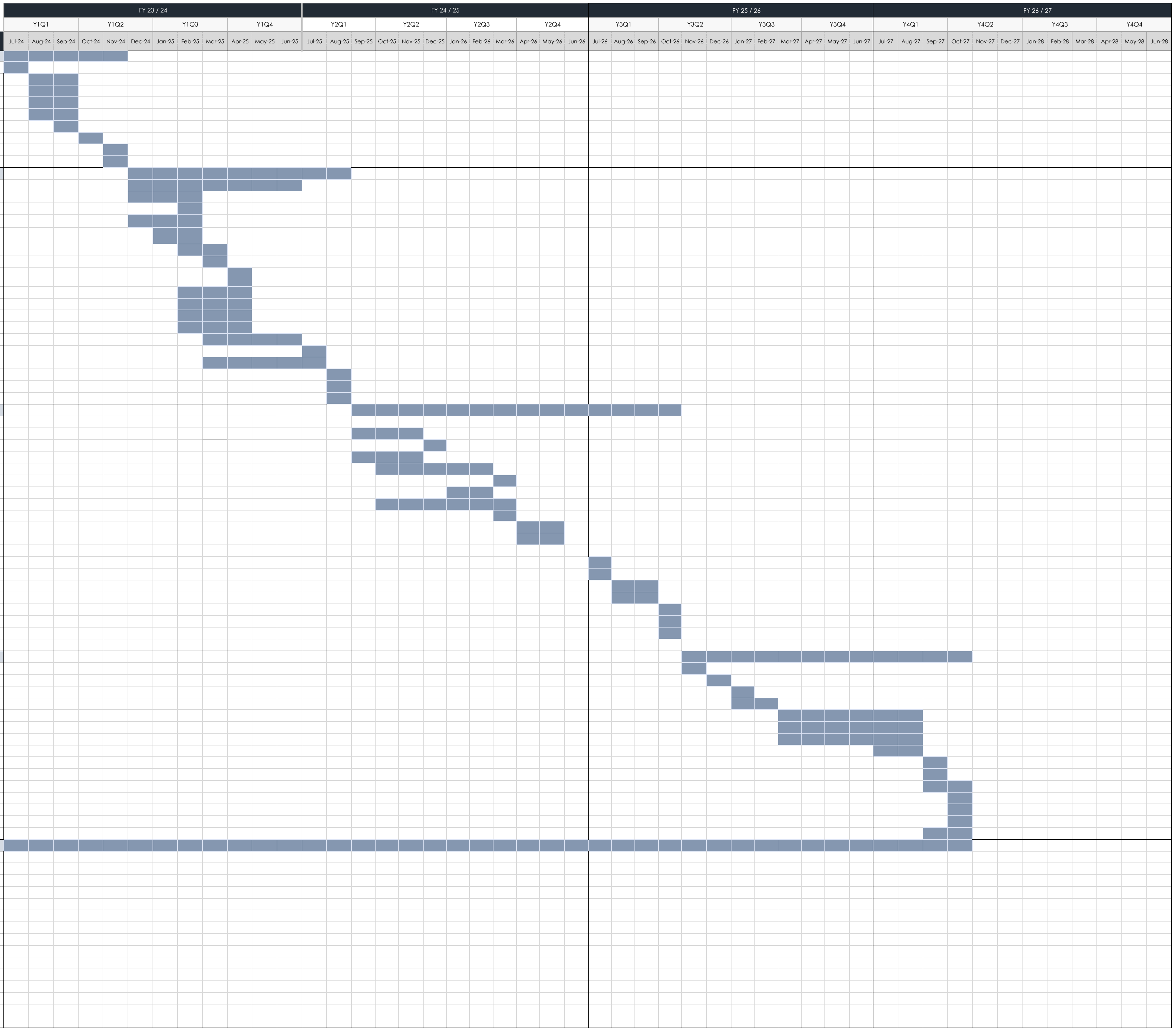
3.16	Finalise Operational & Maintenance Plan			Aug-26	Sep-26	0%
3.17	DPI Fisheries fishway "suitability" signoff			Oct-26	Oct-26	0%
3.18	Finalise asset owner agreements			Oct-26	Oct-26	0%
3.19	Finalise Project Approval			Oct-26	Oct-26	0%
3.20	Prepare Progress Report			Oct-26	Oct-26	0%
4	**CONSTRUCTION**			Nov-26	Oct-27	0%
4.1	Develop procurement documentation			Nov-26	Nov-26	0%
4.2	Tender project			Dec-26	Dec-26	0%
4.3	Award & sign contract w/ preferred contractor			Jan-27	Jan-27	0%
4.4	Finalise Project Approval documentation (e.g. CEMP)			Jan-27	Feb-27	0%
4.5	Construct causeway upgrade			Mar-27	Aug-27	0%
4.6	Safety Audits			Mar-27	Aug-27	0%
4.7	Site survey (as required)			Mar-27	Aug-27	0%
4.8	Defects inspections & notification			Jul-27	Aug-27	0%
4.9	Fishway commissioning			Sep-27	Sep-27	0%
4.10	Initiate post-works monitoring			Sep-27	Sep-27	0%
4.11	Finalise contract with variation claims			Sep-27	Oct-27	0%
4.12	Stakeholder Engagement finalised			Oct-27	Oct-27	0%
4.13	Communications campaign finalised			Oct-27	Oct-27	0%
4.14	Prepare Final Report			Oct-27	Oct-27	0%
4.15	Commissioning / Handover			Sep-27	Oct-27	0%
5	**PM & CONTRACT ADMIN**			Jul-24	Oct-27	0%
5.1	General Contract Administration					0%
5.2	Prepare monthly PCG report					0%
5.3	Organise, chair & minute PCG meetings					0%
5.4	Organise, chair & minute GC21 meetings					0%
5.5	Review the Contractor's WHS, EM, Aboriginal plans					0%
5.6	Review Contractor's insurances, long service levy etc					0%
5.7	Organise, chair & minute monthly contract meetings					0%
5.8	Site inspections (fortnightly)					0%
5.9	Asses variation claims and EOT claims					0%
5.10	Review of conformance documentation etc.					0%
5.11	Monitor Contractor's WHS management on site					0%
5.12	Carry out / organise consultants defects inspections					0%
5.13	Review of Contractor's operational maintenance documents					0%
5.14	Organize handover activities, training of users					0%
5.15	Prepare progress & final reports					0%

