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Lake Moodemere Aquatic Surveys

- Draft Report
- June 2022

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Contents

Abbreviations

The following abbreviations have been used:

AHD	Australian Height Datum
CL	carapace length
DAWE	Department of Agriculture, Water and Environment
DELWP	Department of Environment, Land, Water and Planning
DO	Dissolved Oxygen
eDNA	Environmental DNA
EMP	Environmental Management Plan
EPBC	Environment Protection and Biodiversity Conservation
FMP	Fauna Management PLan
GPS	Global positioning system
MNES	Matter of National Environmental Significance
mg/l	Milligrams per litre
NFA	Native Fish Australia
ntu	Nephelometric Turbidity Units
PMST	Protected Matters Search Tool
RAMSAR	Convention on Wetlands of International Importance Especially as Waterfowl Habitat
RL	Relative level
SECMP	Sediment and erosion control management plan
SPC	Specific conductivity
VBA	Victorian Biodiversity Atlas
VFA	Victorian Fisheries Authority
µs/cm	Microsiemens/centimeter
^{o}C	Degrees Celsius

1. Introduction

Austral Research and Consulting were engaged by SMEC to assist with the Aquatic surveys to identify the species present in Lake Moodemere and Sunday Creek, east of Rutherglen, Victoria. The purpose of the surveys was to identify the aquatic values (species) to inform on potential impacts to these species as a result of the proposed Sunday Creek Reconfiguration Project infrastructure works.

The proposed infrastructure will include the construction of a new regulator between Sunday Creek and Lake Moodemere and a pipeline from the pumping station to directly deliver water to Sunday Creek. The proposed infrastructure will allow for the hydrology of Lake Moodemere and Sunday Creek to be managed independently.

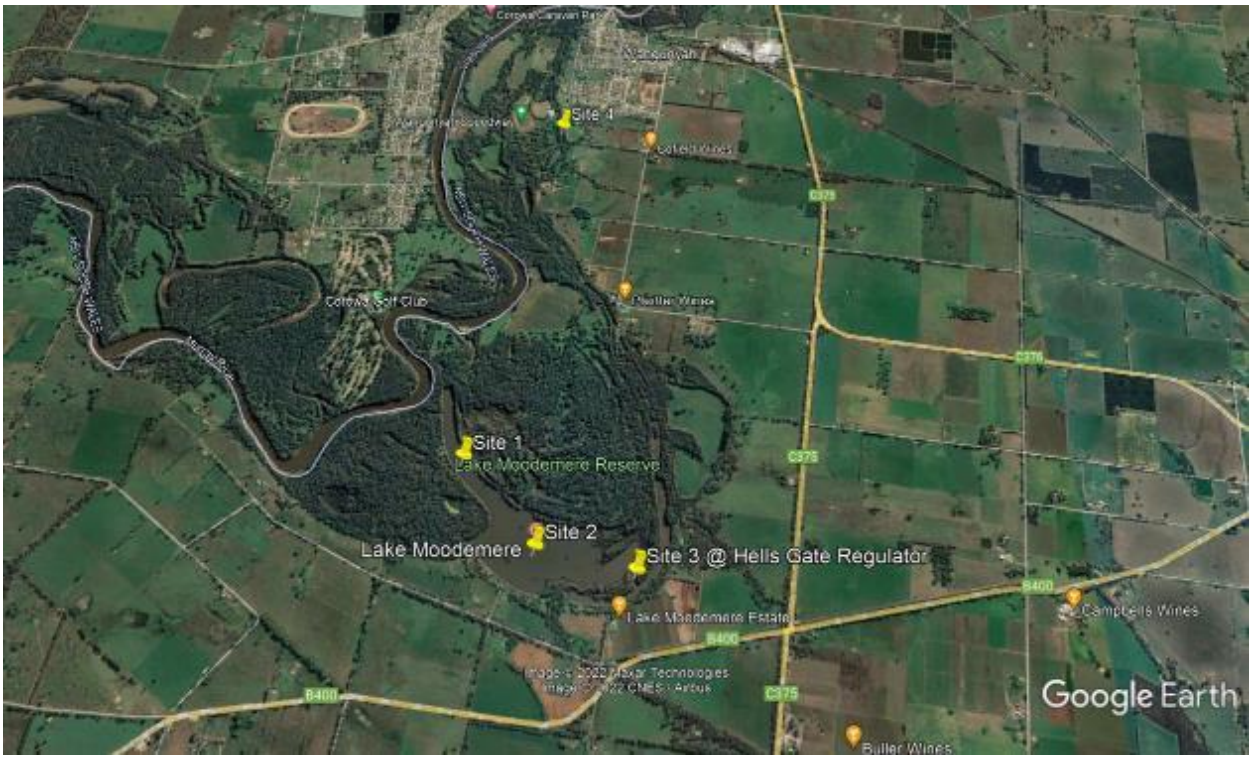
This report details the methods, brief site descriptions and results for the desktop analysis and field surveys. Some discussion and commentary on potential impacts of the proposed works are also included.

2. Methods

Field surveys were completed between the 7th and 11th January 2022, outlined below are the selected survey sites and methods used to complete the field surveys.

2.1. Site Selection and Survey Effort

Lake Moodemere is located adjacent to the Murray River in Victoria and the hydrology of the lake is managed via a regulator located on the western edge of the lake. Four sites were surveyed across the site including two sites within Lake Moodemere and two sites along Sunday Creek (Figure 1). The GPS co-ordinates for the survey sites and the survey effort employed at each site is outlined below in Table 1. The second site on Sunday Creek was intended to be located closer to Lake Moodemere however, access was denied to the site in the vicinity of Distillery Road by the landholder and the site was moved further north toward Wahgunyah.



- **Figure 1: Lake Moodemere and Sunday Creek survey sites (GoogleEarth). Yellow pins are approximate location and path of electrofishing efforts.**

Table 1: Location and survey effort for the sites on Lake Moodemere and Sunday Creek.

Site	Zone	Easting	Northing	Bait traps	Large Mesh Fyke Nets	Small Mesh Fyke Nets	Electrofishing	Cathedral Nets
Lake Moodemere – Ski zone	55	0444400	6010377	10	4	8	1080	4
Lake Moodemere – main lake	55	0444907	6009759	10	4	8	1080	4
Sunday Creek – Hells Gate regulator	55	0445782	6009389	10	4	8	1080	4
Sunday Creek – downstream reach	55	445049	6013512	10	4	8	1200	0

2.2. Desktop Survey

A desktop analysis of the Victorian Biodiversity Atlas (VBA), Protected Matters Search Tool (PMST) and the Victorian Fisheries Authority database (VFA) and other relevant literature was undertaken to determine which aquatic species have historically utilised habitat within, and surrounding the study area, and those environmentally sensitive areas which may be impacted by the proposed works.

A review of the available hydrology data (guage data) and water quality data is also included to provide some context regarding the historic hydrology of the site.

2.3. Fish Survey Methods

A range of survey methods were used to survey Lake Moodemere and Sunday Creek and the Methods are described in sections 2.3.1 - 2.7.

2.3.1. Boat electrofishing

Electrofishing surveys were conducted at three locations in Lake Moodemere and Sunday Creek (Figure 1). Each boat electrofishing survey consisted of a total of 1080 seconds (12 x 90 second shots) of timed electrofishing. The sampling procedure involved electrofishing all navigable areas and suitable habitat such as around snags, stands of emergent vegetation, submerged vegetation and deeper water.

One operator controlled the boat while one operator situated at the front of the boat was used to capture fish. Electrofishing was carried out across each of the designated areas during which immobilised fish were netted from the lake and transferred to a holding tank to recover until the end of each shot.

Fish observed as affected by the electric field and positively identified, but not captured, were recorded and have been included in any analyses where appropriate.

The 4.3m electrofishing vessel “MSV11735” was used for the survey. The vessel was equipped with a Grassl electrofisher unit, two boom arms with 16-dropper anode arrays and hull cathode. The electrofisher unit was configured with the following settings: Voltage setting 2, Impulse Setting 5, Low Frequency 15, Voltage 800 and Amps 3.

2.3.2. Backpack electrofishing

A range of fish species can be sampled using backpack electro fishers in wadable water. Backpack electrofishing was used to target likely fish habitat such as snags, undercut banks and instream vegetation and trailing bank vegetation. A Smith-Root LR24 backpack electrofisher was used with the following settings, Voltage 400, Frequency 30 Hz and Duty cycle 15%.

2.3.3. Fyke netting

Eight single wing fine mesh (2-4mm) and four large mesh fyke nets (15-20mm) were set at each site. The fyke nets were set to capture small and large-bodied species such as Golden perch and Murray cod (*Maccullochella peelii*), during the dusk through to dawn period. All nets were set with an air space and six-inch float placed in the cod end of the fyke net to protect any air breathing fauna that may be captured. Nets were set close to the shoreline and around emergent vegetation to target small bodied species and other species that might not be picked up by the electrofishing method.

2.3.4. Bait traps

Bait traps were set at each site overnight. The bait traps consist of a 2 mm mesh and are approximately 250 mm x 250 mm x 450 mm. This size rating complies with restrictions set by DELWP/Fisheries Victoria (i.e. that a single bait trap must not be larger than 500 mm x 350 mm x 250 mm with an entrance not larger than 65 mm and mesh between 10 mm and 40 mm). Bait traps have a small aperture and are essentially a passive trap. The traps were set overnight and retrieved the next morning.

2.4. Turtle Trapping – Cathedral nets

Four cathedral nets were set at each site (where water depth permitted). The nets were set with a weight in the base to limit the potential for the nets to move in the event of high winds. Nets were baited with offal (ox heart and liver) and a float was placed in the top of the net to maintain an airspace at the water's surface. The cathedral nets were set to capture turtle species during the dusk through to dawn period.

