

Appendix G

Aquatic ecology impact assessment (Cardno Ecology Lab)



Cardno
Ecology Lab

Shaping the Future

Marine and Freshwater Studies



The Macquarie River to Orange Pipeline Project

Aquatic Ecology Assessment

Job Number: EL1112019

Prepared for Orange City Council

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Cover Image: Summer Hill Creek in the vicinity of the 1st Crossing, December 2011.
Photographer: Oliver Silver, Cardno Ecology Lab.

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Executive Summary

Background and Scope of Works

Orange City Council proposes to improve water security for Orange by transferring water from the Macquarie River along a 37 km long purpose-built pipeline to Suma Park Reservoir. The proposed development has been accepted as a Major Project under Part 3A of the NSW Environmental Planning and Assessment Act 1979 (EP and A Act). This Aquatic Ecology Assessment is part of the Environmental Assessment for the Project that is currently being prepared by GHD in accordance with the Director-General (NSW Department of Planning and Infrastructure) Requirements (DGRs) dated 24 March 2011 and Supplementary DGRs issued by the Federal Department of Sustainability, Environment, Water, Population and Communities (DSEWPAC) dated 27 February 2012.

The scope of works for the Aquatic Ecology Assessment included:

- Identification of the legislative requirements and guidelines that are relevant to the effects of the proposed works on aquatic ecology (including consideration at NSW State and Commonwealth levels);
- Description of the existing aquatic environment of the study area/sites that could potentially be impacted by the project;
- Provision of an outline of the issues pertaining to aquatic ecology identified in the Preliminary Environmental Assessment and the DGRs;
- Consultation with the relevant government agencies about potential impacts on riparian vegetation, aquatic habitats and mitigation measures for watercourse crossings;
- Assessment of the impacts of the construction and operation of the pipeline on the aquatic environment and its biota, including any threatened species, populations and communities listed under NSW State legislation;
- Assessment of the impacts of the proposed project on threatened species and communities of aquatic biota and wetlands of international importance listed under Federal legislation;
- Recommendations on practical, cost-effective mitigation/management measures that could be used to avoid or minimise the impacts of the proposed works.

Relevant legislative requirements, policies and guidelines

The major legislative requirements that are relevant to the project are the Commonwealth *Environmental Protection and Biodiversity Conservation Act (EPBC Act) 1999*, NSW *Threatened Species Conservation Act 1995* and NSW *Fisheries Management Act (FM Act) 1994 (including Fisheries Management Amendment Act 1997)*, all of which contain provisions that relate to the conservation of threatened species, populations and communities.

The Policy and Guidelines for Aquatic Habitat Management and Fish Conservation issued by the NSW Department of Primary Industry, NSW Office of Water Guidelines for Controlled Activities and NSW State Groundwater Ecosystem Policy are also applicable.

Information on the Existing Environment

There is no comprehensive existing information on the aquatic ecology of the upper Macquarie River, its tributaries or Suma Park Reservoir. The bank, bed and bar stability, riparian vegetation and aquatic habitats observed in the upper Macquarie River and Summer Hill Creek catchments in October 1998 and July 1999 are described in Baker and Raisin (2000). At that stage, the aquatic habitat in the lower and mid reaches of the upper Macquarie River was in good condition, but in the upper reaches it was in poor to moderate condition. The riparian vegetation in the upper reaches of the river had been subject to moderate to very high levels of disturbance, but that in the mid and lower reaches had been exposed to low to moderate levels, respectively. The aquatic habitat in Summer Hill Creek

was considered to be in moderate, poor and good condition in the upper, mid and lower reaches, respectively. The riparian vegetation in the upper, mid and lower reaches of the creek had been subject to very high, moderate and low levels of disturbance.

The aquatic habitats and fish sampled at sites on the Macquarie River in the vicinity of the proposed extraction point and two of the proposed pipeline crossings on Summer Hill Creek under baseflow conditions are described in GHD (2011a). As part of the present proposal, the results of an additional survey of aquatic habitat, plants, macroinvertebrates and fish undertaken in December 2011 by Cardno Ecology Lab (CEL) at the proposed extraction point, four of the proposed pipeline crossings on Summer Hill Creek and at the proposed site of the Discharge Structure on Suma Park Reservoir. The CEL survey provides an indication of the state of aquatic habitats and biota after a significant flood event.

Further information on the fish fauna of the upper Macquarie River catchment was obtained from:

- The Sustainable Rivers Audit of the Murray-Darling Basin (SRA) (Davies *et al.* 2008);
- Records of species surveyed and numbers of fish stocked in the Upper Macquarie River catchment provided by NSW DPI;
- Recreational fishing websites.

The SRA predicts 16 native species of fish would have occurred in the upland zone of the Macquarie River prior to significant human intervention, but the actual sampling undertaken yielded 3 native and 6 alien fish species. On the basis of these results, the SRA concluded that the fish fauna in the upland zone of the Macquarie River was in extremely poor condition. The NSW DPI fish survey data indicate that 16 species have been recorded upstream of Burrendong Dam. These surveys were of limited frequency, spatial extent, duration and intensity, with only one survey having been undertaken on the Macquarie River and in Burrendong Dam, yielding two and one fish species, respectively. More intensive sampling in the Turon River, a tributary of the Macquarie River, yielded four native and six alien species. The NSW DPI records that 1 native and 2 alien species were caught in the reservoir in July 2010 and one alien species has been caught in Summer Hill Creek.

Records of fish stocking indicate that Golden Perch, Silver Perch and Murray Cod have been released into Burrendong Dam and that Golden Perch, Murray Cod, Trout Cod, Brown Trout and Rainbow Trout have been released into the Macquarie River upstream of the dam. In the last five years, large numbers of Murray Cod and Trout Cod have been released at the proposed extraction point and at adjacent sites in the Macquarie River. Rainbow Trout have been released at two of the road crossings on Summer Hill Creek.

Potential Impacts and Mitigation Measures

Construction Phase

The construction works associated with the project could have the following effects on instream ecology:

- Disturbance of soils and sediments by construction equipment and runoff from the all-weather access road and areas where vegetation has been cleared and soils have been stockpiled could increase the sediment load in the waterways which, in turn, could affect water quality;
- Direct impacts on channel morphology, hydrological characteristics and aquatic habitat;
- Indirect impacts on water quality due to increased sedimentation, accidental release of lubricating oils, hydraulic fluids, drilling fluids, fuel from construction equipment and wet concrete;
- The installation of coffer dams would result in temporary loss of aquatic habitat, displacement of aquatic biota and changes in hydraulic conditions that would persist for approximately two months;

- The degradation of riparian and aquatic habitats and reduction in water quality could have indirect impacts on abundance, distribution, behaviour and physiology of aquatic fauna and health of aquatic and riparian biota.

As the footprint of the instream works would be minimised, these effects would be localised. The effects would also be short-term in nature and thus not significant at the scale of the watercourse.

The potential for impacts associated with construction works would be minimised by:

- Limiting the disturbance of riparian zone and aquatic habitat;
- Rehabilitating disturbed areas;
- Implementing sediment and erosion control measures;
- Establishing a bunded area for storage of fuels, oils, refuelling and maintenance of construction vehicles and mechanical plant;
- Excluding biota from the construction area using coffer dams and translocating aquatic fauna contained therein;
- Screening the pump inlet used to dewater coffer dams; and
- Avoiding instream construction work during the spawning and recruitment phases of the threatened fish species.

Operational Phase

Potential impacts on aquatic ecology that may arise during the operation of the project include:

- Alteration of habitat;
- Disturbance of aquatic fauna resulting from noise and/or vibration;
- Entrainment or impingement of aquatic macroinvertebrates, invertebrate plankton, fish larvae and plant fragments by screens within the Offtake Structure;
- Small aquatic organisms that pass through the screen would be subject to mortality or physical injury due to collision with impellers in the pump and wall of the pipeline and exposure to changes in pressure;
- Increased risk of predation due to stress and/or provision of novel habitat for fish and bird predators;
- Changes in the flow regime downstream of the Offtake Structure in the Macquarie River due to the extraction of water (i.e. small decreases in the volume of low to moderate and moderate to high flows, but no change in low flows);
- Changes in the flow regime of Summer Hill Creek (i.e. an increase in the low to moderate flows and average annual flow);
- Leakage of water and potentially sediment from within the pipe to streams.
- Transfer of pathogens and of eggs, spores and propagules of aquatic biota from the Macquarie River to the reservoir.
- Localised changes in water quality within the reservoir due to periodic transfer of silt, organic material, dissolved nutrients and contaminants in the river water
- Periodic exposure of aquatic biota near the Discharge Structure to changes in water quality during the discharge of extracted water.

The potential for impacts associated with operation of the water transfer system would be avoided, minimised or mitigated by:

- Using a 2 mm mesh screen located in front of the suction manifold to minimise entrainment of fish eggs and larvae into the pump intake;
- Starting the pump up slowly and then ramping up its velocity to a level that reduces the chances of aquatic biota being drawn into the pump;
- Limiting the extraction period to 19 hours per day and to flows above 38 ML/d;
- Passing air through the screen at the end of each day's operation to dislodge organisms trapped on the mesh;

- Prohibiting direct discharge of water contained within the pipeline into watercourses via scour valves, except in emergencies and providing the water quality is of an acceptable standard;
- Installing rock rip rap downstream of the Discharge Structure to dissipate the energy contained in the discharge over a greater area and thereby reduce the risk of erosion of the dam invert;
- Controlling algal blooms by using the existing mixer within the reservoir (i.e. de-stratification) or addition of algicides.

An additional mitigation measures that could be considered is the installation of devices that would deflect fish away from the Offtake Structure.

Impacts would be offset by rehabilitating other areas of habitat equivalent in size to those disturbed by the Project.

Conservation Issues

Matters of National Environmental Significance

The following species of fish listed as threatened under the *EPBC Act* may occur or suitable habitat for them may occur within the Orange and Cabonne LGAs:

- Murray Cod (*Maccullochella peelii peelii*);
- Macquarie Perch (*Macquaria australasica*);
- Trout Cod (*Maccullochella macquariensis*).

The measures that would be used to avoid, minimise and mitigate the potential impacts of the project on these species are outlined above. Assessments of the significance of impacts on these threatened fish species were prepared in accordance with the criteria specified in the Matters of National Environmental Significance Significant Impact Guidelines 1.1. The assessments indicate local Murray Cod, Macquarie Perch and Trout Cod populations may be impacted during the operation of the offtake. The adoption of the recommended mitigation and management measures, however, would reduce the potential for impact on these species to minor levels.

The potential impacts of the Project on ecological character (i.e. the sum of all the ecosystem components, processes and benefits/services of the wetland) of the Macquarie Marshes Ramsar Site, a Wetland of International Importance, were also considered. The key processes that determine the character of the Marshes and hence the Ramsar site are the frequency, duration, extent of inundation and quality of the water. The hydrological modelling shows that the proposed extraction of water would have only a minor impact on flow in the regulated section of the Macquarie River and that its impact on the flow regime within the Macquarie Marshes is likely to be even smaller due to flow regulation and the management of flows in accordance with the Macquarie-Cudgegong Water Sharing Plan. As the proposed extraction would have a negligible impact on the inundation of the Macquarie Marshes Ramsar site, even during drought, it is highly unlikely that the Project would have a significant impact on the ecological character of the Macquarie Marshes Ramsar site.

Matters of State Environmental Significance

The natural distribution ranges of threatened species and populations listed under the *FM Act* indicate that the following could potentially occur in the Project Area:

- Macquarie Perch (*Macquaria australasica*);
- Trout Cod (*Maccullochella macquariensis*);
- Flathead Galaxias (*Galaxias rostratus*);
- Silver perch (*Bidyanus bidyanus*);
- Southern purple-spotted gudgeon (*Mogurnda adspersa*); and

- Murray River Basin Population of the Freshwater (Eel-tailed) Catfish (*Tandanus tandanus*).

Assessments of the significance of impacts on these were prepared in accordance with the Draft Guidelines for Threatened Species Assessment applicable to development proposals to be assessed under Part 3A of the *NSW Environmental Planning and Assessment Act, 1979* (DEC and DPI, 2005). These assessments indicate that the Macquarie River to Orange Pipeline Project is unlikely to have a significant impact on the threatened species and population identified, if the proposed avoidance, mitigation and management measures are adopted. None of the endangered ecological communities listed under the *FM Act* occur in the Project Area.

Overall Conclusion

The aquatic ecology assessment has not identified any major constraints that would jeopardise the Project. It is, however, important that Construction and Operational Environmental Management Plans, stipulating the various control measures that are to be used to minimise the potential for onsite and offsite impacts on aquatic habitats and associated aquatic biota, are developed and implemented.

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1 Introduction

1.1 Purpose of this Report

Orange City Council proposes to undertake the Macquarie River to Orange Pipeline Project (referred to in this report as 'the project'). This report has been prepared to provide an assessment of the aquatic ecology impacts of the project as an input to the environmental assessment. The environmental assessment is being prepared in accordance with the requirements of Part 3A of the NSW Environmental Planning and Assessment Act 1979 (EP and A Act).