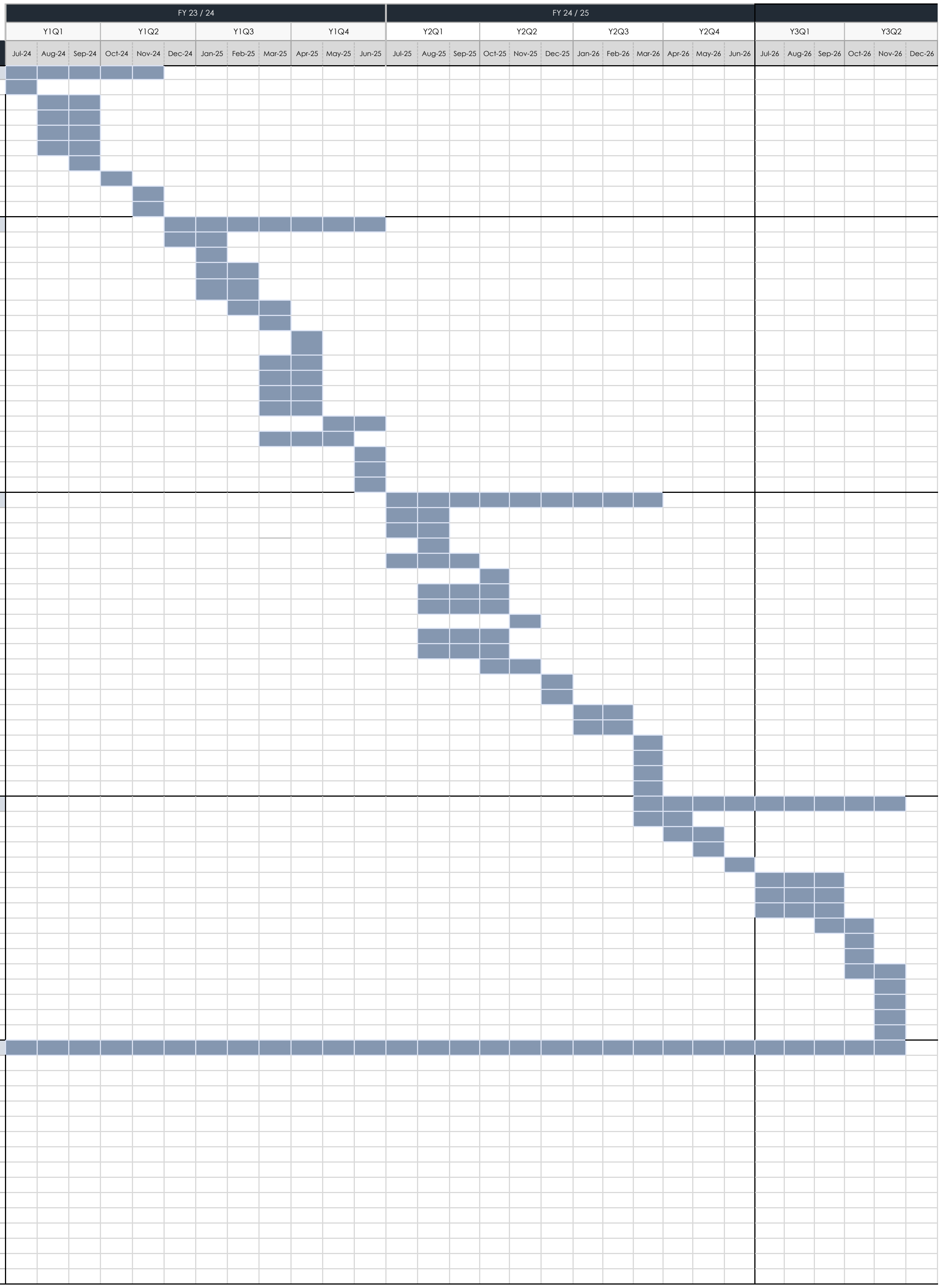


STATUS
Not Commenced
In Progress
Complete
On Hold

New Dungowan Dam and Pipeline Project Fishway Offsets

PROJECT TITLE: Paradise Tamworth Regional Council Water Supply Pipe Relocation
PROJECT MANAGER: Water Infrastructure NSW
START DATE: Jul-24
END DATE: Nov-26
PROJECT DURATION (DAYS): 854