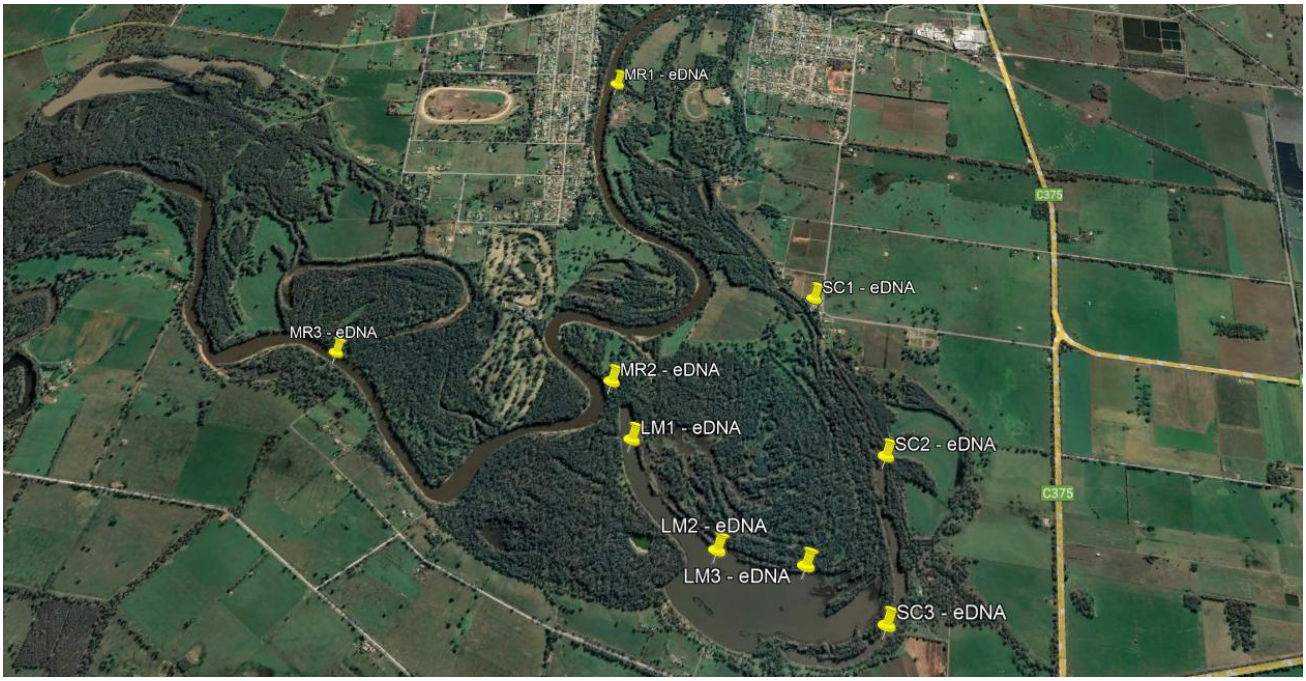
2.5. Platypus eDNA survey methodology

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

During January to April 2022, water samples were collected from 9 sites (Figure 2) by Austral staff following EnviroDNA sampling protocols. At each site, water samples were collected in triplicate by passing up to 500 mL of water (average 488 mL) through a 1.2 µm syringe filter. Filtering on site reduces DNA degradation that may occur during transport of water (Yamanaka *et al.* 2016). Clean sampling protocols were employed to minimise contamination including new sampling equipment at each site, not entering water, and taking care not to transfer soil, water or vegetation between sites. A preservative (approx. 0.5 ml 10xTris-EDTA) was added to the filters after filtering to minimise DNA

degradation. Filters were stored out of sunlight and kept at ambient temperature before being transported to the laboratory for processing. Samples were delivered to EnviroDNA for processing.

DNA was extracted from the filters using a commercially available DNA extraction kit (Qiagen Power Soil Pro) that minimizes compounds that can inhibit PCR reactions. Real-time quantitative Polymerase Chain Reaction (qPCR) assays were used to amplify the target DNA, using species-specific markers targeting a small region of the platypus mitochondrial DNA, previously developed and assessed for specificity and sensitivity by EnviroDNA (e.g. Lugg et al. 2018; Weeks et al. 2015). Positive and negative controls were included for all assays as well as an Internal Positive Control (IPC) to detect inhibition (Goldberg et al. 2016). Assays were performed in triplicate on each sample. At least three positive qPCR assays (out of nine assays undertaken for the site) were required to classify the site as positive for the presence of platypus. To minimise false positives, sites were considered equivocal if only one or two assays returned a positive result, indicating very low levels of target DNA. While trace amounts of DNA may indicate the target species is actually present in low abundance, it may also arise from sample contamination through the sampling or laboratory screening process (minimised through strict protocols and negative controls), facilitated movement of DNA between waterbodies (i.e. water birds, recreational anglers, water transfers, predator scats), or dispersal from further upstream.



- **Figure 2: Location of eDNA sample sites on the Murray River, Lake Moodemere and Sunday Creek (Google Earth).**

2.6. In-situ Water Quality

In-situ water quality was measured at six locations at the time of each electrofishing survey using a YSI ProPlus multiparameter water quality meter to measure dissolved oxygen (DO) (mg/l and % saturation), pH, specific and ambient conductivity (µs/cm), and temperature (ºC). Turbidity (NTU) was measured using a HACH 2100Q turbidity meter.

2.7. Data collection

All fish captured during the surveys were identified to species level and counted. Fish observed but not captured were also recorded. Species captured were measured to the nearest millimetre, with fork length recorded for forked tail species and total length for all other species. All native fish were returned to the water and Carp and goldfish were euthanised in line with approved animal ethics protocols.When more than 30 individuals of a single species were captured, all subsequent captures of that species were only counted, as this number of samples provides sufficient enough data to assess population structure with Length:Frequency analysis.

All turtles captured were identified and plastron and carapace lengths were recorded.

3. Results

Proved below are the site descriptions and results from the field surveys.

3.1. Site descriptions

3.1.1. Lake Moodemere (Site 1 – near ski zone)

Site 1 is located within the vicinity of the ski zone and adjacent to the regulator on Lake Moodemere (Figure 1). The lake has an intact riparian cover of River Redgums (*Eucalyptus camaldulensis*) with an understory of sedges, rushes and terrestrial grasses (Figure 3 and Figure 4). Fringing vegetation included a range of aquatic macrophytes including Giant rush (*Juncus ingens*), water couch (*Paspalum distichum*), Common reed (*Phragmites australis)*, Bull rush (*Typha sp.*) and *Eleocharis sp*. Maximum water depth at the site was 2.5m and recent heavy rains had engaged the fringing wetlands.

- **Figure 3: Photo of site 1.**

- **Figure 4: Photo of site 1.**

3.1.2. Lake Moodemere (Site 2 – Main Lake)

Site 2 was located in the main body of the lake (Figure 1). The main area of Lake Moodemere has the same riparian assemblage as described for site 1 (Figure 5 and Figure 6). The lake is 2 -2.5m deep with some shallow macrophyte dominated islands within the lake. There are extensive macrophyte beds around the perimeter of the lake. There are some Willows (*Salix sp.*) present in and around the lake.

Figure 5: Photos of site 2.

Figure 6: Photos of site 2.

3.1.3. Sunday Creek @ Hells Gate Regulator (Site 3)

Site 3 is located on Sunday Creek at the proposed site of the Hells Gate regulator (Figure 7 and Figure 8). Sunday Creek is approximately 50m wide at this site with an intact riparian zone dominated by mature River Redgums (*Eucalyptus camaldulensis*) and there was a limited shrubby understory. Habitat at this site is very different to site 1 and site 2 with deeper water (~4.5m) and a large amount of woody habitat present. This site more closely represents the old river channel than site 1 and site 2.

Figure 7: Photos of site 3.

Figure 8: Photos of site 3.

3.1.4. Sunday Creek (Site 4)

Site 4 is located near the Wahgunyah Football ground. The site is located in a peri-urban landscape resulting additional impacts not observed at other sites, including stormwater inputs and an increased prevalence of weedy species in the riparian zone. There is an overstory of mature eucalypt trees with some shrubs and an extensive understory of exotic grass primarily Kikuyu. The overstory provides up to 80% shading to the waterway. Flows at this site are likely to be low given the high organic load and tannin-stained waters present. The creek is ~25m wide and unto 1.5m deep. Land use adjacent to the site is residential and recreational.

- **Figure 9: Photos of site 4.**

- **Figure 10: Photos of site 4.**

3.2. Desktop analysis

3.2.1. Relevant literature

Key reports to the project include the *Environmental values and hydrological requirements for Lake Moodemere* prepared for the North-East Catchment Management Authority as part of the Environmental Watering Plan (Richardson and Stoffels, 2011) which details the ecological values of the area and the hydrological requirements of the aquatic values. The second report of note is the *Sunday Creek Irrigation Reconfiguration, Preliminary Design Report* (Jacobs 2019) which details the design and configuration of the infrastructure for the project along with some of the operations details.

3.2.1.1. Environmental values and hydrological requirements for Lake Moodemere (Richardson and Stoffels, 2011)

Richardson and Stoffels (2011) provides an extensive assessment of the aquatic values of the Lake Moodemere and Sunday Creek. The report included a detailed methodology and findings from field surveys completed across two seasons (Winter and Summer). The surveys used fyke nets to survey fish and turtles and identified a range of aquatic species in Lake Moodemere and Sunday Creek including three turtles (Broad-shelled turtle (*Chelodina expansa)*, Eastern long-necked turtle (*Chelodina longicollis*) and Murray River turtle (*Emydura macquarii*)), Golden perch (*Macquaria ambigua*) and four small-bodied fish species (Australian smelt (*Retropinna semoni*), Flyspecked hardyhead (*Craterocephalus stercusmuscarum*), Flathead gudgeon (*Philypnodon grandiceps*) and Carp gudgeon (*Hypseleotris spp*.)). Five exotic pest species were collected including three large-bodied fishes (Goldfish (*Carassius auratus*), Common carp (*Cyprinus carpio*) and Redfin (*Perca fluviatilis*)) and two small-bodied fishes (Oriental weatherloach (*Misgurnus anguillicaudatus)* and Eastern gambusia (*Gambusia holbrooki*)).