The report addresses the requirements of the Director-General of the NSW Department of Planning and Infrastructure (the Director-General's Requirements) dated 24 March 2011 and Supplementary DGRs issued by the Federal Department of Sustainability, Environment, Water, Population and Communities (DSEWPAC) dated 27 February 2012.

1.2 Project Overview

The project is one step to improving the water security for Orange. It involves construction and operation of infrastructure required to transfer approximately 12 ML/day of water a distance of approximately 37 km from the Macquarie River to the Suma Park Dam at Orange.

The infrastructure required to transfer the water includes an Offtake Structure and pump stations, an underground pipeline (approximately 37 km in length), a discharge structure, and ancillary infrastructure (power supply).

In summary, the project would involve construction and operation of the following infrastructure:

- 37 km of 375 mm diameter water rising main between the Macquarie River and Suma Park Dam;
- An Offtake Structure and pump station located at the upper Macquarie River;
- Two booster pump stations and break tanks along the pipeline route;
- Power supply to pumps and other infrastructure
- Telemetry controls to enable remote operation of the infrastructure including pumps and valves, etc
- A Discharge Structure at Suma Park Dam.

1.3 Project Location

The proposed Offtake Structure would be located on the south side of the Macquarie River immediately upstream of the confluence with Boshes Creek (Figure 1). The water carried along the pipeline would discharge into the Suma Park Reservoir at Orange via the discharge structure, located approximately 10 m east of the existing saddle dam (at the north-west corner of the dam wall).

The proposed route for the pipeline contains road reserves, including Ophir Road and Long Point Road. In most (up to 70% of the route) areas the pipeline would need to traverse private land. It is proposed that the majority of the pipeline would be underground and would not impact on farming or other land uses.

The project would be located in both the Orange and Cabonne local government areas. The majority of the pipeline would be located in the Cabonne local government area.

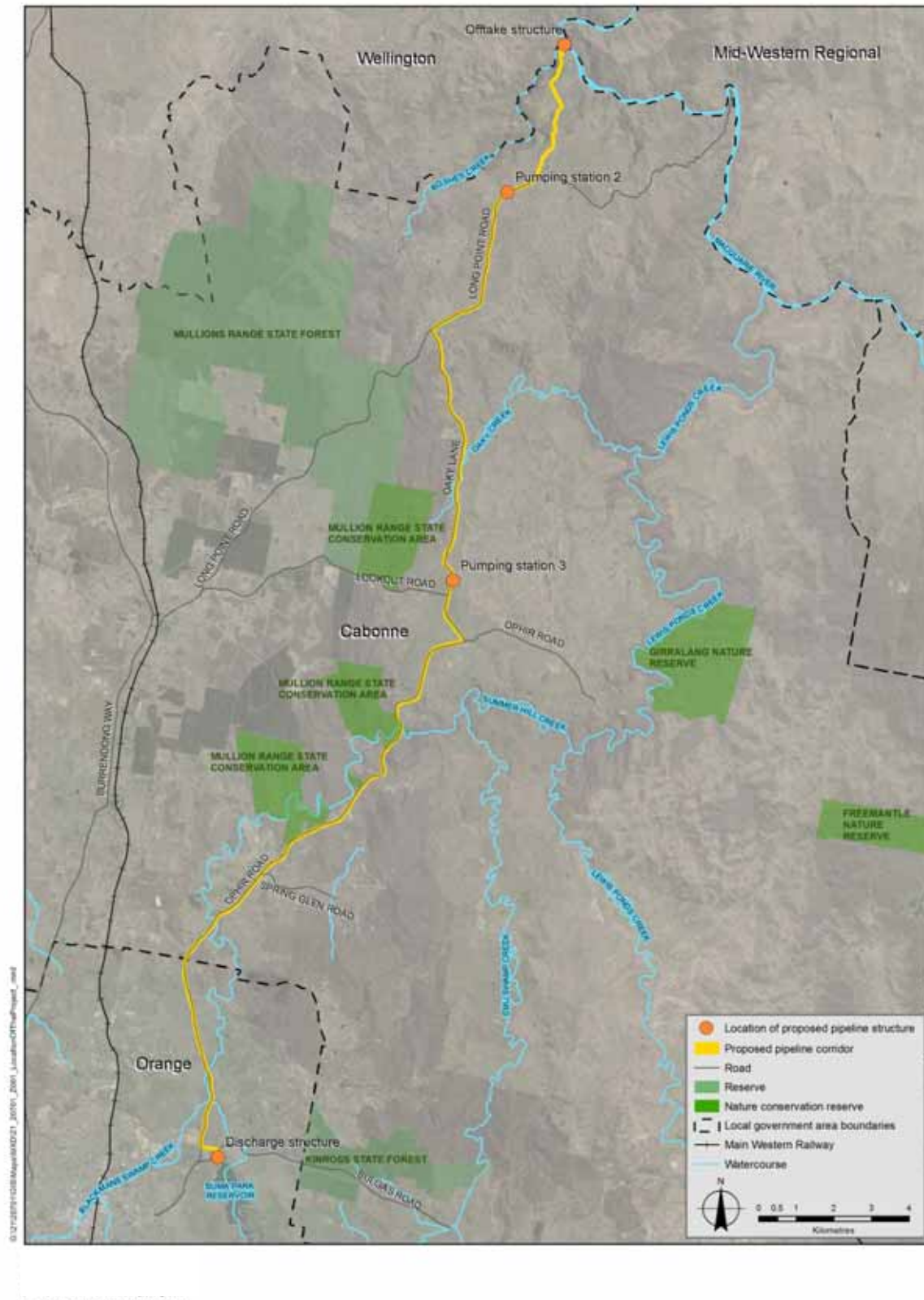


Figure 1: The location of the Project.

1.4 Scope and Structure of report

1.4.1 Scope of Report

The scope of works for the Aquatic Ecology Assessment included:

- Identification of the legislative requirements and guidelines that are relevant to the effects of the proposed works on aquatic ecology;
- Description of the existing aquatic environment of the study area/sites that potentially could be impacted by the project;
- Outlining the issues pertaining to aquatic ecology identified in the Preliminary Environmental Assessment and the Director General's Requirements;
- Consultation with the relevant government agencies about potential impacts on riparian vegetation, aquatic habitats and mitigation measures for watercourse crossings;
- Assessment of the impacts of the construction and operation of the pipeline on the aquatic environment and its biota, including any threatened species, populations and communities listed under NSW State legislation;
- Assessment of the impacts of the proposed project on threatened species and communities of aquatic biota and wetlands of international importance listed under Federal legislation;
- Recommendations on practical, cost-effective mitigation/management measures that could be used to avoid or minimise the impacts of the proposed works.

1.4.2 Sections where Director-General's requirements are addressed

The DGRs addressed by this report are summarised in Table 1a, together with a reference to where they are addressed in the report.

Table 1a: Director General's (DoP) Requirements for the Aquatic Ecology Assessment

Assessment requirements	Where addressed in report
Take into consideration impacts on any threatened species, populations, ecological communities, critical habitat	Section 6.
Riparian, instream ecology, water dependent ecosystems (including RAMSAR wetlands) and groundwater dependent communities affected by the project, including consideration of the NSW Groundwater Dependent Ecosystems Policy	Sections 4 and 6.
Relevant recovery plans	Sections 2.1.1 and 6
Riparian vegetation at watercourse crossings and downstream of the water offtake in the Macquarie River.	Section 3.5
Include a management framework outlining: measures to be implemented to avoid, mitigate, manage, monitor and/or offset aquatic impacts during construction and operation including but not limited to progressive rehabilitation works.	Sections 5 and 6.1.5.
Demonstrate the availability of viable and achievable options to offset the impacts of the project	Sections 5.1.1, 5.2.1 and 5.5 and 6
Where impacts are unavoidable, provide information on how impacts would be minimised, mitigated and offset consistent	Sections 5 and 6.1.5.
Identify impacts of construction of the off take pump on fish passage	Section 4.1.2.3
Identify how the pump would be designed to avoid entrainment or entrapment of fish eggs and larvae.	Section 4.1.3.32

The supplementary DGRs addressed by this report are summarised in Table 1b, together with a reference to where they are addressed in the report.

Table 1b: Director General's (DSEWPAC) Requirements for the Aquatic Ecology Assessment

Assessment requirements	Where addressed in report
Assessment of relevant impacts on threatened ecological communities and threatened species listed under the <i>EPBC Act</i>	Sections 6.1.4 and 6.1.6.
Assessment of impacts on the ecological character of the Macquarie Marshes RAMSAR site.	Section 6.1.7
Description of proposed safeguards, mitigation and offset measures	Section 6.1.5, Table 12

1.4.3 Structure of the report

This report contains the following sections:

- Legislative requirements, policies and guidelines, that are relevant to the potential effects of the project on aquatic ecology (Section 2);
- Existing information on the physical aquatic habitat, riparian and aquatic vegetation and fish fauna of the Upper Macquarie River, Summer Hill Creek, Ophir Creek and Suma Park Reservoir (Section 2);
- Description of field survey methods and of the existing aquatic environment in the vicinity of the offtake, potential pipeline crossing sites on Summer Hill Creek and some of the minor creeks and discharge point at Suma Park Reservoir (Section 3);
- Description of the proposed works from the perspective of aquatic ecology, an assessment of their potential impacts on instream ecology during the construction and operational phases of the project and suggested mitigation measures (Sections 4 and 5);
- Assessments of potential impacts of the project on aquatic biota of National and State conservation significance and on the Macquarie Marshes Ramsar site (Section 6);
- Conclusions (Section 7);
- References cited (Section 8).

The Appendices referred to in the text are presented at the end of the report.

2 Background Information

2.1 Legislative Requirements, Guidelines and Policies

2.1.1 Threatened Species, Populations and Communities

Threatened freshwater species, populations and communities are listed under Commonwealth and NSW State legislation.

The Environmental Protection and Biodiversity Conservation Act (*EPBC Act*) 1999 is administered by the Federal Department of Sustainability, Environment, Water, Population and Communities (DSEWPAC). The *EPBC Act* provides a legal framework for the protection and management of nationally and internationally important flora, fauna, ecological communities and heritage places. It also includes provisions for nationally threatened species of plants, fish, birds, frogs, reptiles, mammals and other animals. These conservation assets are referred to collectively as Matters of National Environmental Significance (MNES). DSEWPAC is also responsible for the development and implementation of recovery plans for threatened fauna, threatened flora (other than conservation dependent species) and threatened ecological communities listed under the *EPBC Act*. These recovery plans describe the research and management actions that are necessary to stop the decline of, and support the recovery of, listed threatened species or threatened ecological communities. The aim of a recovery plan is to maximise the long term survival in the wild of a threatened species or ecological community. The National Recovery Plans for Trout Cod and Murray Cod are relevant to the project (Trout Cod Recovery Team 2008a; National Murray Cod Recovery Team 2010a).

The NSW Threatened Species Conservation Act 1995 (*TSC Act*) administered by the NSW Office of Environment and Heritage (NSW OEH), provides for the conservation of threatened species, populations and ecological communities of animals and plants. The Act also contains provisions for the preparation of recovery plans for listed threatened species, populations and ecological communities and the declaration and mapping of habitats that are critical to their survival. The provisions of the *TSC Act* do not generally apply to fish.

In NSW, threatened species, populations and communities of fish and aquatic invertebrates, such as worms, snails, crayfish and aquatic insects, are listed under the NSW Fisheries Management Act (*FM Act*) 1994 (including Fisheries Management Amendment Act 1997), which is administered by the Department of Primary Industries NSW (DPI NSW). DPI NSW has also prepared several recovery plans that are designed to return threatened species to a point where their survival in nature is assured. These plans contain background information on the biology, habitat and distribution, conservation status and threats to a particular species. They also describe the legislative context for the plan, objectives and criteria for assessing recovery, recovery actions and relevant social, economic and cultural issues. The NSW Recovery Plans for Trout Cod and Silver Perch are relevant to the project.

2.1.2 Key Threatening Processes

A number of key threatening processes (KTP) that threaten or may threaten the survival or evolutionary development of threatened species, population or ecological community are also listed under the *EPBC Act*, *TSC Act* and *FM Act*.

2.1.3 Protected Species

Native fauna and flora are also protected under the NSW National Parks and Wildlife Act 1974 (NP and W Act) that is administered by the Office of Environment and Heritage (OEH). There are also two freshwater fish species that are protected under the *FM Act*.

2.1.4 Critical Habitat

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Registers of critical habitats are maintained by the Office of Environment and Heritage (OEH) and DPI NSW.