TASK NO.	TASK NAME	STATUS	RESPONSIBLE	START DATE	END DATE	PROGRESS
1	**PROJECT DEVELOPMENT**			Jul-24	Nov-24	0%
1.1	Engage Project Manager			Jul-24	Jul-24	0%
1.2	Prepare Project Management Plan			Aug-24	Sep-24	0%
1.3	Prepare Risk and Project Registers			Aug-24	Sep-24	0%
1.4	Prepare Stakeholder Communications Plan			Aug-24	Sep-24	0%
1.6	Prepare Budget and Resourcing Plan			Aug-24	Sep-24	0%
1.7	Preparation of Principal Design Consultant (PDC) brief & agreement			Sep-24	Sep-24	0%
1.8	Tender for PDC			Oct-24	Oct-24	0%
1.9	Engage PDC			Nov-24	Nov-24	0%
1.10	Prepare Progress Report			Nov-24	Nov-24	0%
2	**CONCEPT DESIGN**			Dec-24	Jun-25	0%
2.1	Collation of site information and identification of knowledge gaps			Dec-24	Jan-25	0%
2.2	Inception meeting with key stakeholders, site visit			Jan-25	Jan-25	0%
2.3	Hydrologic assessment & modelling (as required)			Jan-25	Feb-25	0%
2.4	Development of design criteria - ecological, hydrologic, structural			Jan-25	Feb-25	0%
2.5	Development of Feasibility Options			Feb-25	Mar-25	0%
2.6	Complete asset condition assessment			Mar-25	Mar-25	0%
2.7	Review of Feasibility Options and selection of Concept Design Option(s)			Apr-25	Apr-25	0%
2.8	Complete site survey (mAHD)			Mar-25	Apr-25	0%
2.9	Complete geotechnical assessments			Mar-25	Apr-25	0%
2.10	Complete flora / fauna assessments			Mar-25	Apr-25	0%
2.11	Complete cultural heritage assessment			Mar-25	Apr-25	0%
2.12	Obtain Aboriginal Heritage Impact Permit			May-25	Jun-25	0%
2.13	Development of Concept Designs including cost estimates			Mar-25	May-25	0%
2.14	Review of Concept Designs			Jun-25	Jun-25	0%
2.15	Review cost estimates via Quantity Surveyor			Jun-25	Jun-25	0%
2.16	Prepare Progress Report			Jun-25	Jun-25	0%
3	**DETAILED DESIGN**			Jul-25	Mar-26	0%
3.1	Physical Modelling - tender hydraulic laboratory (if required)			Jul-25	Aug-25	0%
3.2	Physical Modelling - Options Assessment (if required)			Jul-25	Aug-25	0%
3.3	Physical Modelling - Report review and finalise (if required)			Aug-25	Aug-25	0%
3.4	Develop Detailed Designs & Costings (50% stage)			Jul-25	Sep-25	0%
3.6	Review Detailed Designs & Costings (50% stage)			Oct-25	Oct-25	0%
3.7	Develop MER Plan			Aug-25	Oct-25	0%
3.8	Develop Project Approval Documentation (e.g. REF)			Aug-25	Oct-25	0%
3.9	Submit Project Approval Documentation			Nov-25	Nov-25	0%
3.10	Develop Draft Operational & Maintenance Plan			Aug-25	Oct-25	0%
3.11	Develop asset owner agreements (if required)			Aug-25	Oct-25	0%
3.12	Develop Detailed Designs & Costings (90% stage)			Oct-25	Nov-25	0%
3.13	Review Detailed Designs & Costings (90% stage)			Dec-25	Dec-25	0%
3.14	Review cost estimates via Quantity Surveyor			Dec-25	Dec-25	0%
3.15	Finalise Detailed Designs & Costings			Jan-26	Feb-26	0%
3.16	Finalise Operational & Maintenance Plan (if required)			Jan-26	Feb-26	0%
3.17	DPI Fisheries fishway "suitability" signoff			Mar-26	Mar-26	0%
3.18	Finalise asset owner agreements (if required)			Mar-26	Mar-26	0%
3.19	Finalise Project Approval			Mar-26	Mar-26	0%
3.20	Prepare Progress Report			Mar-26	Mar-26	0%
4	**CONSTRUCTION**			Mar-26	Nov-26	0%
4.1	Develop procurement documentation			Mar-26	Apr-26	0%
4.2	Tender project			Apr-26	May-26	0%
4.3	Award & sign contract w/ preferred contractor			May-26	May-26	0%
4.4	Finalise Project Approval documentation (e.g. CEMP)			Jun-26	Jun-26	0%
4.5	Construct water supply pipe relocation			Jul-26	Sep-26	0%
4.6	Safety Audits			Jul-26	Sep-26	0%
4.7	Site survey (as required)			Jul-26	Sep-26	0%
4.8	Defects inspections & notification			Sep-26	Oct-26	0%
4.9	Commissioning			Oct-26	Oct-26	0%
4.10	Initiate post-works monitoring			Oct-26	Oct-26	0%
4.11	Finalise contract with variation claims			Oct-26	Nov-26	0%
4.12	Stakeholder Engagement finalised			Nov-26	Nov-26	0%
4.13	Communications campaign finalised			Nov-26	Nov-26	0%
4.14	Prepare Final Report			Nov-26	Nov-26	0%
4.15	Commissioning / Handover			Nov-26	Nov-26	0%
5	**PM & CONTRACT ADMIN**			Jul-24	Nov-26	0%
5.1	General Contract Administration					0%
5.2	Prepare monthly PCG report					0%
5.3	Organise, chair & minute PCG meetings					0%
5.4	Organise, chair & minute GC21 meetings					0%
5.5	Review the Contractor's WHS, EM, Aboriginal plans					0%
5.6	Review Contractor's insurances, long service levy etc					0%
5.7	Organise, chair & minute monthly contract meetings					0%
5.8	Site inspections (fortnightly)					0%
5.9	Asses variation claims and EOT claims					0%
5.10	Review of conformance documentation etc.					0%
5.11	Monitor Contractor's WHS management on site					0%
5.12	Carry out / organise consultants defects inspections					0%
5.13	Review of Contractor's operational maintenance documents					0%
5.14	Organize handover activities, training of users					0%
5.15	Prepare progress & final reports					0%