Richardson and Stoffels (2011) concluded that the biodiversity values of the site were high within the regional context and the site was important as it supported a diverse turtle community and a small-bodied fish community similar to other wetlands within the region. Richardson and Stoffels (2011) noted hypoxic blackwater in Sunday Creek following floods prior to their surveys and a comparison of the biodiversity values of Lake Moodemere and Sunday Creek could not be made due to the seasonality of the surveys and turtle movement during winter.

Richardson and Stoffels (2011) found dissolved oxygen levels were lower in Sunday Creek compared to Lake Moodemere and that the hypoxic gradient increased in a northly direction on Sunday Creek away from Lake Moodemere. They also found that more hypoxic tolerant species (Common carp and Goldfish) were present in Sunday Creek compared to Lake Moodemere which supported more active species with higher oxygen requirements (Flyspecked hardyhead and Australian smelt).

Richardson and Stoffels (2011) also discussed the benefits and risks of the project in returning the hydrology of Lake Moodemere to a more natural regime and facilitating the management of water levels in Sunday Creek independently of Lake Moodemere and the risk are summarised below.

Lake Moodemere

Reinstating a more ephemeral water regime in Lake Moodemere may result in increased macrophyte diversity in terms of species and structure (i.e. floating, submerged and emergent) which is currently dominated by emergent macrophytes. Risk of reduced habitat for some species included, Flyspecked hardyhead as a result of reduced breeding habitat within macrophyte beds, Murray River turtle and Broad-shelled turtle which have a preference for permanent waterbodies. There is also a recognised risk that some exotic species may benefit from the changed hydrology leading to further negative impacts on native species.

Sunday Creek

The major risks to Sunday Creek were identified as fragmentation from adjoining habitat (Lake Moodemere) and changes in water quality including thermal and dissolved oxygen concerns. Thermal issues may arise from the release of cold water from Lake Hume and the pumping of water into Sunday Creek. Dissolved oxygen was found to decrease the further away from the inlet regulator within Sunday Creek.

3.2.2. Protected Matters Search Tool (PMST)

A search of the PMST revealed that the study area is in the vicinity of seven Wetlands of International Importance (RAMSAR Wetlands) and that five listed threatened ecological communities; 30 listed threatened species and 11 listed migratory species are predicted to occur in the vicinity of the study area (DAWE 2021a). For the purposes of this report only aquatic species will be considered.

3.2.2.1. RAMSAR Wetlands

RAMSAR Wetlands are those wetlands that are considered representative, rare or unique, or are considered important for conserving biological diversity (DAWE 2021b). These Wetlands are included on the List of Wetlands of International Importance developed under the RAMSAR convention (DAWE 2021b). Australia currently supports 66 RAMSAR wetlands, of which seven are listed as occurring in the vicinity of the study area (Table 2).

All RAMSAR wetlands listed as occurring in the vicinity of the study area occur some distance downstream or north of the study site (Table 2). The RAMSAR wetland listed as occurring nearest to the study area is both Barmah Forest and NSW Central Murray State Forests (Table 2). Both wetlands are listed as occurring 50 – 100 kilometres downstream from the study site. The Coorong, Lakes Alexandrina and Albert Wetland; Banrock Station Wetland Complex; and Riverland wetlands occur furthest away from the study area at 500 - 600 kilometres upstream (Table 2). As all listed RAMSAR wetlands occur some distance upstream from the study area there is a low likelihood that there will be any impact to RAMSAR wetlands as a result of the proposed works.

- **Table 2: RAMSAR wetlands listed as occurring within the vicinity of the study area (DAWE 2021a).**

Ramsar Site No.	Ramsar Site Name	Proximity
25	THE COORONG, AND LAKES ALEXANDRINA AND ALBERT WETLAND	500 - 600km upstream from Ramsar site
64	NSW CENTRAL MURRAY STATE FORESTS	50 - 100km upstream from Ramsar site
63	BANROCK STATION WETLAND COMPLEX	500 - 600km upstream from Ramsar site
14	BARMAH FOREST	50 - 100km upstream from Ramsar site
15	GUNBOWER FOREST	150 - 200km upstream from Ramsar site
29	RIVERLAND	500 - 600km upstream from Ramsar site
16	HATTAH-KULKYNE LAKES	300 - 400km upstream from Ramsar site

3.2.2.2. Threatened Ecological Communities

Five listed Threatened Ecological Community are predicted as 'likely' or 'may' occur in the vicinity of the study area. None of the five listed Threatened Ecological Communities listed on the PMST search are considered 'aquatic' and are therefore not considered further in this report.

3.2.2.3. Threatened Species

Thirty listed threatened species are predicted to occur in, or in the vicinity of the study area (DAWE 2021b). Of these 30 species only four are aquatic and are considered in this report.

A search of the PMST revealed that Flathead galaxias (*Galaxias rostratus*) (Critically endangered under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)) is predicted to be 'likely' to occur within, or in the vicinity of the study area (Table 3). Macquarie perch (*Macquaria australasica*) (Endangered) is predicted as 'may' occur within, or in the vicinity of the study area (Table 3) and both Trout cod (*Maccullochella macquariensis*) (Endangered) and Murray cod (Vulnerable) are known to occur within, or in the vicinity of the study area (Table 3).

- **Table 3: Threatened species predicted or known to occur within, or in the vicinity of the study area (DAWE 2021a).**

Species ID	Common Name	Scientific Name	Threatened Category	Presence
84745	Flathead galaxias	*Galaxias rostratus*	Critically Endangered	Likely
66632	Macquarie perch	*Macquaria australasica*	Endangered	May
26171	Trout cod	*Maccullochella macquariensis*	Endangered	**Known**
66633	Murray cod	*Maccullochella peelii*	Vulnerable	**Known**

3.2.2.4. Migratory Species

A search of the PMST identified 11 migratory species are listed as occurring in, or in the vicinity of the study area. None of the reported species are considered in this report and it understood that all migratory species are to be addressed as part of an over-arching assessment.

3.2.3. Victorian Biodiversity Atlas (VBA)

A search of the VBA revealed 494 records of listed species occurring within 10 kilometres of the study area (DELWP 2022). Of those records seven listed species were considered aquatic and are addressed within the context of this report (Table 4). It is understood that all species that are reported in the VBA search and not listed in Table 4 are to be addressed as part of an over-arching assessment.

- **Table 4: Those threatened aquatic species recorded within 10 kilometres of the study area (DELWP 2022).**

Taxon ID	Common Name	Scientific Name	EPBC Act	FFG Act
4692	Flathead galaxias	*Galaxias rostratus*	Critically Endangered	Vulnerable
4868	Trout cod	*Maccullochella macquariensis*	Endangered	Endangered
4871	Murray cod	*Maccullochella peelii*	Vulnerable	Endangered
1647	Murray Spiny Crayfish	*Euastacus armatus*	-	Threatened
5135	Murray River Turtle	*Emydura macquarii*	-	Critically Endangered
5136	Platypus	*Ornithorhynchus anatinus*	-	Vulnerable
528545	Eel-tailed Catfish	*Tandanus tandanus*	-	Endangered

Table 5 outlines the likelihood of EPBC or FFG listed species occurring in Lake Moodemere and Sunday Creek and outlines if they are considered further as being likely to be impacted by the project. Justification relating to which species were considered to be potentially impacted by the project are provided below.

One record of Eel-tailed Catfish (*Tandanus tandanus)* is reported as occurring within 10 kilometres of the study area on 7 February 2014. There is habitat for Eel-tailed Catfish present within the study area. As such this species is to be considered as part of the assessment. One record of Murray Spiny Crayfish (*Euastacus armatus*) is reported as occurring within 10 kilometres of the study area on 8 July 2010. A second search of the VBA revealed that no records for Murray Spiny Crayfish occur within five kilometres. As such Murray Spiny Crayfish is not considered as part of this assessment. Two records of Flathead galaxias are reported as occurring within 10 kilometres of the study area on 9 November 2010. Both records are from the Ovens catchment situated to the south east and it is considered unlikely that the species will be impacted by the proposed action. As such Flathead

galaxias is not considered as part of this assessment. Seven records of Trout Cod are reported as occurring within 10 kilometres of the study area on 26 May 2010. Trout cod have a preference for flowing water and are unlikely to occur in still waters or oxbow lakes such as occurs within the study area. As such Trout cod is not considered as part of this assessment. Seventy-eight records of Murray Cod are reported as occurring within 10 kilometres of the study area on 8 July 2010. Murray Cod frequently utilise habitat such as that present within the study area and as such will be considered when assessing the impacts of the proposed action. Five records of Murray River Turtle are reported as occurring within 10 kilometres of the study area on 25 February 2009 and one record of Platypus (*Ornithorhynchus anatinus*) is reported as occurring within 10 kilometres of the study area on 1 March 1982. Both Murray River Turtle and Platypus likely utilise the study area proper and as such will be considered when assessing the likely impacts of the proposed action.

- **Table 5: Shows likelihood of occurrence within the study area and consideration of species.**

Common Name	Scientific Name	Likelihood of Occurrence	Considered in Results
Flathead galaxias	*Galaxias rostratus*	Low	No
Trout cod	*Maccullochella macquariensis*	Low	No
Murray cod	*Maccullochella peelii*	High	**Yes**
Murray Spiny Crayfish	*Euastacus armatus*	Low	No
Murray River Turtle	*Emydura macquarii*	High	**Yes**
Platypus	*Ornithorhynchus anatinus*	High	**Yes**
Eel-tailed Catfish	*Tandanus tandanus*	High	**Yes**

3.2.4. Victorian Fisheries Authority database (VFA)

A search of the VFA stocking report revealed that three native fish species have been stocked in Lake Moodemere across the last 10 years (VFA 2022a). A total of 60 000 Golden perch have been stocked in Lake Moodemere between 2017 and 2022 (Table 6). Eel-tailed Catfish (1 997) have been stocked in Lake Moodemere between 2016 and 2017 (Table 6). Murray Cod (1000) were stocked in Lake Moodemere in 2011. Typically stocked fish are not required to be considered as part of an aquatic assessment however the study area is within the known natural range for all three species, and supports habitat for all three species and as such must be considered when addressing potential impacts to listed species and their habitat.