2.1.5 Key Fish Habitat

One of the objectives of the *FM Act* is to conserve key fish habitats. 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. In freshwater systems, most permanent and semi-permanent rivers, creeks, lakes, lagoons, billabongs, weir impoundments and impoundments up to the top of the bank are considered key fish habitats. Small headwater creeks and gullies that flow for a short period after rain and farm dams on such systems are excluded, as are artificial waterbodies except for those that support populations of threatened fish or invertebrates.

The NSW DPI maps showing the distribution of key fish habitats within the Orange and Cabonne LGAs indicate that the Macquarie River, Summer Hill Creek, Ophir Creek and Suma Park Reservoir are considered key fish habitats. Watercourses such as Oaky Creek, Kitty Creek and Eldorado Gully that occur along the pipeline route but flow only for a short period after rain do not constitute key fish habitat.

2.2 Relevant Guidelines and Policies

2.2.1 NSW Office of Water Guidelines for Controlled Activities

Approval is required under the Water Management Act 2000 (*WM Act*) for certain types of developments and controlled activities that are carried out in or near a river, lake or estuary. Four types of controlled activities are recognised:

- Erection of a building or the carrying out of a work (within the meaning of the Environmental Planning and Assessment Act 1979), or
- Removal of material or vegetation from land, by way of excavation or other means,
- Deposition of material on land as a result of landfill operations or other means;
- Carrying out any other activity that affects the quantity or flow of water in a water source.

The NSW Office of Water, the agency responsible for administering the *WM Act*, has developed guidelines to assist applicants who are considering carrying out controlled activities on waterfront land (i.e. the land within 40 m of the highest bank of the river, lake or estuary). These guidelines provide information on the design and construction of a controlled activity, and other mechanisms for the protection of waterfront land. The following guidelines are relevant to the potential effects of the proposed pipeline on aquatic ecology:

- Laying pipes and cables in watercourses (NSW Office of Water 2010a);
- Riparian corridors (NSW Office of Water 2011a);
- In-stream works (NSW Office of Water 2010b); and
- Outlet structures (NSW Office of Water 2010c).

Part 3A projects do not require approval under the NSW Water Management Act, so the project is not considered a controlled activity under this Act. The controlled action guidelines, however, are still government policy and will be promoted by the NSW Office of Water within any Part 3A assessment process (Tim Baker, email communication 14 March 2011). The NSW Office of Water (2011b) has also stipulated that the design and construction of works

for the Project within 40 m of watercourses are to be done in accordance with the guidelines for controlled activities.

2.2.2 NSW DPI Policy and Guidelines for Aquatic Habitat Management and Fish Conservation

The policy and guidelines are applicable to all planning and development proposals and various activities that affect freshwater, estuarine and marine ecosystems. This document contains:

- General policies for the conservation of fish, marine vegetation and aquatic habitats;
- Descriptions of aquatic habitats, fish and fisheries resources in NSW waters;
- An outline of NSW fisheries legislation;
- Background information, legislation, policy and guidelines that are applicable to activities that may impact on aquatic habitats, including dredging and reclamation (including that involved in laying of pipelines), water front development, water extraction, bridges, roads, causeways, culverts, pipelines, cables or similar structures, water pollution and snag management, harm of selected aquatic habitats and species;
- A description of biodiversity conservation and habitat rehabilitation activities;
- An outline of the requirements for the preparation of environmental planning and assessment documents.

The following policies and /or guidelines may be relevant to the current project:

Section 5.1.3

- Disposal of spoil into the waterway is generally unacceptable, as it can impact on the aquatic environment.

Section 5.2.5

- In the case of waterfront developments, riparian vegetation should (to the greatest extent possible) be retained in an undamaged and unaltered condition;
- The recommended foreshore or river frontage buffer distance of 50 m should be increased if the riparian zone is unstable, susceptible to erosion or the proposed development is particularly threatening;
- Revegetation of disturbed areas with local native species should be undertaken upon completion of works and should be monitored subsequently to ensure successful establishment;
- Mesh fences that may obstruct fish passage will not be allowed to cross waterways.

Section 5.4.3

- Roads, bridges, causeways, culverts and similar structures (e.g. pipeline crossings) must be constructed to minimise habitat loss, changes in sediment transport and stream siltation, and to maintain natural tidal exchange or river flow.

Section 5.6.3

- Further extraction of water from streams or the upstream tributaries of streams that are known to support populations of endangered or threatened species will be opposed.

2.2.3 NSW State Groundwater Dependent Ecosystems Policy

The species composition and natural ecological processes within some ecosystems (e.g. wetlands, red gum forests, limestone caves, springs, hanging valleys and swamps) are

dependent on water that has filtered down below the surface of the earth and is held in rocks, gravel and sand. In NSW, groundwater often provides the base flows in rivers and streams after rainfall events that appears as springs or as diffuse flows from saturated sediments or rock underlying the watercourse or its banks. In rivers and streams with sand or gravel beds, exchanges between surface water and groundwater occur in a region known as the hyporheic zone.

The State Groundwater Dependent Ecosystems Policy (DLWC 2002) is designed to protect valuable ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of their dependent ecosystems are maintained or restored, for the benefit of present and future generations. The document provides guidance on the protection and management of groundwater-dependent ecosystems (GDEs) and includes information on:

- The location of groundwater systems in NSW;
- Different types of GDEs;
- Value of and threats to GDEs;
- The principles that underpin the management of GDEs;
- Policies and legislation relating to management of GDEs, including how policy will be implemented and reviewed.

2.3 Review of Existing Information

Existing information on the aquatic ecology of the upper Macquarie River, its tributaries and Suma Park Reservoir is limited. The information presented on bank, bed and bar stability, riparian vegetation and aquatic habitats in various sections of the upper Macquarie River and Summer Hill Creek catchments is based on a snapshot assessment of riverine health in the Macquarie, Castlereagh and Bogan River catchments undertaken during a wet period (i.e. October 1998 and July 1999) (Baker and Raisin 2000). The description of aquatic habitat and fish is adapted from GHD (2011). Information on the occurrence of threatened species, populations and communities listed under Commonwealth and NSW legislation is presented in Section 6.

2.3.1 Upper Macquarie River

2.3.1.1 Physical Setting

The Macquarie River is formed by the joining of the Campbell and Fish Rivers, which drain a high plateau area near Oberon in the Great Dividing Range. The river flows northward through steep gorge areas in the Hill End area into Burrendong Dam, which is situated 30 km upstream of Wellington, from there it flows in a north-westerly direction downstream until it joins the Barwon River near Brewarrina. The unregulated section of the Macquarie River upstream of the storage receives inflows from Campbells River, Fish River, Queen Charlottes Vale and Evans Plains Creek, Winburndale Rivulet, Turon River, Crudine River and Summer Hill Creek.

2.3.1.2 Bank and Bed Stability

In 1999, the stability of banks, beds and bars was assessed at 9 sites on the Macquarie River upstream of Lake Burrendong, one of which was just upstream of the proposed offtake site (Baker and Raisin 2000). Bank stability was found to be good in the upper reaches and very good in the lower and middle reaches. In the lower reaches, erosion resistant components, such as extensive areas of exposed bedrock, and excellent vegetation cover, were responsible for bank stability. In the upper and mid reaches, disturbance of vegetation by livestock and flow diversion contributed to erosion of the banks. Rocks and vegetation such as willows also obstructed flows and resulted in localised erosion. Deposits of sand and gravel were evident on bench formations and the floodplain of the Macquarie River,

particularly in the upper reaches. The bed and bar stability was poor-very poor in the upper reaches, but moderate in the lower and middle reaches. It should be noted that the banks at the proposed offtake site are composed of bedrock.

2.3.1.3 Aquatic Habitat

In May 2011, the quality of the aquatic habitat at two potential offtake locations on the Macquarie River and at additional upstream and downstream reach was assessed (GHD 2011a).

2.3.1.4 Riparian and Aquatic Vegetation

Baker and Raisin (2000) noted that the riparian vegetation in the upper reaches had been subject to moderate to very high levels of disturbance, but that in the mid and lower reaches had been exposed to low to moderate levels, respectively. The species recorded by Baker and Raisin (2000) are listed in Table 2. The riparian strip generally lacked native overstorey and understorey species and was dominated by introduced species such as willows, blackberries and hawthorns. She-Oak (*Casuarina cunninghamiana*) was the dominant canopy species, with Crack and Weeping Willows (*Salix* sp.), Long-Leaved Box (*Eucalyptus goniolocalyx*), Apple Box (*E. bridgesiana*), Kurrajong (*Brachychiton populneus*) and Black Cypress Pine (*Callitris endlicheri*) also present. Various noxious species, including Blackberry (*Rubus fruticosus*) and Sweet Briar (*Rosa rubiginosa*) were present in the understorey layer. Native species, such as Hickory Wattle (*Acacia implexa*), Silver Wattle (*A. dealbata*), Western Golden Wattle (*A. decora*), Giant Hop bush (*Dodonea viscosa*) and Native Blackthorn (*Bursaria spinosa*) were also common. The groundcover included native species such as Kangaroo Grass (*Themeda australis*), Wallaby Grass (*Danthonia* sp.) and *Poa* sp. and introduced species such as Phalaris (*Phalaris aquatica*), Cocksfoot (*Dactylis glomerata*), *Bromus* sp. and Serrated Tussock (*Nassella trichotoma*).

Baker and Raisin (2000) found that the aquatic habitat in the lower and mid reaches was in good condition, but that in the upper reaches was in poor/moderate condition. The substratum in the upper reaches was composed mostly of sand, which was mobilised to varying degrees by flow events. Unconsolidated sandy bed and bank attached bar formations were evident upstream. The canopy and fringing vegetation on the channel fringe was in good quality, but composed mainly of willow species. The mid and lower reaches had a relatively stable substratum which supported a diverse range of aquatic habitats in healthy condition. The overstorey in these reaches provided moderate levels of canopy cover and aquatic habitats in the form of roots, leaf litter and branches. Low emergent aquatic plants were common, with *Cyperus* sp. and *Juncus* sp. being the dominant forms, but *Eleocharis* sp. and *Carex* sp. were also present. Isolated clumps of tall emergent plants, such as Common Reed (*Phragmites australis*), Cumbungi (*Typha* sp.), Marsh Clubrush (*Bolboschoenus fluviatilis*) and River Clubrush (*Schoenoplectus validus*) were present but less common. Filamentous green algae were also observed in the river. The aquatic plant species recorded by Baker and Raisin (2000) are listed in Table 2.

Table 2: Species of riparian and aquatic plants recorded in the upper Macquarie River and Summer Hill Creek catchments by Baker and Raisin (2000). Bold type indicates that these species were also observed during the aquatic ecology survey undertaken in December 2011 (Cardno, this study).

Common Name	Scientific Name	Upper Macquarie above Burrendong	Summer Hill Creek
RIPARIAN VEGETATION			
Alpine bottlebrush	<i>Callistemon paludosus</i>		X
Applebox	<i>Eucalyptus bridgesiana</i>	X	X
Blakely's red gum	<i>E. blakelyi</i>	X	
Box leaf wattle	<i>Acacia buxifolia</i>	X	
Brome grass	<i>Bromus sp.</i>	X	X
Bulbous canarygrass	<i>Phalaris aquatica</i>		X
Common velvetgrass	<i>Holcus lanatus</i>		X
Crack willow	<i>Salix fragilis</i>	X	X
Hickory wattle	<i>A. implexa</i>	X	
Hopbush	<i>Dodonaea viscosa</i>	X	X
Eglantine rose	<i>Rosa rubiginosa</i>	X	
Kangaroo grass	<i>Themeda australis</i>		X
Kurrajong bottle tree	<i>Brachychiton populneus</i>	X	
Long leaved box	<i>E. goniocalyx</i>	X	
Manna gum	<i>E. viminalis</i>	X	X
Oatgrass	<i>Danthonia sp.</i>	X	
Orchardgrass	<i>Dactylis glomerata</i>	X	X
Red box	<i>E. polyanthemus</i>	X	
River she-oak	<i>Casuarina cumminghamiana</i>	X	X
Serrated tussock	<i>Nassella trichotoma</i>	X	
Shrubby blackberry	<i>Rubus fruticosus</i>	X	X
Silver wattle	<i>A. dealbata</i>	X	X
Snow grass	<i>Poa sieberana</i>	X	X
Sweet bursaria	<i>Bursaria spinosa</i>	X	
Tumbledown red gum	<i>E. dealbata</i>		X
Weeping acacia	<i>A. vestita</i>		X
Weeping willow	<i>S. babylonica</i>		X
Western silver wattle	<i>A. decora</i>		X
White mountain gum	<i>E. dalrympleana</i>		X
Wimmera ryegrass	<i>Lolium rigidum</i>		X
Yellow box	<i>E. melliodora</i>	X	X
AQUATIC FLORA			
Arrow grass	<i>Triglochin sp.</i>		X
Bulrush	<i>Typha sp.</i>	X	X
Common reed	<i>Phragmites australis</i>	X	X
Pondweed	<i>Potamogeton tricarlinatus</i>		X
River bulrush	<i>Bolboschoenus fluviatilis</i>	X	
River club rush	<i>Schoenoplectus validus</i>	X	
Rush	<i>Juncus sp.</i>	X	X
Sedge	<i>Carex sp.</i>		X
Sedge	<i>Cyperus sp.</i>	X	X
Sedge	<i>Eleocharis sp.</i>	X	X

2.3.1.5 Fish

Sources of information on the occurrence of fish within the upper Macquarie River and adjoining waterways include:

- Predictions about the likely fish fauna prior to significant human intervention (Reference Condition) and results of sampling undertaken in this area as part of the Sustainable Rivers Audit of the Murray-Darling Basin (SRA) (Davies *et al.* 2008);
- Records of species surveyed and numbers of fish stocked in the Upper Macquarie River catchment obtained from John Pursey, NSW DPI;
- A survey of fish at the two offtake locations initially proposed for the Macquarie pipeline project (GHD 2011a);

Studies undertaken on fish in the Macquarie River downstream of Lake Burrendong (Davies *et al.* 2008; Rayner *et al.* 2009) have not been discussed, because the 76 m high dam wall prevents upstream passage of fish.