STATUS
Not Commenced
In Progress
Complete
On Hold

New Dungowan Dam and Pipeline Project Fishway Offsets

PROJECT TITLE: Calala Water Gauging Station Upgrade

PROJECT MANAGER: Water Infrastructure NSW

START DATE: Jul-24

END DATE: Nov-26

PROJECT DURATION (DAYS): 854

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1.6	Prepare Budget and Resourcing Plan			Aug-24	Sep-24	0%
1.7	Preparation of Principal Design Consultant (PDC) brief & agreement			Sep-24	Sep-24	0%
1.8	Tender for PDC			Oct-24	Oct-24	0%
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2.5	Development of Feasibility Options			Feb-25	Mar-25	0%
2.6	Complete asset condition assessment			Mar-25	Mar-25	0%
2.7	Review of Feasibility Options and selection of Concept Design Option(s)			Apr-25	Apr-25	0%
2.8	Complete site survey (mAHD)			Mar-25	Apr-25	0%
2.9	Complete geotechnical assessments			Mar-25	Apr-25	0%
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2.12	Obtain Aboriginal Heritage Impact Permit			May-25	Jun-25	0%
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4.2	Tender project			Apr-26	May-26	0%
4.3	Award & sign contract w/ preferred contractor			May-26	May-26	0%