- **Table 6: Fish reported as being stocked within the study area across the last 10 years (VFA 2022a).**

Date Stocked	Common Name	Species Name	Number Stocked
21 January 2022	Golden perch	*Macquaria ambigua*	10 000
28 January 2021	Golden perch	*Macquaria ambigua*	10 000
7 February 2019	Golden perch	*Macquaria ambigua*	10 000
21 February 2018	Golden perch	*Macquaria ambigua*	20 000
7 March 2017	Golden perch	*Macquaria ambigua*	10 000
4 April 2016	Eel-tailed Catfish	*Tandanus tandanus*	37
10 March 2016	Eel-tailed Catfish	*Tandanus tandanus*	560
11 February 2014	Eel-tailed Catfish	*Tandanus tandanus*	1 400
12 May 2011	Murray Cod	*Maccullochella peelii*	1000

3.3. In-situ Water quality

In situ water quality data collected at the time of the survey is presented below in Table 7 - Table 10 for surveys conducted at the four sites. Profile data was collected at 0.5m intervals where water depth permitted. Water quality data is within the range that would support a wide range of aquatic species, with the only notable result being for dissolved oxygen (DO) which was suppressed. Low dissolved oxygen levels were also observed by Richardson and Stoffels (2011).

Water quality was recorded in the morning at sites 1 – 3, and lower DO levels are anticipated in lentic waterbodies such as shallow lakes and wetlands where overnight respiration levels result in the consumption of oxygen resulting in lower DO levels overnight and into the morning before photosynthesis can produce more oxygen within the water body. Site 4 was located at the "end of the system" and is a narrow creek line. As flows do not pass through the creek at this site there is a build-up of leaf litter and detritus and low DO levels are present and not unexpected.

Water quality data was not compared to any guidelines or benchmarks.

Table 7: Water quality profile data collected for survey site 1. Data was collected at 0900hr on the 8th January 2022. Turbidity was only collected from the surface.

Depth below surface (m)	0	0.5	1.0	1.5	2.0	2.5
Parameter						
Temperature (°C)	23.5	23.2	23.1	23.0	23.0	22.8
Dissolved oxygen (mg/l)	2.91	2.92	2.72	2.36	2.37	0.63
Dissolved oxygen (% saturation)	34.1	34.3	32.0	27.6	27.7	7.2
Conductivity (µs/cm)	80.6	80.3	80.2	80.2	80.2	81.7
Specific conductivity (µs/cm)	83.3	83.1	83.2	83.4	83.4	85.4
pH	8.1	7.94	7.85	7.75	7.65	7.49
Turbidity (ntu)	14.0	-	-	-	-	-

Table 8: Water quality profile data collected for survey site 2. Data was collected at 1000hr on the 8th January 2022. Turbidity was only collected from the surface.

Depth below surface (m)	0	0.5	1.0	1.5	2.0
Parameter					
Temperature (°C)	23.2	23.0	22.6	22.7	22.7
Dissolved oxygen (mg/l)	4.0	3.58	3.02	2.88	2.62
Dissolved oxygen (% saturation)	47.0	41.7	35.2	33.5	30.5
Conductivity (µs/cm)	79.7	79.2	78.9	78.9	79.0
Specific conductivity (µs/cm)	82.4	82.4	82.5	82.6	82.7
pH	7.40	7.33	7.30	7.25	7.20
Turbidity (ntu)	18.6	-	-	-	-

Table 9: **Water quality profile data collected for survey site 3. Data was collected at 1030hr on the 8th January 2022. Turbidity was only collected from the surface.**

Depth below surface (m)	0	0.5	1.0	1.5
Parameter				
Temperature (ºC)	23.3	22.8	22.6	22.2
Dissolved oxygen (mg/l)	1.61	1.21	0.67	0.0
Dissolved oxygen (% saturation)	19.1	11.1	8.1	0.0
Conductivity (µs/cm)	82.7	82.4	82.2	83.7
Specific conductivity (µs/cm)	86.1	85.9	86.1	87.8
pH	6.98	6.96	6.92	6.77
Turbidity (ntu)	13.8	-	-	-

Table 10: **Surface water quality data collected at site 4.**

Parameter	Site 4
Date	10/1//22
Time	1130
Dissolved oxygen (mg/l)	0.93
Dissolved oxygen (% saturation)	11.3
Conductivity (µs/cm)	75.2
Specific conductivity (µs/cm)	76.3
pH	7.12
Turbidity (ntu)	10.2
Temperature (ºC)	24.1

3.4. Fish Survey Results

A total of 8485 fish and turtles were sampled across the four survey sites during the fish, crustacea and turtle surveys. Native fish dominated the system based on abundance. Sampled natives consisted of four species: Flyspecked hardyhead, Carp gudgeon, Flathead gudgeon and Australian smelt. A total of five exotic fish species were sampled across the four survey sites. Species consisted of: Goldfish, Redfin perch, Oriental weather loach, Common carp and Mosquito fish. One species of crustacea was sampled during the surveys, Common yabby (*Cherax destructor*). Three species of freshwater turtle were sampled across the survey period: Broad-shelled Turtle (listed under the Flora and Fauna Guarantee Act 1988 (FFG Act)), Eastern long-necked Turtle and Murray River Turtle (Listed as Critically Endangered under the FFG Act) (Table 11).

- **Table 11: Fish survey results for the Lake Moodemere.**

Taxon Scientific Name	Common Name	Site 1	Site 2	Site 3	Site 4	Total
Native Fish species						
Craterocephalus stercusmuscarum	Flyspecked hardyhead	17	97	55	-	169
Hypseleotris spp.	Carp gudgeon	363	331	574	31	1299
Philypnodon grandiceps	Flathead gudgeon	2	3		-	5
Retropinna semoni	Australian smelt	354	4886	338	-	5578
Exotic Fish Species						
Carassius auratus	Goldfish	78	70	18	14	180
Perca fluviatilis	Redfin perch	6	31	2	1	40
Misgurnus anguillicaudatus	Oriental weather loach	-	-	-	2	2
Cyprinus carpio	Common carp	320	283	137	106	846
Gambusia holbrooki	Mosquito fish	62	76	79	6	223
Decapods						
Cherax destructor	Common Yabby	3	9	15	-	27
Turtles						
Chelodina expansa	Broad-shelled turtle	7	4	6	5	22
Chelodina longicollis	Eastern long-necked turtle	2	-	1	9	12
Emydura macquarii	Murray River turtle	23	29	30	-	82
Grand Total		**1237**	**5819**	**1255**	**174**	**8485**

All native fish sampled across the survey period are considered common to Victorian waters. Native species made up 83.1 percent of the catch (fish, turtles and crustacea) sampled across all sites with the dominant species being Australian smelt with 5578 individuals (Sites 1, 2 and 3). Carp Gudgeon were also prevalent being present at all four sites with 1299 individuals sampled. Flyspecked Hardyhead was less common with 169 individuals sampled across three sites and Flathead Gudgeon,

although a common species, was uncommon and only sampled at two sites being represented by five individuals (Table 11).

Exotic fish species were significantly less dominant than native species making up 15.22 percent of all sampled fish, crustacea and turtles. Despite lower numbers, all species of exotic fish except Oriental Weather Loach were present at all four survey sites. Common Carp was the dominant species with 846 individuals sampled across the four sites. Mosquito Fish was also prevalent with 223 individuals sampled across all four sites. Goldfish were less dominant with 180 individuals sampled across all four sites and Oriental Weather Loach was rare with two individuals sampled at site 4 (Table 11).

Relatively few Common yabby were sampled during the surveys. Twenty-seven individuals were sampled across three sites (Table 11).

Turtle were sampled at all four sites however the only turtle species sampled at all four sites was Broad-shelled turtle (twenty two individuals) (Figure 11). Murray River Turtle was the most prevalent with 82 individuals sampled across sites 1, 2 and 3 (Figure 12). Eastern long-necked (Figure 13) Turtle was least prevalent with 12 individuals sampled across sites 1, 3 and 4 (Table 11). All turtles captured during the current survey were large mature individuals with not juveniles of any species detected. Fox raided nests were observed.

The analysis conducted from this survey was not as extensive as Richardson and Stoffels (2011) however the general findings concur regarding the species present in both Lake Moodemere and Sunday Creek.

- **Figure 11: Broad-shelled turtle collected during the current surveys.**

- **Figure 12: Murray River turtle collected during the current surveys.**

- **Figure 13: Eastern long-necked turtle collected during the current surveys.**

3.1. Platypus eDNA results

Results from the eDNA analysis indicate that there are low levels (ie equivocal) of Platypus DNA detected in the Murray River (Table 12) suggesting that Platypus may be present in the low abundances in the Murray River around the sample locations or DNA has been transported downstream from populations located upstream. No Platypus DNA was detected in Lake Moodemere suggesting that Platypus were not utilising the habitat at the time of the survey, this result does not preclude the seasonal utilisation of the habitat present in Lake Moodemere. Results for Sunday Creek indicate that there was a strong positive detection of Platypus DNA at Site 1 located at Pfeiffer Wines (Table 12) where there is a known population of Platypus. No DNA was detected at Site 2 and Site 3 on Sunday Creek.

Results from the eDNA survey indicate that there is a small isolated population of the platypus located present around Pfeiffer Wines and this is supported by the anecdotal evidence that the Platypus population is concentrated around this location. The absence of any positive eDNA results at either site 2 or site 3 on Sunday Creek or in Lake Moodemere suggests that the Platypus population in the area is small and isolated to the upper reaches of Sunday Creek. Anecdotal evidence indicates that the population is a breeding population and dispersal and moment from the upper reach of Sunday Creek to the Murray River would only occur via Lake Moodemere as there is no connectivity with the Murray River in the other direction (east or upriver). It is unlikely that Lake Moodemere is an important feeding habitat for the Platypus population based on the current available data (survey data, eDNA data and anecdotal evidence).