On the basis of expert knowledge, previous research, museum collections and historical data the SRA determined that 16 native and 5 alien species of fish are likely to have occurred in the upland zone of the Macquarie River in the absence of significant human intervention (Davies *et al.* 2008) (Table 3). In February and March 2007, the fish occurring at seven sites within this zone were sampled using a combination of boat-mounted, backpack or bank-mounted electrofishing gear and traps. Three native species, Carp Gudgeon (*Hypseleotris* spp.), Freshwater Catfish (*Tandanus tandanus*) and Mountain Galaxias (*Galaxias olidus*), and six introduced species, Brown Trout (*Salmo trutta*), Eastern Gambusia (*Gambusia holbrooki*), European Carp (*Cyprinus carpio*), Goldfish (*Carassius auratus*), Rainbow Trout *Onchorhynchus mykiss*) and Redfin Perch (*Perca fluviatilis*) were caught (Table 3). Native fish were less diverse than expected and also relatively scarce, comprising only 51% of the total numbers and 2% of the biomass caught. The native fish were also patchily distributed, with two sites having no native fish and four having only one species. Mountain galaxias and Eastern Gambusia were the most abundant native and introduced species caught, respectively. On the basis of these results, the SRA concluded that the fish fauna in the upland zone of the Macquarie River was in extremely poor condition.

The NSW DPI fish survey records from the Macquarie Catchment upstream of Burrendong Dam indicate that 16 species have been recorded (Table 3). It is important to note that the fish surveys undertaken at some sites have been limited in frequency, spatial extent, duration and intensity. The records include one site on the Macquarie River, at Bruinbun approximately 36 km upstream of the proposed offtake site, with Freshwater Catfish and Eastern Gambusia being the only species caught in February 2006. The records also indicate that Redfin Perch were present in Burrendong Dam in December 1975. NSW DPI has also undertaken surveys in the two rivers (Campbells and Fish) that form the Macquarie River. Seven alien species and one native species were caught in Campbells River and four alien and two native species were found in the Fish River (Table 4).

NSW DPI surveyed fish in the Turon River on 11 occasions between September 1994 and January 2009. The Turon River is an unregulated system that flows into the upper Macquarie River approximately 18 km upstream of the offtake site, so the fish species therein could potentially access the offtake site. The surveys yielded a total of four native and six alien fish species (Table 4). The fish occurring in Winburndale Rivulet and Pyramul Creek have also been surveyed (Table 4).

The freshwater fish stocking records for the period 01/01/2001-31/10/2011 provided by NSW DPI indicate that Golden Perch, Silver Perch and Murray Cod have been released into Burrendong Dam and that Golden Perch, Murray Cod, Trout Cod, Brown Trout and Rainbow Trout have been released into the Macquarie River upstream of the dam (Table 3).

Table 3: Fish species predicted (P) to occur in the upland zone of the Macquarie River in the absence of human intervention and records of fish species caught (X) during surveys of or known to have been stocked (S) in the upper Macquarie River and Lake Burrendong.

Common Name	Scientific Name	Upper Macquarie	Upper Macquarie	Macquarie River @ Bruinbun	Lake Burrendong	Macquarie River near proposed Offtake	Macquarie River near proposed Offtake
	Source	Davies et al. (2008)	DPI NSW	DPI NSW	DPI NSW	GHD (2011)	Cardno (2012)
NATIVE FISH							
Australian smelt	<i>Retropinna semoni</i>	P	X				
Carp gudgeon	<i>Hypseleotris spp.</i>	P	X				X
Dwarf flathead gudgeon	<i>Philypnodon macrostomus</i>	P	X				
Flat-headed gudgeon	<i>Philypnodon grandiceps</i>	P	X				
Flat-head galaxias	<i>Galaxias rostratus</i>	P					
Freshwater catfish	<i>Tandanus tandanus</i>	P	X	X		X	X
Golden perch	<i>Macquaria ambigua</i>	P	X, S		S		X
Macquarie perch	<i>Macquaria australasica</i>	P					
Mountain galaxias	<i>Galaxias olidus</i>	P	X				
Murray Cod	<i>Maccullochella peelii peelii</i>	P	X, S		S		
Murray Darling rainbowfish	<i>Melanotaenia fluviatilis</i>	P					
River blackfish	<i>Gadopsis marmoratus</i>	P	X				
Silver perch	<i>Bidyanus bidyanus</i>	P			S		
Southern purple-spotted gudgeon	<i>Mogurnda adspersa</i>	P					
Trout Cod	<i>Maccullochella macquariensis</i>	P	S				
Unspecked hardyhead	<i>Craterocephalus stercusmuscarum fulvus</i>	P					
ALIEN FISH							
Brown trout	<i>Salmo trutta</i>		X, S				
Eastern gambusia	<i>Gambusia holbrooki</i>	P	X	X		X	X
European carp	<i>Cyprinus carpio</i>	P	X	X		X	
Goldfish	<i>Carassius auratus</i>	P	X	X			X
Rainbow trout	<i>Onchorhynchus mykiss</i>	P	X	X, S			
Redfin perch	<i>Perca fluviatilis</i>	P	X	X	X	X	X
Brook Trout	<i>Salvelinus fontinalis</i>		X				

Table 4: Fish species that have been recorded (X) or stocked (S) into the tributaries that flow into the Macquarie River upstream of Lake Burrendong and Suma Park Reservoir by NSW DPI.

Common Name	Scientific Name	Campbells River	Fish River	Winburndale Rivulet	Turon River	Summer Hill Creek	Suma Park Reservoir	Pyramul Creek
NATIVE FISH								
Australian smelt	<i>Retropinna semoni</i>			X	X		X	
Carp gudgeon	<i>Hypseleotris spp.</i>				X			X
Dwarf flathead gudgeon	<i>Philypnodon macrostomus</i>							
Flat-headed gudgeon	<i>Philypnodon grandiceps</i>							
Flat-head galaxias	<i>Galaxias rostratus</i>							
Freshwater catfish	<i>Tandanus tandanus</i>				X			
Golden perch	<i>Macquaria ambigua</i>		S		S			
Macquarie perch	<i>Macquaria australasica</i>							
Mountain galaxias	<i>Galaxias olidus</i>	X	X	X	X			
Murray Cod	<i>Maccullochella peelii peelii</i>				S			
Murray Darling rainbowfish	<i>Melanotaenia fluviatilis</i>							
River blackfish	<i>Gadopsis marmoratus</i>			X				
Silver perch	<i>Bidyanus bidyanus</i>							
Southern purple-spotted gudgeon	<i>Mogurnda adspersa</i>							
Trout Cod	<i>Maccullochella macquariensis</i>							
Unspecked hardyhead	<i>Craterocephalus stercusmuscarum fulvus</i>							
ALIEN FISH								
Brown trout	<i>Salmo trutta</i>	X, S	X, S	X, S	X, S			
Eastern gambusia	<i>Gambusia holbrooki</i>	X	X		X	X		
European carp	<i>Cyprinus carpio</i>	X			X		X	X
Goldfish	<i>Carassius auratus</i>	X			X			
Rainbow trout	<i>Onchorhynchus mykiss</i>	X, S	X, S	X, S	X, S	S		
Redfin perch	<i>Perca fluviatilis</i>	X	X	X	X		X	X
Brook Trout	<i>Salvelinus fontinalis</i>	X						

The records show that several hundred Murray Cod fry were released at Gardiners Hole (i.e. the proposed offtake site) during November/December 2008, 2010 and 2011 and that similar numbers of this species were released at several nearby localities, including Jumbo Hole, Dixons Long Point and Noisy Hole (Table 5a). NSW DPI has also implemented a five-year restocking program for Trout Cod in the Macquarie River above Burrendong Dam, as part of the Recovery Plan for this threatened species. In 2009, hatchery-bred Trout Cod were released at seven sites on the upper Macquarie River, with one of the sites being Gardiners Hole (the proposed offtake site) and two others being nearby (i.e. Boat Hole and Dixons Hole). Three sites further upstream were stocked in 2010. A further stocking event, involving the release of 9,000 Trout Cod fingerlings took place in December 2011 (NSW DPI 2011). NSW DPI has also released Golden Perch, Murray Cod, Trout Cod, Brown Trout and Rainbow Trout into the Turon River.

The Sweetwater Fishing website indicates that Burrendong Dam has also been stocked with the native Freshwater Catfish, and with four introduced species, Brown Trout, Rainbow Trout, Redfin Perch and European Carp (Swanson 2006).

In March/April 2011, three species, Common Carp, Redfin Perch and Freshwater catfish, were caught at the upstream offtake site but only Redfin Perch and Eastern Gambusia were found at the downstream offtake site (GHD 2011a) (Table 6).

Table 5: Numbers of (a) Murray Cod and (b) Trout Cod released at various sites on the upper Macquarie River between 2004 and 2011 and 1991 and 2010, respectively.

(a) Murray Cod

Release Site	Latitude	Longitude	Year							
			2004	2005	2006	2007	2008	2009	2010	2011
Wallaby Rocks, 200m D/S of Wallaby Rocks Bridge on Sofala Hill End Road	-33.0758	149.6502							758	
Bridle Track Crossing, 120m U/S of causeway	-33.0702	149.4079								687
Turondale Road, 200m U/S from Coles Bridge	-33.0635	149.6196							757	686
Public road at Dixons Long Point Crossing	-33.0240	149.2813				5000				
Jumbo Hole	-33.0129	149.2564					730		889	805
Noisy Hole	-33.0116	149.2603					730			
Dixons Long Point	-33.0079	149.2800					730			
Gardiners Hole	-33.0005	149.2349					730		889	805
Crudine Road bridge, 6.2km along Crudine Road from major road junction	-32.9942	149.6414							758	
Boat Hole	-32.9936	149.2400					730		889	805
Boulder Hole	-32.9781	149.2450					730		889	805
Crudine Road bridge, 9.5km along Crudine Road from major road junction	-32.9767	149.6628							757	
Dick Burke's Hole	-32.9676	149.2450					730		889	805
Cleveland Hole	-32.9644	149.2568					730		889	805
Bundi Hole	-32.9563	149.2749					730		889	805
Pumpkin Hole	-32.9518	149.2782					730		889	805
Cockatoo Hole	-32.9464	149.2817					730		888	805
Mudgee town area	-32.5864	149.5779					660			
Walkers Reserve	-32.5864	149.5779		311						
Walkers Reserve + other sites	-32.5864	149.5779	6000							
Camping Tree Reserve	-32.5596	149.5757		312			660			
Poverty Point	-32.5417	149.2725						311		
Wilburtree rail bridge	-32.5221	149.5735					660			
Wilburtree Reserve and Road Bridge	-32.5138	149.5715		311						
River Bridge at Glen Esk	-32.4920	149.2697						311		
Belenfante Bridge T.S.R. Reserve	-32.4814	149.5077		311						
Castlereagh Hwy	-32.4814	149.5077						311		

continued

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Release Site	Latitude	Longitude	Year							
			2004	2005	2006	2007	2008	2009	2010	2011
Gooree Park, upstream and downstream	-32.4814	149.5077								1,378
Beaudesert	-32.4727	149.4852					660			
Kaludabah	-32.4677	149.4750					660			
Yamble Bridge	-32.4076	149.3337		1454	1455	1500	3000	311		
Yamble Bridge, U/S and D/S	-32.4076	149.3337								1,378
Cudgegong River Park	-32.4033	149.4716		1,454						
Guntawang Bridge	-32.4033	149.4716		311	1,454	1,500	3,518	311		1,378
Riverside Station Yards	-32.3960	149.3777						311		
Cullerrgarali Station	-32.3643	149.4173						311		

(b) Trout Cod

River	Release site	Latitude	Longitude	1991	1992	1993	2009	2010
Upper Macquarie	Boat Hole	32.9936	149.2400				9125	
	Gardiner's Hole	33.0001	149.2349				9125	
	Dixon's Hole	33.0237	149.2811				18250	
	Peisleys Hole	33.0552	149.3120				9125	
	The Pump Hole	33.0572	149.3101				9125	
	Root Hog	33.0930	149.3996				9125	
	Randwick Hole	33.1019	149.3934				9125	
	Killongbutta	33.2024	149.4293					3,500
	Warra Creek	33.2177	149.4205					3,000
	Freemantle	33.2225	149.4101					3,500
Turon	Turon River	NS	NS	1,800				
	Hill End	NS	NS	1,800				
	Crudine River	NS	NS			5,600		

Table 6: Species of fish recorded during the recent surveys of sites within the Project area undertaken by GHD (2011) and Cardno (2012).