4.4	Finalise Project Approval documentation (e.g. CEMP)			Jun-26	Jun-26	0%
4.5	Construct water gauging station upgrade			Jul-26	Sep-26	0%
4.6	Safety Audits			Jul-26	Sep-26	0%
4.7	Site survey (as required)			Jul-26	Sep-26	0%
4.8	Defects inspections & notification			Sep-26	Oct-26	0%
4.9	Commissioning			Oct-26	Oct-26	0%
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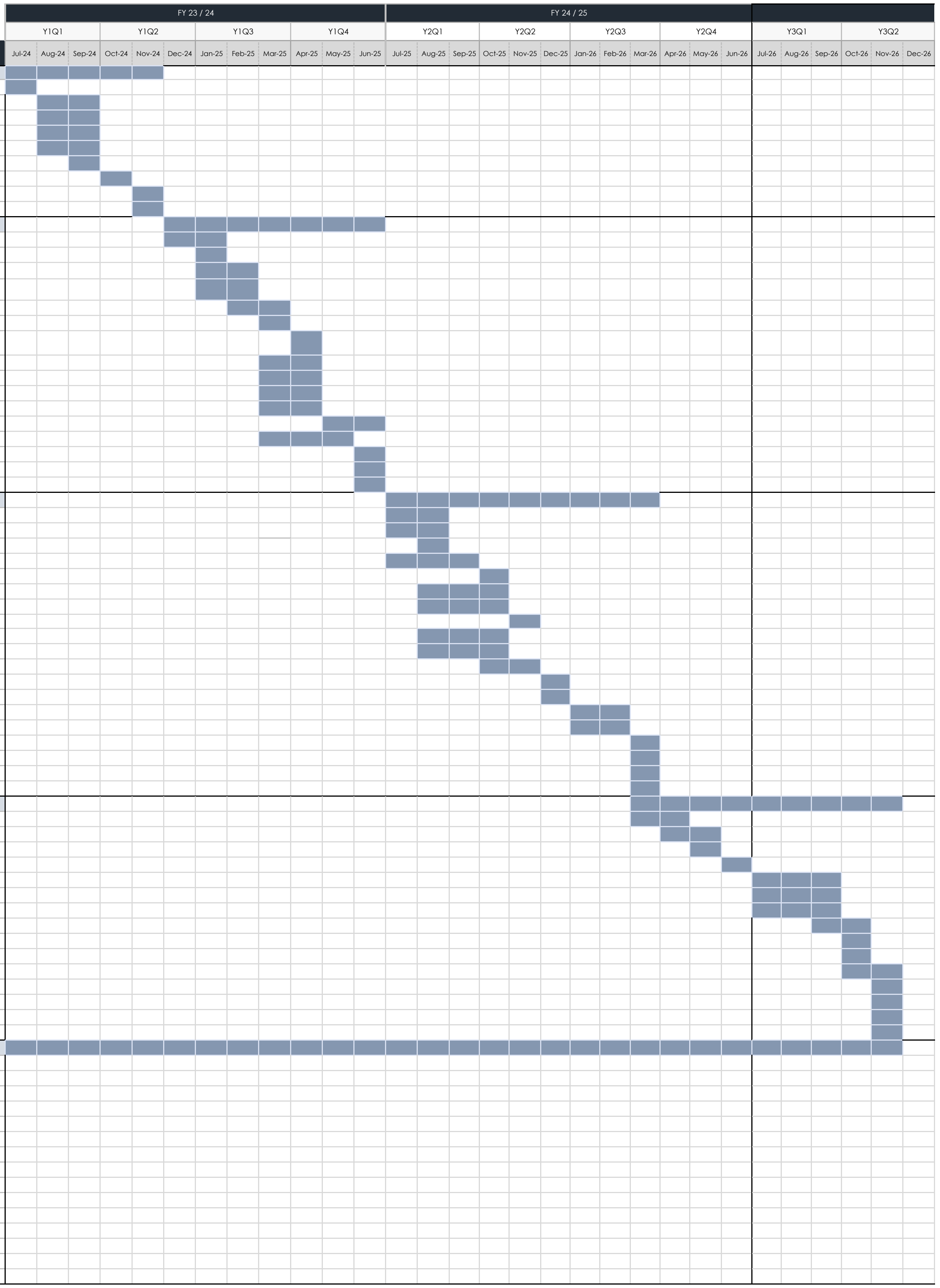

STATUS
Not Commenced
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Australia

SYDNEY
Ground floor 20 Chandos Street
St Leonards NSW 2065
T 02 9493 9500

NEWCASTLE
Level 3 175 Scott Street
Newcastle NSW 2300
T 02 4907 4800

BRISBANE
Level 1 87 Wickham Terrace
Spring Hill QLD 4000
T 07 3648 1200

CANBERRA
Level 2 Suite 2.04
15 London Circuit
Canberra City ACT 2601

ADELAIDE
Level 4 74 Pirie Street
Adelaide SA 5000
T 08 8232 2253

MELBOURNE
Suite 8.03 Level 8 454 Collins Street
Melbourne VIC 3000
T 03 9993 1900

PERTH
Suite 9.02 Level 9 109 St Georges Terrace
Perth WA 6000

Canada

TORONTO
2345 Younge Street Suite 300
Toronto ON M4P 2E5

VANCOUVER
60 W 6th Ave Suite 200
Vancouver BC V5Y 1K1

linkedin.com/company/emm-consulting-pty-limited

emmconsulting.com.au