- **Table 12: eDNA results for Sunday Creek, Lake Moodemere and the Murray River.**

Site Code	Waterway	Latitude (UTM)	Longitude (UTM)	No. of Samples	Filter Volume (ml)	Laboratory Results			
						Scoring (out of 9 technical reps)	Conclusion (for SITE)	Total score (for SITE)	ng DNA uL for SITE (averaged)
MR1	Murray River	55H 444064	6013803	3	500	1	Equivocal	1	2.97E+09
MR2	Murray River	55H 444130	6011058	3	500	1	Equivocal	1	3.47E+09
MR3	Murray River	55H 442266	6011253	3	500	1	Equivocal	1	3.09E+09
SC1	Sunday Creek	55H 445509	6011763	3	400	8	Positive	8	5.65E+09
SC2	Sunday Creek	55H 445903	6010540	3	500	0	Negative	0	0.00E+00
SC3	Sunday Creek	55H 445811	6009421	3	500	0	Negative	0	0.00E+00
LM1	Lake Moodemere	55H 444277	6010623	3	500	0	Negative	0	0.00E+00
LM2	Lake Moodemere	55H 444819	6009872	3	500	0	Negative	0	0.00E+00
LM3	Lake Moodemere	55H 445355	6009783	3	500	0	Negative	0	0.00E+00

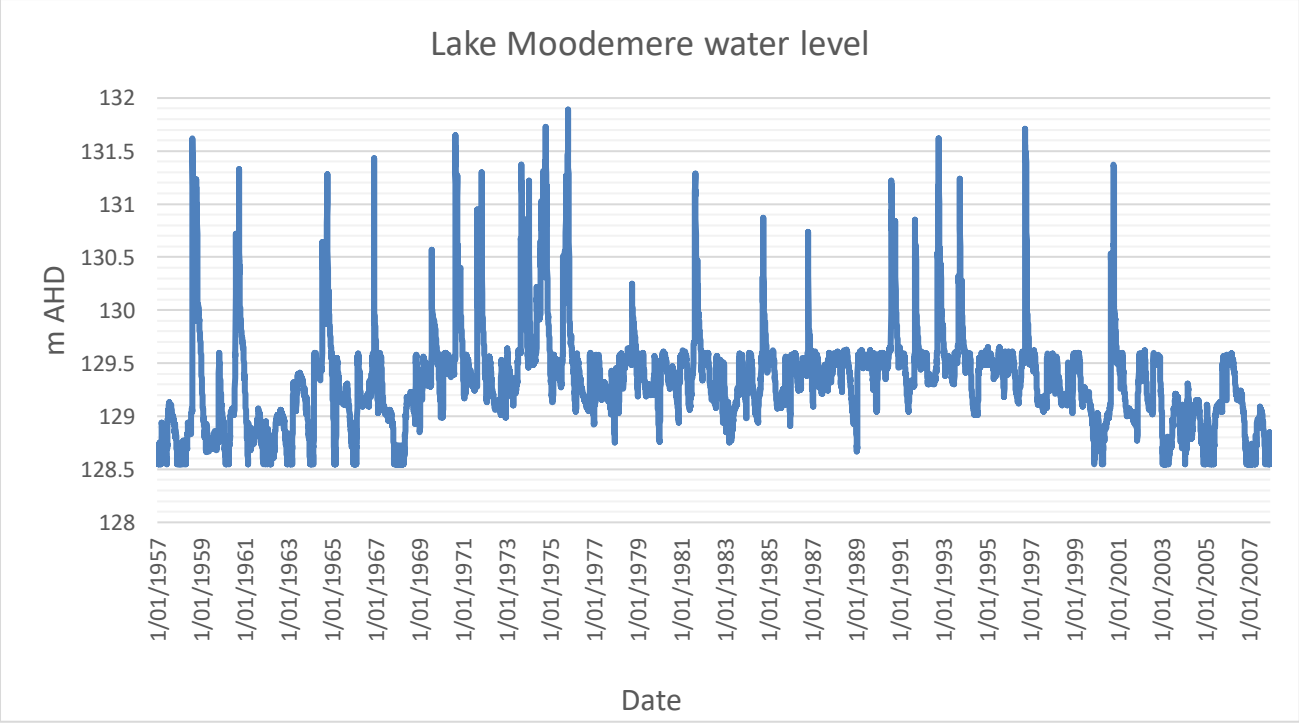
3.2. Historic Hydrology

Detailed bathymetry survey of Lake Moodemere and Sunday Creek completed in 2022 (Advance Survey Design Pty Ltd May 2022) has identified the following key features relevant to the hydrology of the site;

1) In current invert of the Hells gate channel site is 128.6m AHD, and

2) Water levels below 128.5m AHD will result in Sunday Creek connectivity being further reduced at a high point known as “the narrows” located approximately 1.5km upstream (east) of the proposed Hells Gate Regulator.

Water levels within Lake Moodemere and Sunday Creek have fluctuated significantly over time and have been influenced by high flows and flooding from the Murray River and drought periods resulting in low water levels along with irrigation demand. A plot of the data for lake level (SKM 2008) illustrates the fluctuating water level over time between 1957 and 2008 (Figure 14). The data indicates that in the water level in Lake Moodemere has dropped below the Hells gate channel invert of 128.6m AHD on 18 occasions between 1957 and 2008 indicating that Sunday Creek will have experienced periods of hydrologic isolation from Lake Moodemere. No data is available for the water levels in Sunday Creek during these periods of disconnection, but it can be assumed that water levels will have continued to fall.



- **Figure 14: Water Levels in Lake Moodemere from 1957 – 2008. Data from SKM 2008.**

3.2.1. Irrigation Demand

Irrigation demand for customers on Sunday Creek are dependent on seasonal constraints and climate conditions. Irrigation demand is highly variable and over the last four irrigation seasons has ranged from 253 ML – 502 ML (Table 13).

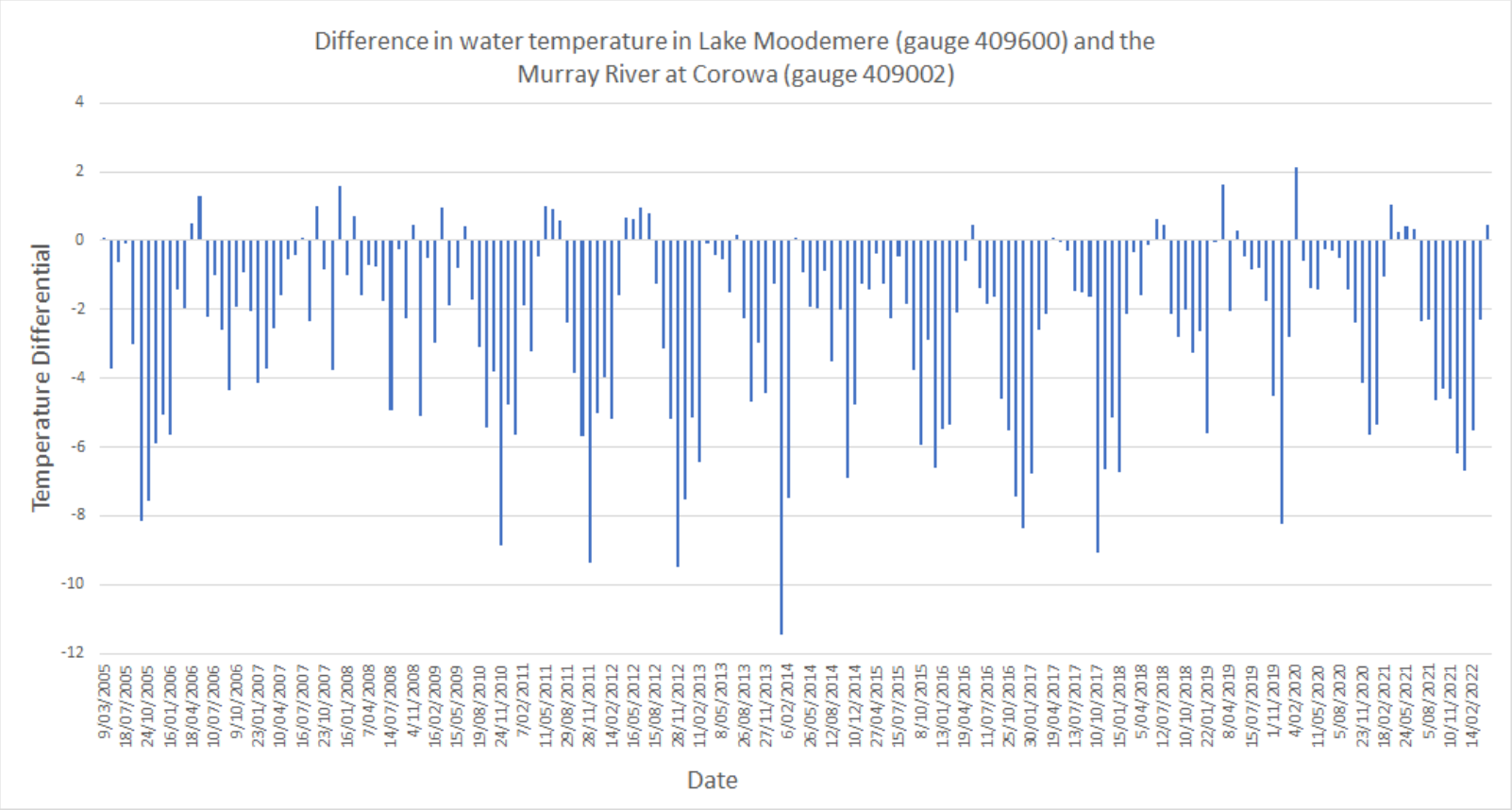
- **Table 13: Sunday Creek irrigation demands over the last four irrigation seasons (Goulburn Murray Water)**

Irrigation Season	Sunday Creek Irrigation Demand (ML)
17/18	410
18/19	489
19/20	502
20/21	253

3.3. Water Quality/Cold Water Pollution (CWP)

CWP is a recognised environmental threat and risk to ecological values in the throughout Australia downstream of water storages (Lugg and Copeland 2014), of which Lake Hume is the seventh largest storage in Australia (Sherman et al 2007). The presence of Lake Hume upstream of Lake Moodemere on the Murray River and the operational constraints of Lake Hume results in CWP impacts downstream to lake Mulwala (Preece 2004). A plot of the temperature differential between the gauge in Lake Moodemere (409600) and the Murray River at Corowa (409002) between 2005 and 2022 indicates that there is potential for CWP impacts to Lake Moodemere (Figure 15). Figure 15 illustrates that the temperature differential can be over 10^0C colder in the Murray River and has a seasonal pattern driven by irrigation demand and releases during spring – summer periods. The

While there is no temperature data available for Sunday Creek, under the current operational guidelines water enters Sunday Creek via Lake Moodemere and the temperature impacts will have been mitigated as water passes through the lake warms and enters Sunday Creek.