Common Name	Scientific Name	Macquarie River		Summer Hill Creek		Suma Park Reservoir
		GHD (2011)	Cardno (2012)	GHD (2011)	Cardno (2012)	Cardno (2012)
Source						
NATIVE FISH						
Carp gudgeon	<i>Hypseleotris spp.</i>		X			
Freshwater catfish	<i>Tandanus tandanus</i>	X	X			
Golden perch	<i>Macquaria ambigua</i>		X			
Mountain galaxias	<i>Galaxias olidus</i>			X	X	
ALIEN FISH						
Eastern gambusia	<i>Gambusia holbrooki</i>	X	X	X	X	
European carp	<i>Cyprinus carpio</i>	X				
Goldfish	<i>Carassius auratus</i>		X	X		
	<i>Onchorhynchus mykiss</i>					
Rainbow trout	<i>mykiss</i>			X	X	
Redfin perch	<i>Perca fluviatilis</i>	X	X	X	X	X

2.3.2 Summer Hill Creek

2.3.2.1 Water Quality

An environmental flow equivalent to the inflow up to a maximum of 1ML/ day is released into the creek from Suma Park Reservoir (SMEC 2003). The water is discharged from a low-level offtake and is therefore likely to be considerably colder than the water within the creek, because the depth of the dam leads to thermal stratification. It is not known how far downstream any cold water pollution effects extend, if present.

2.3.2.2 Bank and Bed Stability

In 1999, the stability of banks, beds and bars was assessed at nine sites on Summer Hill Creek (Baker and Raisin 2000). The bank stability was found to be moderate, good and very good in the upper, mid and lower reaches of the creek, respectively. The instability in the upper reaches was due to the clearing of vegetation, alteration of flows for grazing and other agricultural developments and impact of livestock on the riparian zone. Willows also contributed to the diversion of flows. In the lower reach of the creek, the steep terrain has restricted development and limited disturbance. The bed and bar stability was found to be moderate/good, poor and moderate in the upper, mid and lower reaches of the creek, respectively. These features were less stable in areas where there was a high level of catchment development and channel incision.

2.3.2.3 Aquatic Habitat

In May 2011, the quality of the aquatic habitat was assessed at two major waterway crossings on Summer Hill Creek (GHD 2011a).

At the first location, situated to the north east of Orange, a large amount of woody debris was trapped on the upstream side of the box culvert next to the road bridge. The substratum in this section of the creek ranged from a silty mud bottom in the upstream pool to a cobble/gravel dominated substrate downstream of the culvert. A riffle area was evident downstream of the culvert. The stream bank was composed primarily of soil and appeared to be of moderate stability. The stream approximately 250 m upstream of the crossing was characterised by poor bank stability, turbid water and silty sediments and a large pool with several large snags but no perceptible flow. The substratum of the pool was composed of a

pebble and cobble matrix covered in a layer of silty mud. The stream downstream of the crossing consisted primarily of pool habitat with several large snags and occasional boulders present, and a small amount of riffle habitat. The substratum consisted of a silty mud matrix with sub-angular gravel.

The second location, located several kilometres further north-east along Ophir Road, was a box culvert crossing. The creek adjacent to the crossing was characterised by pool, run and riffle habitat and relatively clear water. The substratum varied from silty gravel within the pool area upstream of the culvert to clean cobbles and boulders downstream. Snags were evident throughout this reach. There was a small concrete weir upstream of the crossing that might cause a slight barrier to fish passage during times of low flow. The upstream reach consisted primarily of pool habitat but with some riffles and runs. The substratum within the pools was made up of a gravel/silt matrix. The riffles were composed of cobbles and occasional boulders. The downstream reach was dominated by riffle/run areas, with pools and backwaters also present. The substratum consisted mostly of cobbles and boulders. There were large amounts of gravelly-silty substrata and several small snags within the pool areas.

2.3.2.4 Riparian and Aquatic Vegetation

Baker and Raisin (2000) noted that the riparian vegetation in the upper, mid and lower reaches of the creek had been subject to very high, moderate and low levels of disturbance, respectively. The riparian strip generally lacked native overstorey and understorey species and was dominated by introduced species such as willows, blackberries and hawthorns. The species recorded by Baker and Raisin (2000) are listed in Table 2.

The aquatic habitat was considered to be in moderate, poor and good condition in the upper, mid and lower reaches of the creek, respectively. Emergent, submerged and floating aquatic plants were present in the catchment. The emergent species included Common Reed (*Phragmites australis*), Cumbungi (*Typha* sp.), *Carex* sp., *Juncus* sp., *Cyperus* sp. and *Eleocharis* sp. Fringing vegetation, such as reeds and sedges, was of minor to moderate importance. Submerged and floating aquatic vegetation were common in pool and run habitats, but their distribution was patchy. Floating Pondweed (*Potamogeton tricarlinatus*) and Ribbon Weed (*Triglochin* sp.) were the main floating and submerged aquatic plants observed. The species recorded by Baker and Raisin (2000) are listed in Table 2. Willows were common downstream of Suma Park Dam.

The roots of these trees form mats that alter the substratum in the channel, divert flows, reduce channel capacity and affect the availability of aquatic habitat. These also affect nutrient input, water availability and shading.

In 2009, Summer Hill Creekecare Inc. obtained funding through the Caring for Country programme to address the following degradation issues at the Third Crossing on Summer Hill Creek:

- Replacement of native vegetation by invasive species such as willows;
- Choking of the stream by willow logs and gouging of stream banks which causes erosion and impedes natural flows required by aquatic flora and fauna;
- Loss of biodiversity, including declining number of platypus.
- Decomposition of willow bark leading to the release of salicylic acid, a potentially toxic chemical;
- Trampling of phosphorus-rich river banks by stock, leading to erosion and eutrophication of downstream storage area.

At the major watercourse crossing to the north-east of Orange, the riparian zone consists largely of grasses and introduced weeds, but scattered eucalypt trees are present upstream (GHD 2011a). The riparian zone at the crossing several kilometres further north-east along Ophir Road is fairly dense, with several large trees and small shrubs present. Sections of

the riparian zone in the upstream part of the reach had been replaced with a car park and access road along the creek edge. The riparian zone upstream and downstream of the crossing is moderately dense and continuous for at least 20 metres on both banks and composed of native and introduced species.

2.3.2.5 Fish

The NSW DPI records indicate that the introduced pest species Eastern Gambusia (*Gambusia holbrooki*) was present in Summer Hill Creek in March 2006 and that fry and fingerlings of another introduced species, Rainbow Trout (*Onchorhynchus mykiss*), have been released into the creek at the 3rd and 4th crossings on Ophir Road on several occasions between 2001 and 2010 (Table 4). Rainbow trout fry are also known to have been released into this creek between 1984 and 2001 by the Orange Trout Acclimatisation Society (NSW Fisheries 2003).

In May 2011, one native species (Mountain Galaxias) and four introduced species, Eastern Gambusia, Redfin Perch, Goldfish (*Carrasius auratus*), and Rainbow Trout, were caught at the two sites sampled in Summer Hill Creek (GHD 2011a) (Table 6).

2.3.3 Ophir Creek

The freshwater fish stocking records on the NSW Fisheries database indicate that Rainbow Trout fingerlings and Trout Cod fry were released into this creek by the Orange Trout Society Acclimatisation Society in 1995 and Central Acclimatisation in 1991, respectively (NSW Fisheries 2003).

2.3.4 Suma Park Reservoir

2.3.4.1 Setting

Suma Park Reservoir, the major water storage for Orange, is located on Summer Hill Creek, approximately 6 km north east of Orange (SMEC 2003). The reservoir has a catchment area of approximately 179 km², a surface area of 1.6 km² at Full Supply Level (FSL) and storage capacity of 17, 290 ML (Geolyse 2012). The dam wall is a concrete arch structure approximately 31 m high, 208 m long and 2.4 m wide. There is a 62 m spillway in the centre of the main dam. A plunge pool at the base of the main dam wall dissipates energy from spillway flows. There is an intake tower just upstream of the main dam wall and a small access bridge linking the dam wall to the top of the tower. There is a 6 m high earth fill saddle dam approximately 400 m west of the main dam wall. The dam is approximately 30 m deep, so the water within is likely to be thermally stratified, with a cold bottom layer overlain by a warmer surface layer. An environmental flow equivalent to the inflow up to a maximum of 1ML/ day is released into the creek from Suma Park Reservoir (SMEC 2003).

2.3.4.2 Water Quality

The water usually remains within the reservoir for sufficient time to allow suspended solids to settle from the water column. As a result, the total suspended solids and turbidity levels are generally low. According to SMEC (2003), the standard turbidity range is 1.5 to 4 ntu and the maximum level is about 40 ntu.

2.3.4.3 Riparian and Aquatic Vegetation

SMEC (2003) noted the reservoir was fringed by willows, rushes and sedges and that water ribbons (*Triglochin procera*) was the most common aquatic plant.

2.3.4.4 Fish

NSW Fisheries identified that one threatened species, the Silver Perch (*Bidyanus bidyanus*), and an endangered population of the Olive Perchlet (*Ambassis agassizi*) could potentially occur in Suma Park Dam (SMEC 2003). This issue is considered further in Section 5 of the report.

The records obtained from NSW DPI indicate that one native species, Australian Smelt (*Retropinna semoni*), and two alien species, European Carp and Redfin Perch, were caught in the reservoir in July 2010 (Table 4). There is no indication of any stocking activity.

2.3.5 Groundwater Dependent Ecosystems

In NSW, there are five major types of groundwater systems: Deep Alluvial, Shallow Alluvial, Fractured Rock, Coastal Sand bed and Sedimentary Rock. The groundwater resources in the Macquarie-Bogan catchment are located within inland alluvial, porous rock and fractured rock aquifers (Green *et al.* 2011). These resources are spread across 14 Groundwater Management Areas (GMAs). The Project Area is situated within the Lachlan Fold Belt GMA and is underlain by fractured rock which yields little groundwater. The groundwater resources in this GMA are managed under the Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011. The map that accompanies this plan indicates that none of the high priority GDEs that have been identified within the Lachlan Fold Belt GMA is situated within the Project Area.

The downstream reaches of the Macquarie River are located above the following GMAs:

- Upper Macquarie Alluvium which extends from Narromine to 8km upstream of Wellington, and incorporates the urban areas of Dubbo and Wellington and consists of alluvial deposits associated with a section of the Upper Macquarie River;
- Lower Macquarie Alluvium which extends downstream from Narromine;
- Great Artesian Basin Alluvium which underlies the Macquarie catchment downstream of Warren.

The map that accompanies the Water Sharing Plan for the NSW Great Artesian Basin Shallow Groundwater Sources 2011 does not show any GDEs adjacent to the Macquarie River downstream of Warren. No high priority GDEs are identified on the Water Sharing Plan for the Lower Macquarie Groundwater Sources 2003. The map accompanying the Water Sharing Plan for the NSW Murray Darling Porous Rock Groundwater Sources 2011 shows that high priority GDEs occur on the margins of the Gunnedah-Oxley Basin MDB (Macquarie) Management Zone.

2.4 Conclusions

The review of existing information on the aquatic ecology of the Upper Macquarie River indicates

- Riparian and aquatic habitats in the upper reaches have been subject to more disturbance than those in the mid and lower reaches;
- Aquatic substratum in the upper reaches consisted mostly of sand and was more mobile than that in the mid and lower reaches;
- Introduced species were common in both the riparian zone (e.g. willows, blackberries and hawthorns) and water column (e.g. trout, goldfish, carp and redfin perch).
- Filamentous green algae, low and tall emergent aquatic plants were present;
- The fish fauna was relatively diverse, but native species were relatively scarce;
- Threatened fish species may occur in the Project Area.

The review of existing information on the aquatic ecology of Summer Hill Creek indicates:

- Riparian and aquatic habitats in the upper and mid reaches of the creek were more disturbed than that in the lower reaches;
- Introduced species such as willows, blackberries and hawthorns were common in the riparian zone;
- Emergent, submerged and floating aquatic plants were present;

- Fish fauna was not diverse, consisting of four alien and one native species;
- No threatened species were identified.

Existing information on the aquatic ecology of Suma Park Reservoir is limited.