- **Figure 15: Surface water temperature differential between Lake Moodemere (gauge 409600) and the Murray River at Corowa (gauge 409002) at selected dates between 2005 and 2022**

4. Species Ecology

4.1. Trout Cod (*Maccullochella macquariensis)*

The Trout Cod is a large, elongated fish, bluish grey in colour or sometimes dark to light brown and is listed as Endangered under the EPBC Act, and the FFG Act. The Trout Cod is known to grow up to 85 cm and 16 kg but mostly grows to between 40 – 50 cm and less than 5 kg (Allen 1989; McDowall 1996).

Trout Cod are known to occupy stream positions characterized by a high abundance of large woody debris in water that is relatively deep and close to riverbanks. Mid-stream snags are also thought to be an important component (NSW Fisheries 2001).

Trout Cod reach sexual maturity at three to five years of age and at a weight of 0.75 – 1.5 kg (Douglas et al. 1994). The diet of the Trout Cod includes macroinvertebrates including yabbies, crayfish, shrimp and insects. Trout Cod may leap from the water to take food items just above the surface. Large Trout Cod will take Macquarie Perch (*Macquaria australasica*) and Goldfish (*Carassius auratus*) (Cadwallader & Backhouse 1983).

Radio tracking surveys in the Murray River showed that Trout Cod demonstrate high site fidelity, with a small home range and no evidence of any large scale or migratory movements such as spawning migration (DAWE 2022).

Threats to Trout Cod are reported as: habitat degradation, cold water pollution, removal of habitat, barriers to movement, fishing, low genetic variation, exotic species, disease, low recruitment levels and lack of community awareness (DAWE 2022).

- A recovery plan is in place and supports the following objectives (DSE 2008):
- Investigate key aspects of biology and ecology.
- Determine the growth rates and viability of populations.
- Identify and map habitat critical to survival.
- Investigate and control threatening processes.
- Manage Murray River population to ensure its continued sustainability natural and reintroduced populations to achieve self-sustainability.
- Manage Seven Creeks (Vic) population to ensure its continued sustainability.
- Manage Ovens River population to ensure its continued sustainability.
- Manage the Murrumbidgee River and Cotter River populations (ACT) to ensure their continued sustainability.
- Breed Trout Cod for reintroduction.
- Undertake reintroductions to establish new populations.
- Encourage community awareness and support.
- Trial a stocked recreational fishery for Trout Cod in Victoria.
- Manage Recovery Plan implementation

4.2. Murray Cod (*Maccullochella peelii*)

The Murray Cod is the largest freshwater fish in Australia and is listed as vulnerable under the EPBC Act and a threatened under the FFG Act. Having been caught and measured at sizes up to 1.8 metres in length and over 100 kilograms in weight (DAWE 2021c). The Murray Cod has a broad head with a rounded snout and a concave profile. The species has a large mouth with the lower jaw approximately equal in length to the top jaw (DAWE 2021c). Colouring is predominantly light to dark green with a mottled patterning and white to cream undersides. Pectoral fins are large and rounded and the dorsal, anal and caudal fins are soft and typically have a distinct white, sometimes red edge. The causal fin is rounded and the lateral line has 65-81 scales (Whitley 1980).

Historically the Murray Cod was distributed throughout the Murray-Darling Basin. The species still occurs in much of this range up to approximately one kilometre above sea level (DAWE 2021c). There have been numerous attempts to translocate cultured and wild-caught Murray Cod and introduced populations exist in all states of Australia (DAWE 2021c).

The Murray Cod utilises a diverse range of habitats from clear rocky streams, such as those found in the upper western slopes of NSW (including the ACT), to slow-flowing, turbid lowland rivers and oxbow lakes (McDowall 1996). Microhabitats preferred by Murray Cod include complex instream structures such as large rocks, snags, undercut banks and overhanging vegetation. It is thought that such structures reduce stream flow and provide Murray Cod with shelter from fast flowing water as well as providing predatory ambush points for feeding (Koehn 2009).

Murray Cod are known to move actively through the water column from sunset to sunrise. During the day they are known to hunt through ambush predation (McDowall 1996; Schultz 2006). Diet is reported to change with age with the typical adult diet consisting of crustaceans such as crayfish, yabbies and shrimp. Murray Cod are known to predate upon other fish species (DAWE 2021c).

4.3. Broad-shelled Turtle (*Chelodina expansa*)

The Broad-shelled Turtle, also known as the Giant Snake-necked Turtle is a freshwater turtle that occurs in eastern and south-eastern Australia (Bower and Hodges 2014) and is listed as endangered under the FFG Act. The Broad-shelled Turtle is considered Australia's largest Snake-necked Turtle. The Broad-shelled Turtle display marked sexual dimorphism with males typically smaller than females and maturing earlier than females (Spencer 2002). Males can be distinguished by an elongate tail that extends beyond the margin of the carapace when mature. Maximum adult female size is a carapace length (CL) of 500 millimetres with an additional neck length of 65-75 percent of the CL (Cann 1998). Females attain a maximum mass of six kilograms and males can grow to four kilograms (Bower 2021). Males reach maturity at 9-11 years and females at 14-15 years (Spencer 2002).

The species occurs broadly through inland rivers and oxbow lakes throughout its range. Little is known of specific habits of the species despite occupying waters heavily exploited and regulated by humans (Bower and Hodges 2014). Originally thought to predominantly utilise riverine habitat, recent studies

have shown that the species is more commonly found in permanent lakes and billabongs, typically those connected to main river channels (Bower and Hodges 2014). The Broad-shelled Turtle is carnivorous in nature and typically feeds on fast moving prey such as fish and crustaceans, but has also been observed to consume carrion (Bower and Hodges 2014). The Broad-shelled Turtle is unique amongst other Australian freshwater turtles in that in response to low temperatures embryos enter diapause, which enable them to survive over winter in nests, resulting in a year long incubation period. The Broad-shelled Turtle has lower population densities than other species in its range which may increase its vulnerability to threats. Persistence of the species relies heavily on habitat quality and longitudinal connectivity of freshwater systems within southeast Australia (Bower and Hodges 2014).

4.4. Murray River Turtle (*Emydura macquarii*)

The Murray River Turtle is an omnivorous species of freshwater turtle located in the Murray-Darling drainage system (Cann 1998; Spencer et al. 1998) and are listed as critically endangered under the FFG Act. The Murray River Turtle's diet is dominated by carrion and terrestrial insects whilst only occasionally predating upon mobile prey (Spencer et al. 1998). The Murray River Turtle is a medium sized turtle growing to a CL of over 300 millimetres (Chessman 1978). Typically the species is confined to permanent waters with mating occurring between March and April with turtles over-wintering in the water (Cann 1998; Chessman 1978).

The Murray River Turtle is sexually dimorphic with females (CL >300 mm) growing larger than males (CL 270 mm). Adult males can be identified by a longer, thicker tail than that found on the female (Chessman 1978).

4.5. Platypus (*Ornithorhynchus anatinus*)

The Platypus is one of only three monotremes and was recently listed as Vulnerable in Victoria under the FFG Act. The Platypus is a semi-aquatic mammal, endemic to freshwater habitats of eastern Australia (Hawke et al. 2021a). Platypus are highly dependent on riverine systems and other waterbodies feeding exclusively on freshwater macroinvertebrates (Hawke et al. 2021), occasionally in backwater areas (Hawke et al. 2021b). Platypus typically live in areas where banks are suitable for burrowing and where the water is shallow enough to allow feeding on the bottom of the waterway (DELWP 2018). Platypus also prefer intact riparian zones (DELWP 2018). The average length (head to tail) of male Platypus is 500 millimetres with females averaging approximately 430 millimetres (DPE 2020). The Platypus is dark brown on its back and typically light brown on the underside. Platypus are typically active at night but are known to display diurnal behaviour (Hawke et al. 2021). Platypus have a polygamous mating system, generally resulting in overlapping home ranges of males and females (Hawke et al. 2021b), with male Platypus known to range further than females. This is likely due to territorial and mate acquisition behaviour (Hawke et al. 2021). Platypus breed between August and September with the female laying 2-3 eggs around September – October (DELWP 2018). 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

4.6. Eel-tailed Catfish (*Tandanus tandanus*)

Eel-tailed Catfish, also known as Freshwater Catfish has an elongated eel-like body with the tail tapering to a point (VFA 2022b) and are listed as endangered under the FFG Act. Colouring is olive green to grey to brown, often with pale yellow mottling on the rear of the body and the ventral surface is typically white (Gomon and Bray 2020). The Eel-tailed Catfish has four pairs of barbels surrounding the mouth and sharp, serrated dorsal- and pectoral-fin spines which are venomous (Gomon and Bray 2020). The Eel-tailed Catfish occurs through much of the Murray-Darling River drainage and in coastal drainages from Northern Queensland to central New South Wales (Allen 1989). Primarily a benthic feeder the Eel-tailed Catfish inhabits lakes and slow moving, turbid streams with banks that support fringing vegetation (NFA 2022). Eel-tailed Catfish feed on freshwater crustaceans such as Common Yabbie and shrimp in addition to molluscs and other organisms inhabiting the benthos (NFA 2022). Reproduction occurs in late spring to mid-summer. Gravel substrate is preferred for breeding. The species typically builds a nest one to two weeks prior to spawning. If the nest is exposed by lowered water levels it is abandoned, and another is built. Typically one parent, although occasionally both will attend the nest, aerating and protecting eggs until hatching (NFA 2022).

5. Potential Project Impacts

Provided below is an assessment and comment regarding the potential impacts of the proposed project on both the EPBC listed species sand the state listed FFG species. The assessment below is based on limited detail around the construction process available at the time of writing and the proposed hydrological operation of Lake Moodemere and Sunday Creek post construction of the new Hells Gate regulator. It has been assumed that the construction process will cause temporary impacts on aquatic ecological values only and that water will be maintained in both Lake Moodemere and Sunday Creek with some changes to the hydrology. The biggest impact will be a change in connectivity between the two water bodies under the proposed regime which is described in detail in Jacobs (2019) and summarised below;

a. Sunday Creek will be used to deliver irrigation water to the clients from the new pipeline and this may result in Sunday Creek being drawn down lower than hase previously been recorded, (note that at RL 127m (AHD) Lake Moodemere is dry.

b. Lake Moodemere is to be maintained at a minimum level of RL 128.7m (AHD) from the start of September to the end of January each year. This should be achieved from opening the Lake Moodemere Regulator and filling from the Murray River. Where this arrangement drops below RL 128.7m (AHD), the regulator should be closed, and the new pump station operation should be changed to allow filling of the lake from Sunday Creek as needed to achieve the RL 128.7m (AHD) level.

c. From the start of February to the end of August each year, the Lake Moodemere Regulator should be closed and the lake should be allowed to drawdown. The pump station should only supply the irrigators in Sunday Creek with no water pumped into the lake.

Based on our understanding of the project the likely impacts will include,

2) Construction impacts including but not limited to;
   a. dewatering,
   b. installation of sheet pilling,
   c. noise and vibration, and
   d. production of turbid water.

3) Operational impacts will result in;
   a. Pump operation (Murray River transfers to Sunday Creek) and entrainment of aquatic species,
   b. Unquantified changes to the hydrology of the site from the current situation (our assessment assumes that major changes to hydrology that change the ecological value of the sites is not proposed, i.e. drying out Sunday Creek or Like Moodemere),

c. Changes in hydrological operation of Lake Moodemere will result in the drawdown of the lake between February and August each year and it has been assumed that the lake will not dry out.
d. Changes in hydraulic connectivity between Sunday Creek and Lake Moodemere. It has been assumed intermittent flooding will facilitate hydraulic connectivity to support movement between Sunday Creek and Lake Moodemere along with the periods when the regulator is open.
e. Changes in irrigation (i.e. reduced irrigation demand) demand and an increase in the frequency of low/no flow periods is a risk to Platypus.
f. Operational changes to the pumping regime may result in thermal and dissolved oxygen impacts to Sunday Creek and these impacts may extend to Lake Moodemere. The potential thermal impacts as identified by Richardson and Stoffels (2011) from pumping water out of the River Murray into Sunday Creek cannot be quantified with the available data. A detailed analysis of the operational framework, water demand and instream thermal data would be required to fully assess any potential impacts.
    i. It is likely that the observed poor DO conditions observed in Sunday Creek will remain similar to the current situation however, the gradient of poorer water quality will be reversed with better water quality located at the upstream end and water quality deteriorating toward the Hells Gate Regulator. The extent of any change is likely to be seasonal and also be dependent on irrigation demand.
    ii. Irrigation demand driven changes to hydrology resulting in elevated water levels are a potential impact.
    iii. CWP as a result of the changed operational guidelines are a potential impact to a range of aquatic species.

5.1. Significant Impact Assessment (EPBC)

The proposed action has the potential to impact the habitat of one species listed as Vulnerable, (Murray Cod) and one species as Endangered (Trout Cod) under the EPBC Act. As such the proposed action must be considered a Matter of National Environmental Significance (MNES). If an impact to an MNES is proposed then an assessment must be undertaken to determine whether the proposed impact is a 'significant impact'. If the action is deemed a 'significant impact' then a referral must be prepared and submitted to the Minister for the Environment for assessment. The minister will then make a decision as to whether the proposed action is a 'Controlled Action' (action is subject to the assessment and approval process under the EPBC Act); 'Not Controlled Action – particular manner' (approval is not required if the action is taken in accordance with the manner specified; or, 'Not controlled action' (approval is not required if the action is taken in accordance with the referral). Murray Cod is the only threatened species listed under the EPBC Act relevant to the project.

The significant impact assessment undertaken in Table 14 based on the available information illustrates that the proposed action *will not* result in a significant impact on Murray Cod. As such a referral under the EPBC Act based on impacts on aquatic ecological values (including Ramsar wetlands) is not recommended.

The significant impact assessment undertaken in Table 15 based on the available information illustrates that the proposed action *will not* result in a significant impact on Trout Cod. As such a referral under the EPBC Act based on impacts on aquatic ecological values (including Ramsar wetlands) is not recommended.

- **Table 14: Significant impact assessment for Murray Cod and the proposed action.**

Significant impact criteria	Response
lead to a long-term decrease in the size of an important population of a species	The proposed action will not decrease the overall breeding capacity of Murray cod. The proposed action will not lead to a long-term decrease in the size of an important population of a species
reduce the area of occupancy of an important population	The area proposed to be impacted is less than one percent of the current area of occupancy for Murray cod. It is also understood that the current natural flood regime will not be impeded by the proposed action. Natural flooding will allow the movement of fish into, and out of the study area post implementation of the proposed action. The proposed action will not reduce the area of occupancy of an important population
fragment an existing important population into two or more populations	The proposed action will not fragment an existing important population into two or more populations
adversely affect habitat critical to the survival of a species	Whilst Murray cod may intermittently breed in this area the habitat that is proposed to be impacted is not considered habitat critical to the survival of the species. Natural flooding will allow the movement of fish into, and out of the study area post implementation of the proposed action which will allow Murray cod to breed within the study area post implementation of the proposed action.
disrupt the breeding cycle of an important population	Whilst Murray cod may intermittently breed within the study area the habitat within the study area is not considered 'critical breeding habitat'. Natural flooding will allow the movement of fish into, and out of the study area post implementation of the proposed action which will allow Murray cod to breed within the study area post implementation of the proposed action. The proposed action will not disrupt the breeding cycle of an important population
modify, destroy, remove or isolate or decrease the availability or quality of habitat	The proposed action will impact only a small area of 'non-critical habitat'. Natural flooding will allow the movement of fish into, and out of the study area post implementation of the proposed action allowing Murray cod to continue to utilise the study area. The proposed action will not modify,

Significant impact criteria	Response
to the extent that the species is likely to decline	destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	The prosed action will not result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat
introduce disease that may cause the species to decline, or	The prosed action will not introduce disease that may cause the species to decline
interfere substantially with the recovery of the species.	The prosed action will not interfere substantially with the recovery of the species.

- **Table 15: Significant impact assessment for Trout Cod and the proposed action.**

Significant impact criteria	Response
lead to a long-term decrease in the size of an important population of a species	The proposed action will not decrease the overall breeding capacity of Murray cod. The proposed action will not lead to a long-term decrease in the size of an important population of a species
reduce the area of occupancy of an important population	The area proposed to be impacted is less than one percent of the current area of occupancy for Trout cod. It is also understood that the current natural flood regime will not be impeded by the proposed action. Natural flooding will allow the movement of fish into, and out of the study area post implementation of the proposed action. The proposed action will not reduce the area of occupancy of an important population
fragment an existing important population into two or more populations	The proposed action will not fragment an existing important population into two or more populations
adversely affect habitat critical to the survival of a species	The mapped habitat is unlikely to support Trout cod and the available habitat would is not considered critical habitat.
disrupt the breeding cycle of an important population	There is no important population of Trout cod present at the site.
modify, destroy, remove or isolate or decrease the availability or quality of habitat	The proposed action will impact only a small area of 'non-critical habitat' mapped habitat. The proposed action will not modify, destroy, remove or

Significant impact criteria	Response
to the extent that the species is likely to decline	isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	The prosed action will not result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat
introduce disease that may cause the species to decline, or	The prosed action will not introduce disease that may cause the species to decline
interfere substantially with the recovery of the species.	The prosed action will not interfere substantially with the recovery of the species.

5.2. FFG Listed species and potential impacts

Discussion regarding the potential impacts and threats to the FFG listed species likely to occur in the area are proved below.

5.2.1. Turtles (Murray River Turtles and Broad-shelled turtles)

Both Murray River turtles and Broad-shelled turtles are likely to persist in the study area post construction provided the hydrology is maintained. The proposed changes are unlikely to significantly impact turtle movements between Lake Moodemere and Sunday Creek in the long term. There is likely to be an increase in potential predator pressure from foxes and dogs during land-based transit between the waterbodies post construction if turtle movement between the waterbodies occurs. Land based movement between the waterbodies is likely to be driven by a requirement to move due to poor water quality or resource requirements which is not likely to occur provided the hydrology remains similar to the existing situation. Opportunities for movement during infrequent periods of connectivity during flooding will still occur post construction.