3 Existing Aquatic Environment

3.1 Objectives

The description of the existing aquatic environment is based on the results of a five day field survey of nine study sites conducted from 9-12 December 2011. The field studies were divided into two components: an initial investigation of all the proposed stream crossings followed by in-depth studies of aquatic ecology at selected sites. The primary objective of these investigations was to describe the existing aquatic environment at sites that may be impacted by the Project and identify issues that may arise from the proposed works.

The specific objectives of the studies at the stream crossings were to:

1. Assess the condition of the aquatic and riparian habitats and water quality at the proposed pipeline crossings over the major creeks and minor creeks/gullies (e.g. Oak Creek and Kitty Creek), if water is present;
2. Identify potential issues associated with the installation of the proposed pipeline;
3. Identify study sites for more in-depth studies of aquatic ecology.

The objectives of the in-depth studies were to

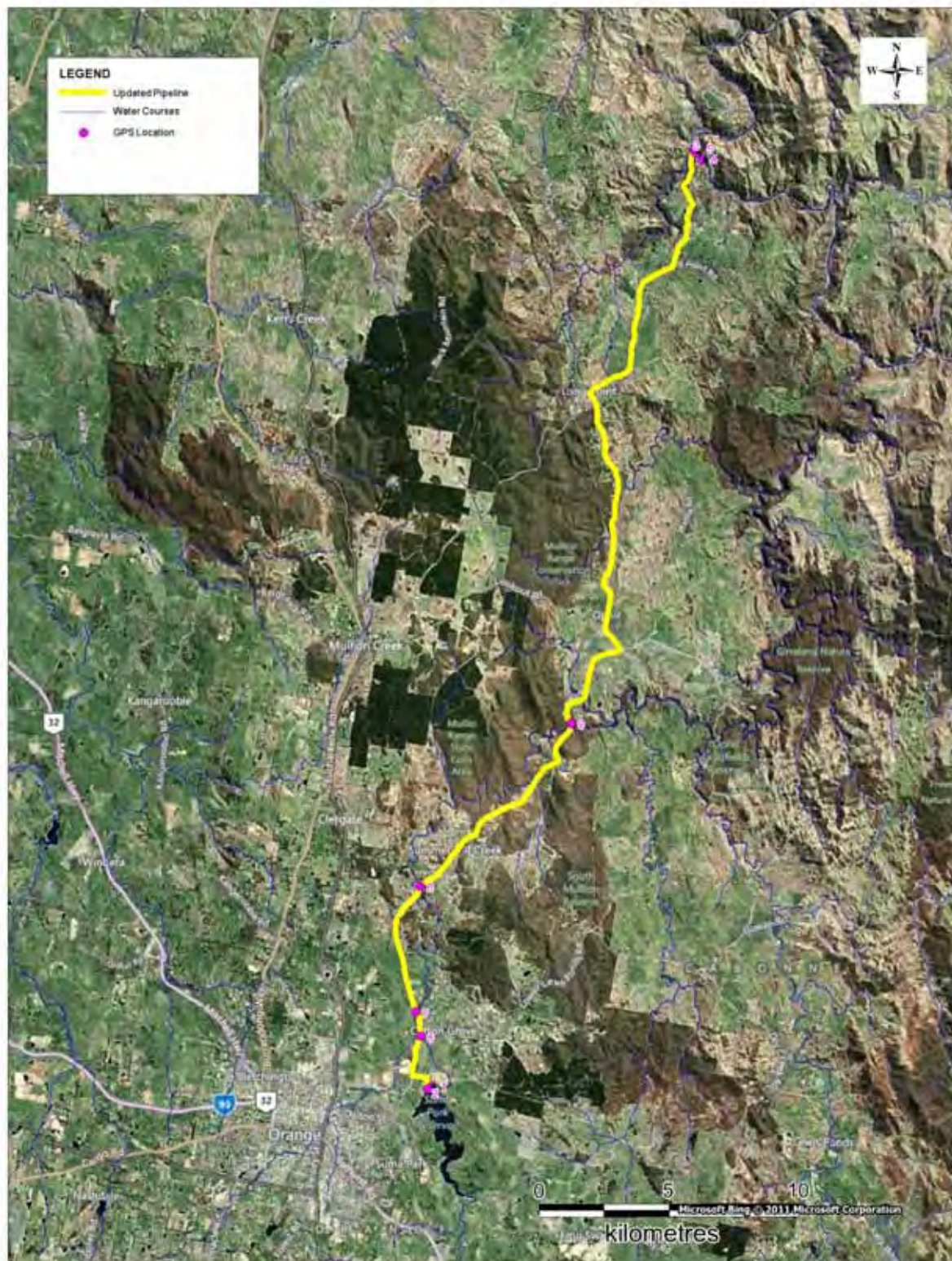
1. Assess the condition of aquatic and riparian habitat features and water quality at the time of sampling;
2. Determine the species composition, structure and condition of native and non-native aquatic vegetation;
3. Determine the taxonomic composition and “health” of the aquatic macroinvertebrate fauna associated with riffle and pool edge habitats;
4. Identify and estimate the relative abundance of native and alien fish species and confirm the presence of any threatened species; and
5. Determine whether platypus is present.

The survey undertaken was not intended to serve as a baseline for impact assessment.

3.2 Study Sites

In-depth aquatic ecology studies were undertaken at the proposed offtake site on the Macquarie River and at sites 300 m upstream and 200 m downstream, at the four existing road crossings over Summer Hill Creek and in the vicinity of the proposed Outlet in Suma Park Reservoir. The location of study sites on the river and creeks depended on provision of access by landholders. In some cases it was possible to sample both upstream and downstream of the crossing. The study sites on the Macquarie River were approximately 100 m long.

The GPS co-ordinates of the study sites are listed in Appendix 1 and their position along the pipeline corridor is shown in Figure 2. The survey methodology is described in Section 3.3 and the findings of the field investigations are presented in Sections 3.4 and in Table 6, Appendix 3 and Plates 1-13.



 **Cardno**
W4916
March 2012

Figure 2: Map showing the position of the aquatic ecology survey sites along the pipeline corridor.

3.3 Sampling Conditions

The survey was undertaken 19 days after the commencement of a significant rainfall and flood. During this event, the discharge volume at the gauging station downstream of Long Point increased from 176 ML/day (21 November) to over 7,600 ML/day (28 November), water depth increased from 1.33 m (19 November) to 2.99 m (27 November) and water temperature declined from 24.9° C (21 November) to 17.0 °C (25 November).

There was also significant rainfall several days before and on the first day of the survey. The data from the gauging station downstream of Long Point indicates that the depth, flow and temperature of water at the time of the survey (14 December), were 1.75 m, 1223 ML/d and 22.2 °C, respectively. The flow at the time of the survey was consequently still well above baseflow. The relatively high flow levels that prevailed during the survey period prevented:

- Assessments of the condition of exposed stream banks, particularly in terms of stability, erosion and other forms of disturbance (e.g. access by livestock);
- Searches for platypus burrows along the banks;
- Use of some fish sampling equipment in the Macquarie River.

The sampling conditions were thus very different from those experienced during the survey undertaken by GHD (2011).

3.4 Study Methodology

3.4.1 Aquatic Habitat Assessment

The position of each creek crossing and selected study site was recorded using a hand-held GPS unit. Digital photographs showing upstream and downstream views of the aquatic and riparian habitat were taken at each site and crossing. A standardised description of adjacent land and condition of riverbanks, channel and bed was then recorded using a modified version of the Riparian, Channel and Environmental Inventory (RCE) modified for Australian conditions by Chessman *et al.* (1997). The RCE score for each site was calculated by summing the scores for each of the 13 standard descriptors. Total score vary from 13 for a heavily channelled site without any riparian vegetation to 52 for a site with little or no obvious physical disruption.

At each crossing and study site, general observations of water characteristics, such as flow rates, clarity and odour, identity and condition of riparian vegetation, substratum characteristics and presence of impediments to fish passage were recorded. Morphological features, such as the width-depth ratio, bank stability and composition, silt cover, gravel bars, pools, riffles, runs and snags were also noted. The potential for sites to provide fish habitat was assessed according to criteria developed by NSW DPI (Fairfull and Witheridge 2003).

3.4.2 Water Quality

At the First, Second and Third Crossing on Summer Hill Creek, two replicate measures of the following water quality parameters were recorded using a calibrated Yeokal 611 multi-sensor water quality probe deployed just below the surface:

- Electrical conductivity (µs/cm);
- Salinity (ppt);
- Temperature (°C);
- Turbidity (ntu);
- Dissolved oxygen (mg/L and % saturation);
- pH; and
- Oxidation reduction potential (mV).

The quality of water at the other sites could not be determined because of an electrical fault in the probe.

Water quality measurements were compared with the ANZECC/ARMCANZ (2000) default trigger values for slightly disturbed upland streams in South-east Australia.

3.4.3 Riparian and Aquatic Vegetation

At each of the selected study sites, the width, nature (native, exotic, and mixture), completeness and the extent to which the riparian zone overhangs the bank of the river/creek were assessed.

The identity and percentage cover of submerged and emergent macrophytes was also assessed. Macrophytes were identified in the field using guide books, such as *Waterplants of Australia* by Sainty and Jacobs. Identifications were to species level, if feasible.

3.4.4 Aquatic Macroinvertebrates

Aquatic macroinvertebrates, such as prawns, shrimps, crayfish, snails, mussel, larval dragonflies, damselflies, mayflies and other insects are an important food source for many species of fish and platypus. At each study site, dip nets (250 µm mesh) were used to sample the aquatic macroinvertebrates associated with pool edge habitats, in accordance with the Australian River Assessment System (AUSRIVAS) methodology described in Turak *et al.* (2004). Pool edge habitats were sampled by using the dip net to agitate and scoop up material from vegetated river edges. Each sample was collected over a period of 3-5 mins from a 10 m length of habitat along the river. If the pool habitat was discontinuous, patches of habitats with a total length of 10 m were sampled.

The chemical and physical variables required for running the AUSRIVAS predictive model were also recorded. The substratum grain size, alkalinity of the water, modal; stream width, modal depth of water in riffles, composition and cover of algae and detritus were recorded in the field prior to sampling. The other variables, distance from source, altitude, land-slope and rainfall, were determined in the laboratory.

Each sample was rinsed out of the dip net onto a white sorting tray from which animals were picked using forceps and pipettes. Each tray was picked for a minimum period of forty minutes, after which they were picked at ten minute intervals for either a total of one hour or until no new specimens had been found. Care was taken to collect cryptic and fast moving animals in addition to those that were conspicuous or slow. The animals collected at each site were placed into a labelled jar containing 70% alcohol.

In the laboratory, each sample was sorted under a binocular microscope (at 40 X magnification), macroinvertebrates were extracted, identified to family level using standard references and up to ten animals of each family counted, in accordance with the latest AUSRIVAS protocol (Turak *et al.* 2004). Identifications were confirmed using standard references. After confirmation of sample identifications, samples were stored in 70% alcohol in containers appropriate for long-term storage.

The AUSRIVAS spring predictive model for NSW pool edge habitats was used to assess the health of the river at each site on the Macquarie River and in Summer Hill Creek (Coysh *et al.* 2000). This method is not appropriate for samples collected in reservoirs or lakes. Two of the indices generated by the AUSRIVAS model were examined:

- **OE50 Taxa Score** - This is the ratio of the number of macroinvertebrate families with a greater than 50% predicted probability of occurrence that were actually observed (i.e. collected) at a site to the number of macroinvertebrate families expected with a greater than 50 % probability of occurrence. OE50 taxa values range from 0 to 1 and provide a measure of the impairment of macroinvertebrate assemblages at each site, with values close to 0 indicating an impoverished assemblage and values close to 1 indicating that the condition of the assemblage is similar to that of the reference streams.

- Overall Bands derived from OE50 Taxa scores which indicate the level of impairment of the assemblage. These bands are graded as follows:
 - o Band X = Richer invertebrate assemblage than reference condition.
 - o Band A = Equivalent to reference condition.
 - o Band B = Sites below reference condition (i.e. significantly impaired).
 - o Band C = Sites well below reference condition (i.e. severely impaired).
 - o Band D = Impoverished (i.e. extremely impaired).

The revised SIGNAL2 biotic index (Stream Invertebrate Grade Number Average Level) developed by Chessman (2003) was used to determine the “environmental quality” of sites on the basis of the presence or absence of families of macroinvertebrates. This method assigns grade numbers to each macroinvertebrate family or taxa found, based largely on their responses to chemical pollutants. The sum of all grade numbers for that habitat was divided by the total number of families recorded in each habitat to calculate the SIGNAL2 index. The SIGNAL2 index therefore uses the average sensitivity of macroinvertebrate families to present a snapshot of biotic integrity at a site. SIGNAL2 values greater than 6, between 5 and 6, 4 and 5 and less than 4 indicate that the quality of the water is clean, mildly, moderately or severely degraded, respectively.