5.2.2. Platypus

Platypus are present in Sunday Creek based on anecdotal evidence and the eDNA results. The population is assumed to be a breeding population that is restricted in its distribution to the area around Pfeiffer Wines. Platypus dispersal from this area can only occur toward the Murray River via Lake Moodemere. The construction of the Hells Gate regulator will impede the free movement

between Sunday Creek and Lake Moodemere. Opportunities for movement during infrequent periods of connectivity during flooding will still occur post construction and movement will still be possible with short land crossings between Sunday Creek and Lake Moodemere and the Murray River. Overland crossings will currently be required under the existing conditions between Lake Moodemere and the Murray River.

The proposed operation guidelines for Sunday Creek will result in water being delivered to Sunday Creek via the new pipeline based on irrigation demand. Based on the historical hydrology data (1957 -2008) Lake Moodemere and Sunday Creek have experienced low water levels and periods of reduced connectivity, and water levels will have been lower than 128.5m AHD in the past. While the size and status of the Platypus population across the period (1957 -2008) is not known, Platypus have persisted across this range of environmental conditions and varying hydrology.

The impact of the proposed operation regime on water levels is unknown. Irrigation demand is highly variable across seasons and long-term impacts to the hydrology of Sunday Creek may also be impacted by reduced irrigation demand into the future (i.e. changed irrigation practice by one of the customers).

If irrigation demand and the new operational guidelines result in the large fluctuations in water levels there is the potential risk of flooding platypus nests.

It is likely that there will be temperature impacts to Sunday Creek as a result of CWP with water being directly pumped from the Murray River. The resultant impacts can not be quantified with the available data as outlined above. Platypus are tolerant of cooler temperatures as their distribution is extends from the cooler latitudes in Tasmania to higher altitudes above Jindabyne Dam in the Thredbo River. The greatest risk as a result of CWP is the changes to food resources (i.e. macroinvertebrate communities). Evidence of the persistence of Platypus at sites immediately below dams (i.e. Jindabyne Dam on the Snowy River) would suggest that the habitat and food resources are able to adapt.

5.2.3. Native fish including Eel-tailed Catfish

It is possible that Eel-tailed catfish are present in Sunday Creek and Lake Moodemere based on the stocking of the species. Potential impacts of the project during construction are likely to be minor based on the small footprint of the proposed works. Post construction impacts due to connectivity are likely to have the greatest potential impacts on Eel-tailed catfish as a result of reduced potential for fish movement. CWP is recognised to impact Australian freshwater fish reproduction and may be an impact to their spawning success in Sunday Creek

6. Conclusions

Based on the current field surveys the following conclusions can be made;

1) All of the native species detected were small bodied species. Australian smelt were the most abundant native species encountered.

2) No large bodied native species were detected during the current surveys. Large bodied native species are known to have been recently stocked by the Victorian Fisheries Authority and are likely to be present in Lake Moodemere and Sunday Creek

3) A number (5) of noxious and introduced fish species were detected during the current survey. Common carp were the most abundant introduced species detected during the current surveys.

4) Three species of freshwater turtles were collected across all sites. Murray River Turtles were the most abundant turtle species detected. No juvenile turtles were detected in the current surveys.

5) The results of this survey concur with the findings of the Richardson and Stoffels (2011).

6) The EPBC significant impact assessment indicates that an EPBC Referral is not recommended based on potential impacts on aquatic ecological values (Murray cod and Trout cod)..

7) Consideration of the VBA data and large bodied native species, Murray Cod, Golden Perch and Eel-tailed Catfish are likely to be present (but not confirmed in the current surveys) and should be addressed with regard to the potential construction impacts.

8) The magnitude of thermal impacts as a result of the proposed operational changes for the delivery of water to Sunday Creek are unknown and will require further investigation. The changed operation for watering Sunday Creek may also have impacts on the observed poor DO conditions during the current survey and reported by (Richardson and Stoffels, 2011).

9) Changed hydrology as a result of the new operational framework and connectivity between Lake Moodemere and Sunday Creek has the greatest potential to negatively impact the fauna values of Sunday Creek and Lake Moodemere as described in section 5.

10) Platypus may be negatively impacted by construction of the Hell's Gate Regulator without the implementation of mitigation measures however the risk of impacts to Platypus during the construction phase are considered to be unlikely based on the small population and its restricted distribution based on the data collected.

11) It is possible that Platypus may be impacted by the new operational guidelines, however if water levels in Sunday Creek are maintained within the historic ranges (RL 128.7 – 128.9 m AHD) with

the short periods of lower water level as has been observed in the past it is likely that Platypus will persist in Sunday Creek.

a. The impacts of a changed irrigation demand are unknown and could become a major impact if there was no irrigation demand and Sunday Creek dried below is historic low levels.

b. To preserve the connectivity of Platypus habitat in Sunday Creek water levels should be maintained at or above RL 128.5 AHD.

c. The new operational guidelines should ensure that the water levels in Sunday Creek do not risk flooding Platypus burrows during the breeding and nesting season.

12) CWP has the potential to disrupt native fish spawning and recruitment.

13) Platypus are known to tolerate CWP conditions below dams through out Australia and would be expected to persist and tolerate any changes and impacts associated with CWP in Sunday Creek.

6.1. Mitigation Measures

The following general mitigation measures have been prepared with limited information regarding the construction timing and methodology and are recommended to be included for consideration during the preparation of the EMP:

1) Whilst a referral under the EPBC Act is not recommended there is potential for a number of species listed under the EPBC Act to occur within the study area. A number of species listed under the FFG Act also have the potential to occur or have been identified to occur within the study area. In the context of this project the Precautionary Principle (Kriebel et al 2001) should be applied and presence of the following species should be assumed and appropriate mitigation measures implemented to minimise potential impacts:
    - Murray cod (EPBC Act)
    - Murray River Turtle (FFG Act)
    - Platypus (FFG Act)
    - Eel-tailed Catfish (FFG Act)
    - Broad-shelled Turtle (FFG Act);
2) An aquatic fauna management plan (FMP) should be prepared to address potential impacts to the above species. The FMP should include protocols for the salvage of any native aquatic fauna and should include management actions to control any noxious species encountered during the construction process;

3) An EMP should be developed that will outline measures to mitigate impacts on waterways (Lake Moodemere, Sunday Creek and The River Murray) and should address at a minimum;
   - Aquatic fauna management throughout the construction process/program across the site. Specifically, but not limited to those species listed above.
   - Sediment and erosion control, this will include the development of Sediment and Erosion Control Management Plan (SECMP).
   - Water quality management.
   - Dewatering, if required.
   - Reinstatement of the impact areas post construction.
4) If the construction will result in the drawdown of Lake Moodemere the FMP must consider the management of fauna under this scenario and a salvage plan may be required.
5) If construction activities require dewatering or bypassing flows, then the following mitigation measures should be adopted in addition to the mitigation measures above;
   - A fauna salvage plan should be prepared. This should address the details of where any salvaged fauna should be translocated and the permits that will be required.
   - Where dewatering is required, a suitably qualified ecologist should be present to salvage fauna.
   - If a bypass is to be installed to facilitate passing flows around the works site then the time that the bypass is in place should be minimised.
   - Any bypass infrastructure should be fauna friendly to ensure that aquatic fauna does not become entrapped in the pumps or bypass structures and is able to move upstream and downstream of the works area;
6) Construction of the Hells Gate Regulator has the potential to disturb turtle nesting habitat. The site should be assessed for its potential as nesting habitat. If the area of impact includes nesting habitat that can't be avoided, then additional mitigation measures in the form of fencing to protect the habitat into the future could be considered (See mitigation measure 7 below);
7) The lack of juvenile turtles and evidence of nests being raided supports the general observation that freshwater turtles are suffering significant losses with limited recruitment. Nesting sites are present around the lake and recruitment should have been evident during the outcomes of the current survey. The protection of turtle nesting sites is becoming a critical aspect for the preservation of the three species found within the study area. Efforts to protect turtle nesting sites have been undertaken at other sites in Victoria (Barmah-Millewa and Gunbower Forests) along with extensive fox baiting programs (Howard et al. 2013). The construction of infrastructure

provides an opportunity to enhance protection of breeding sites in selected circumstances. The location and construction of the proposed Hells Gate regulator provides an opportunity for the protection of some potential nesting habitat (Figure 16). If the option of protecting the areas was to be considered further there are a number of other tasks to be considered which include:

- Determine the suitability of the land between the Hells Gate Regulator and the proposed fence sites to support nesting habitat. This will require additional surveys and inspections.
- Liaise with Parks Victoria, Traditional owners, and other stakeholders regarding the proposal.
- Consider impacts of constructing predator proof fencing.
- Assess and monitor hydrology of Lake Moodemere and Sunday Creek after the installation of Hells Gate regulator to ensure the proposed fences would be effective at reducing predator access.
- If an access track is being constructed there is the potential to augment the habitat during the rehabilitation of the site post construction to maximise the available nesting habitat. Further advice and planning about the material and topography of the landform would need to be considered;

- **Figure 16: Hells gate regulator and location of possible fox proof fencing to protect nesting sites.**

8) Platypus have the potential to be impacted by the installation of the Hells Gate Regulator. The construction impacts are likely to be short term and limited based on the current understanding from eDNA surveys that the Platypus population is small and is confined to Sunday Creek around Pfeiffer Wines. Any construction impact will be addressed via the preparation of the SECMP and FMP. The greatest potential impacts to Platypus are through the dispersal of Platypus from Sunday Creek toward the Murray River. Dispersal will be possible during flood events when the barrier between Sunday Creek and Lake Moodemere is flooded. When floods do not facilitate dispersal short overland migrations will be required between Sunday Creek and Lake Moodemere

and between Lake Moodemere and the Murray River. No specific mitigation measures are recommended.

Water levels should be maintained at levels similar to those observed historically (between RL 128.7 – 128.9) with occasional periods of drawdown to lower levels. Water levels should not fall below RL 128.5m AHD which would result in the habitat fragmentation for the Platypus population on Sunday Creek.

Long term changes to irrigation demand by Sunday Creek customers has the potential to impact water level/hydrology within Sunday Creek and need to consider impacts on the Platypus population.

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