3.4.5 Fish and Mobile Invertebrates

A variety of sampling techniques (e.g. backpack electrofishing, gill nets and baited traps) were used to target small, medium and large fish and mobile invertebrates (e.g. crayfish) at each study site. The decision to use specific sampling tools depended on site conditions, safety issues and the need to avoid drowning platypi. All fish caught were placed into a tub containing water, identified, measured, counted, checked for abnormalities and then released as quickly as practicably possible. The numbers of each species of fish captured at each site were recorded on data sheets. Non-native species were humanely disposed of, as per DPI NSW guidelines. All fish captured and their fates were reported to DPI NSW and the Director General's Ethics Committee as per the conditions of our permit to sample fish.

Backpack electrofishing, a non-destructive technique that is restricted to depths of approximately 1 m (hip height) and water bodies with low to moderate salinity, was used to sample fish occurring in the creeks and shallow sections of the river. The operator of the electrofisher stunned fish by discharging electric pulses into the water, thus enabling them to be captured by an assistant equipped with a dip net. Electrofishing was conducted in riffles, shallow pools and beneath overhanging banks and vegetation along standardised 50 m lengths of river bank.

Gill nets were used to capture fish in the Macquarie River and Suma Park Reservoir. The gill nets used consisted of rectangular mesh panels that form a wall into which fish swim and become entangled by their gills or spines. The nets consisted of various sizes of mesh and various lengths and targeted relatively large fish. The nets were deployed using a 5 m canoe and set for a maximum period of three hours during daylight and checked every hour to minimise harm to fish and platypus.

At each site, six collapsible bait traps were deployed overnight in discrete locations on the streambed, amongst vegetation and near submerged logs or within dense vegetation. The traps used were 350 mm long, 200 mm wide, had an entrance that tapers in to 15 mm and were constructed of 3 mm wide mesh.

3.5 Results

3.5.1 Macquarie River

The offtake site is located adjacent to Gardiners Hole on the southern bank of the Macquarie River near the confluence with Boshes Creek. Gardiners Hole is approximately 1 km long and around 3 m deep adjacent to the left bank. The surrounding land is steep, vegetated with native eucalypt forest, but with some cleared areas. A residential property occurs on the upper bank.

Three sites were sampled: the proposed offtake site, 300 m further upstream and 200 m downstream. The prevailing flow and depth of water limited use of the backpack electrofisher.

3.5.1.1 Offtake Site

The width of the river at this point ranged from 50 m to 70 m and the maximum water depth was approximately 3.5 m (Plates 1a and b). The site was classified as 100% pool throughout. The river substratum was composed mostly of silt and clay, but with boulders and cobbles in some sections. Snags were present in approximately 5% of the site. The large rocky outcrop evident on the river bank extended into the river under the prevailing flows, but may not do so at low flows. The RCE score for this site (37) indicated moderate habitat degradation.

Fine detritus mixed with sediment resulted in fair water visibility. The water quality was not measured.

Invasive grasses and shrubs dominated the riparian vegetation. Sparse patches of Rice Sedge (*Cyperus difformis*) and Common Reed (*Phragmites australis*) were observed.

The macroinvertebrate sample yielded 9 taxa and was dominated by water boatmen (Corixidae) and shrimps (Atyidae) (Appendix 3). The sample was severely impaired relative to the AUSRIVAS freshwater reference condition, lacking 54% of the families with a 50% probability of occurrence predicted to occur in pristine streams with similar characteristics. The SIGNAL2 score (4.0) for this site is indicative of moderate degradation.

This site contained significant fish habitat, but no fish or aquatic macroinvertebrates were caught in the bait traps.

a)



b)



Plate 1: Macquarie River Offtake site – (a) Upstream view; b) Point of water extraction.

3.5.1.2 Upstream Site

The width of the river ranged between 30 m and 60 m with a maximum water depth of approximately 3.2 m (Plates 2a and b). The site was classified as 100% pool throughout. The substratum was composed of silt and clay with boulders and cobble. Large fallen trees created snags that occupied approximately 10% of the wetted width. The RCE score (37) for this site indicated moderate habitat degradation.

Fine detritus mixed with sediment resulted in fair water visibility.

The riparian vegetation was dominated by invasive grasses and shrubs. Occasional patches of Rice Sedge and Common Reed were also present.

The macroinvertebrate sample yielded eight taxa and was dominated by water boatmen (Corixidae) and shrimps (Atyidae) (Appendix 3). The sample was significantly impaired relative to the AUSRIVAS freshwater reference condition, lacking 36% of the families with a 50% probability of occurrence predicted to occur in pristine streams with similar characteristics. The SIGNAL2 score (2.6) for this site indicates severe degradation.

This site contained significant fish habitat (i.e. it is situated on a major permanently flowing waterway that is known to be inhabited by threatened fish species). Six golden perch (*Macquaria ambigua*) with fork lengths of 40, 42, 43, 46, 46, 50 mm (Plate 2c) and one redfin perch (*Perca fluviatilis*) with a fork length of 27.5 mm (Plate 2d) were caught in the gill nets. No animals were caught in the baited traps.

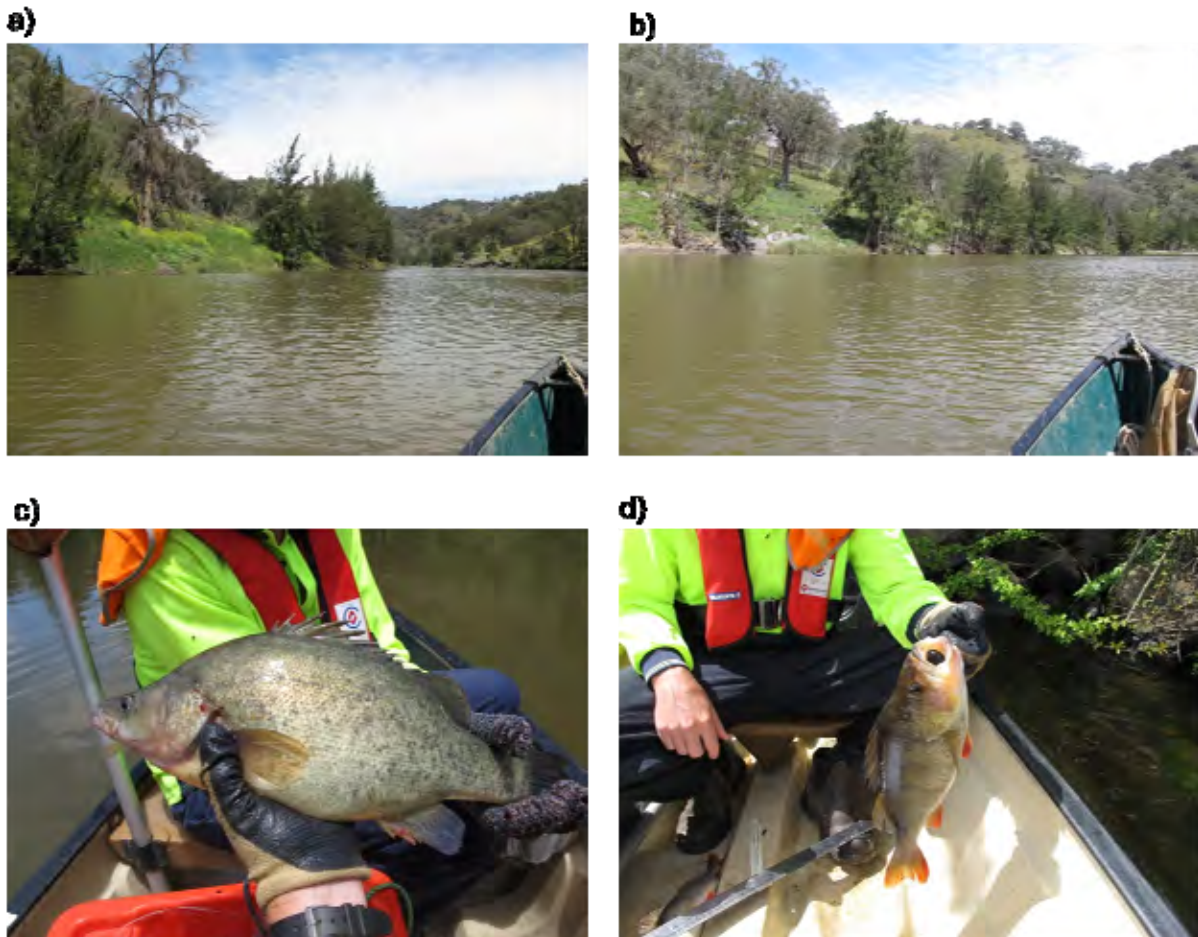


Plate 2: Macquarie River - Upstream site - (a) upstream view; (b) downstream view ; (c) Golden perch (*Macquaria ambigua*) (d) Redfin perch (*Perca fluviatilis*).

3.5.1.3 Downstream Site

The width of the river ranged between 8 – 12 m and the maximum water depth was approximately 2.1 m (Plates 3a and b). Surrounding land use consisted of native eucalypt forest with large areas of exposed cobble stone in downstream sections. The site was classified as 70% pool and 30% riffle habitat with riffle habitat occurring at the downstream end of the site. The substratum in the deep pools was silt and clay. The riffles were composed of boulders and cobbles. Snags were present in approximately 5% of the waterbody. Fine detritus mixed with sediment resulted in fair water visibility. The RCE score for this site (38) indicated moderate habitat degradation.

Invasive grasses and shrubs dominated the riparian vegetation along the river's edge. There were sparse patches of Rice Sedge, an emergent macrophyte, amongst the grasses.

The macroinvertebrate sample yielded 17 taxa, with water boatmen (Corixidae), shrimps (Atyidae) and stick caddis flies (Leptoceridae) being dominant (Appendix 3). The sample was equivalent to the AUSRIVAS reference condition and lacked only 13% of families with a 50% probability of occurrence predicted to occur in pristine streams with similar characteristics. The SIGNAL2 score (3.7) for this site indicates severe degradation.

This site contained significant fish habitat. Electrofishing in the shallow downstream riffle area yielded 3 Firetailed Gudgeon (*Hypseleotris galii*), 1 Freshwater Catfish (*Tandanus tandanus*) (Plate 3c), 2 yabbies (*Cherax destructor*) and 1 freshwater prawn (*Macrobrachium australiense*), all of which are native species. The following alien fish were also caught: 14 Eastern Gambusia, 11 Goldfish (*Carassius auratus*) (Plate 3d) and 3 Redfin Perch.



Plate 3: Macquarie River - Downstream site - (a) Upstream view ; b) Downstream view; (c) Eel tailed catfish (*Tandanus tandanus*) and (d) Goldfish (*Carassius auratus*) caught by electrofishing.

3.5.2 Pipeline Stream Crossings

3.5.2.1 First Crossing Summer Hill Creek

The first crossing of Summer Hill Creek is located 2.4 km downstream of Suma Park Reservoir adjacent to Ophir Road. The crossing consists of a bridge supported by four concrete piles and is equipped with a safety rail (Plate 4a). The surrounding land is used for agricultural grazing.

The survey at this site was restricted to the upstream side of the bridge, because of limited land access issues. The river was 3 – 5 m wide and the maximum water depth was 1.2 m (Plates 5a and b). The site was classified as 100% pool. The substratum was comprised entirely of silt and clay. The willows (*Salix* sp.) and native trees at the shallow upstream end of the site provided dense shading but restricted flows (Plate 5c). Snags and woody debris

were present along approximately 70% of the water body. The RCE score for this site (32) indicated moderate habitat degradation. The bridge was clear of woody debris at the time of the survey, so there was no impedance of stream flow.

The water visibility was good. The electrical conductivity and turbidity of the water was within the ANZECC/ARMCANZ (2000) default trigger values (DTV) for slightly disturbed upland rivers in south-east Australia, but dissolved oxygen and pH levels were below the lower DTV (Table 7).



Plate 4: Summer Hill Creek Crossings: (a) First Crossing; (b) Second Crossing; (c) Third Crossing 3; (d) Fourth Crossing.

Dense patches of the emergent macrophytes Curled Dock (*Rumex crispus*) (Plate 5d) and River Club Rush (*Schoenoplectus validus*) were present along the creek edges. Small patches of rice sedge (*Cyperus difformis*) and sedge (*Carex* sp.) were also observed. A submerged macrophyte, the pondweed, *Potamogeton tricarlinatus*, was also present.

The macroinvertebrate sample contained 20 taxa, with pond snails (Physidae), copepods, water fleas (Cladocera), mites (Hydracarina), water boatmen (Corixidae), water scavenger beetles (Hydrophilidae) and chironomid fly larvae being relatively abundant (Appendix 3). The sample was significantly impaired relative to the AUSRIVAS reference condition, lacking 37% of the families with a 50% probability of occurrence predicted to occur in pristine streams with similar characteristics. The SIGNAL2 score (2.9) for this site indicates severe degradation.

This site contained moderate fish habitat. Eastern Gambusia was the only fish caught, with one individual being caught in the baited traps and 20 by electrofishing.

(a)



(b)



(c)



(d)



Plate 5: Summer Hill Creek, First Crossing: - (a) Upstream view; (b) Downstream view; (c) Upstream section of river shaded by mixed native and exotic vegetation; (d) Dense patches of Curled Dock (*Rumex crispus*) fringing the creek.

Table 7: Mean ($\pm$ S. E.) physico-chemical water quality measurements for the First, Second and Third Crossings over Summer Hill Creek. Bold indicates measurements were outside the ANZECC/ARMCANZ (2000) trigger values for slightly disturbed upland streams in south-east Australia.

Parameter	Trigger Values	First Crossing		Second Crossing		Third Crossing	
		Mean	SE	Mean	SE	Mean	SE
Temperature ($^{\circ}$ C)		17.3	0.0	17.3	0.0	18.2	0.0
Conductivity (μ S/cm)	30-350	177.5	2.5	182.5	2.5	188.5	2.5
pH	6.5 - 7.5	7.6	0.0	7.7	0.0	7.7	0.0
ORP		361.5	0.5	391.5	1.5	401.0	0.0
DO (% sat)	90 - 110	61.8	0.0	67.5	1.3	72.7	0.1
Turbidity (ntu)		7.4	3.3	13.6	0.2	10.7	0.0

3.5.2.2 Second Crossing Summer Hill Creek

The second crossing over Summer Hill Creek is situated 3.4 km downstream of Suma Park Reservoir adjacent to Ophir Road on land belonging to Charles Sturt University. The crossing consists of a low bridge supported by three concrete piles (Plate 4b). The flood marker down the road suggests that this crossing may be prone to flooding. The surrounding land is used for agricultural grazing.

At this site, the survey was also conducted upstream of the existing bridge, due to land access issues. The width of the river ranged from 3 m to 8 m and the maximum water depth was approximately 1.3 m (Plates 6a and b). The site was classified as 100% pool throughout. The substratum was heavily silted but stable. Snags comprised <1% of the water body, reflecting their absence from the riparian zone. The bridge was clear of woody debris at the time of the survey, so stream flow was not impeded.

The water visibility was poor. The electrical conductivity and turbidity measurements were within the ANZECC/ARMCANZ (2000) guidelines, but dissolved oxygen and pH levels were below the lower DTVs for slightly disturbed upland rivers (Table 7). The RCE score for this site (29) indicates severe degradation.

River Club Rush was abundant along the edge of the main water body (Plate 6c). Curled Dock and Rice Sedge were restricted to the river bank. No submerged macrophytes were evident.

The macroinvertebrate sample contained 15 different taxa, with pond snails (Physidae), mites (Hydracarina), ostracod and copepod crustaceans being the most common (Appendix 3). The samples were severely impaired relative to the AUSRIVAS reference condition, lacking 64% of the families with a 50% probability of occurrence predicted to occur in pristine streams with similar characteristics. The SIGNAL2 score (3.0) for this site indicates severe degradation.

This site contained moderate fish habitat. Eastern Gambusia was the only fish species observed at this site, with one individual being caught by electrofishing (Plate 6d). No fish were caught in the baited traps.

a)



b)



c)



d)



Plate 6: Summer Hill Creek, Second Crossing: (a) Upstream view; (b) Downstream view; (c) River Club Rush (*Schoenoplectus validis*); (d) Electrofishing at downstream location.

3.5.2.3 Third Crossing Summer Hill Creek

The third crossing over Summer Hill Creek is located 10.4 km downstream of Suma Park Reservoir adjacent to Ophir Road. The crossing comprises a bridge supported by six concrete pillars (Plate 4c), two of which are within the 'wetted width'. The bridge is equipped with a safety rail. There is a box culvert just downstream of the bridge. It did not restrict flow at the time of the survey, but would be a barrier to migrating fish during low flows. In March/April, the culvert was blocked by large amounts of woody debris (GHD 2011a). The land on the left bank is used for agricultural grazing, whereas that on the right consists of a mixture of native and exotic forest, with Eucalypts predominating.

Sampling was undertaken upstream and partially downstream of the bridge, due to land access issues. The width of the river ranged from 8 m to 12 m and the maximum water depth was approximately 1.3 m (Plates 7a and b). The site was classified as 90% pool and 10% riffle habitat, with riffles being present downstream of the creek crossing. The substratum in the pool section was composed entirely of silt and clay. The riffles were composed of cobbles and pebbles. Snags were evident along approximately 5% of the site.

Water visibility was fair. Some undercutting of the bank was evident. The electrical conductivity and turbidity measurements were within the ANZECC/ARMCANZ (2000) guidelines, but dissolved oxygen and pH levels were below the lower DTVs for slightly disturbed upland rivers (Table 7). The RCE score for this site (29) indicated significant habitat degradation.

Fringing common reed (*Phragmites australis*) (Plate 7c) was the dominant emergent aquatic macrophyte at this site, with occasional patches of rush (*Juncus* sp.) and rice sedge also present. No submerged macrophytes were observed.

The macroinvertebrate sample contained 19 taxa, with stick caddis flies (Leptoceridae), back swimmers (Notonectidae), water boatmen (Corixidae) and ostracod crustaceans being relatively abundant (Appendix 3). The sample was significantly impaired relative to the AUSRIVAS reference condition, lacking 37% of the families with a 50% probability of occurrence predicted to occur in pristine streams with similar characteristics. The SIGNAL2 score (3.2) for this site indicates severe degradation.



Plate 7: Summer Hill Creek, Third Crossing - (a) Upstream view; (b) Downstream view; (c) Common Reed (*Phragmites australis*); (d) Yabby (*Cherax destructor*) caught by electrofishing.

This site contained moderate fish habitat. Electrofishing yielded five yabbies (*Cherax destructor*) (Plate 7d) and 11 Eastern Gambusia. No animals were caught using baited traps. Redfin perch, goldfish and Eastern Gambusia were found at this site in March/April 2011 (GHD 2011a).

3.5.2.4 Fourth Crossing Summer Hill Creek

The fourth crossing over Summer Hill Creek is located 24.2 km downstream of Suma Park Reservoir adjacent to Ophir Road. The bridge is a box culvert crossing supported by three concrete piles and was partially blocked with woody debris (Plate 4d). During the survey undertaken in March/April, woody debris was evident in front of the entire structure (GHD 2011a). This debris would impede the passage of fish, particularly during periods of low flow. The banks downstream of the crossing are characterised by rock bars, while that downstream is composed mostly of cobble. The surrounding land is rural with forest composed of mixed native and exotic trees. Eucalypts and Casuarinas were the dominant tree species observed.

Sampling was conducted within a broad valley upstream and downstream of the bridge.

The width of the river varied from 5 m to 10 m and the maximum water depth was approximately 1.3 m (Plates 8a and b). Invasive grasses and shrubs dominated the riparian vegetation. This site was classified as 60% pool and 40% riffle habitat. The substratum consisted of silt and clay in the upstream pool sections with boulders and cobbles in the riffles downstream of the crossing. Snags occupied approximately 10% of the study site, but were present downstream of the crossing only. The RCE score for this site (38) indicated moderate habitat degradation.

a)



b)



c)



d)



Plate 8: Summer Hill Creek, Fourth Crossing: - (a) Upstream view; b) Downstream view; (c) Rainbow Trout (*Oncorhynchus mykiss*); (d) Mountain Galaxid (*Galaxias olidus*).

No water quality measurements were taken at this site due to equipment failure. Fine detritus mixed with sediment resulted in poor water visibility.

Sparse patches of the emergent macrophytes, Common Reed, River Club Rush and Rice Sedge were present, but mostly outside the wetted width.'

The macroinvertebrate sample contained 25 taxa and was dominated by pond snails (Physidae), stick caddis flies (Leptoceridae), and water boatmen (Corixidae) (Appendix 3). The sample was significantly impaired relative to the AUSRIVAS reference condition, lacking 21% of the families with a 50% probability of occurrence predicted to occur in pristine streams with similar characteristics. The SIGNAL2 score (3.9) for this site indicates severe degradation.

This site contained moderate fish habitat. Three species of fish, Rainbow Trout (*Oncorhynchus mykiss*) (Plate 8c), Mountain Galaxid (*Galaxias olidus*) (Plate 8d) and Redfin Perch (*Perca fluviatilis*), and yabby were caught by electrofishing. No species were caught in the baited traps. The three fish species were also recorded at this site in March/April 2011 (GHD 2011b).

3.5.2.5 Other Creeks

The crossings over Oaky Creek (Plates 9a and b), Kittys Creek (Plates 10 a and b) and Eldorado Gully (Plates 11 a and b) were also inspected briefly. These ephemeral systems contain water only during and for a short time after periods of high rainfall. The crossings were surrounded by rural and residential land with mixed native and exotic riparian vegetation.

Water visibility was fair to poor. The substratum consisted of silt and clay in pool sections and boulder and cobble stones in riffle sections. Oaky Creek represented potential fish habitat, but no fish species were observed. Kittys Creek and Eldorado Gully are unlikely to provide fish habitat, even under high flow conditions.



Plate 9: Oaky Creek: - (a) Upstream view; (b) Downstream view.

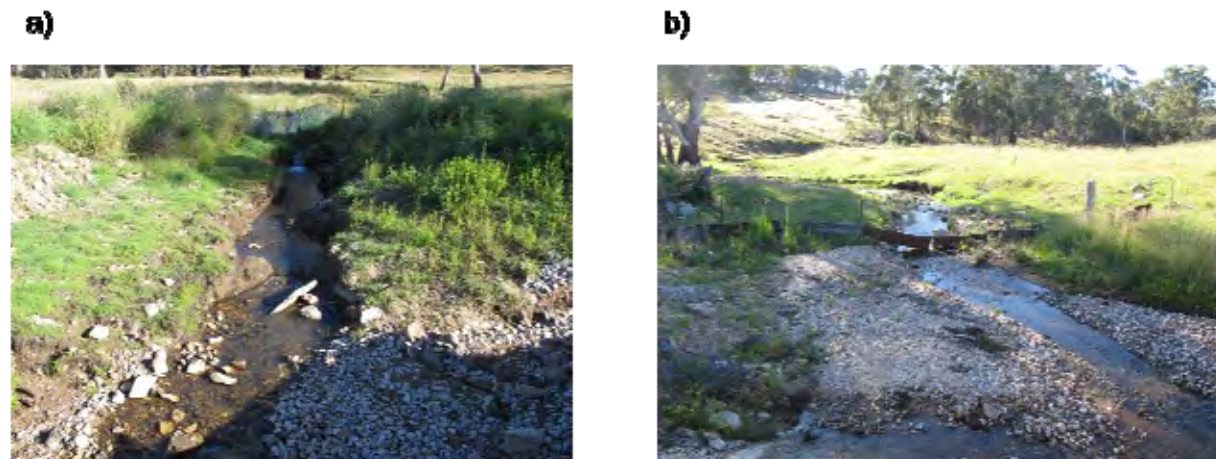


Plate 10: Kittys Creek: - (a) Upstream view; (b) Downstream view.

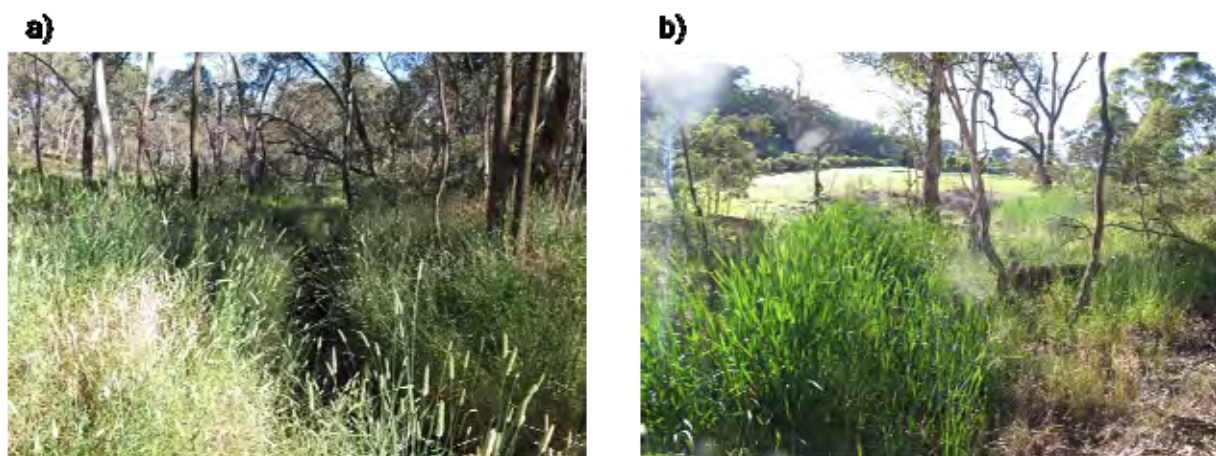


Plate 11: Eldorado Gully: – (a) Upstream view; (b) Downstream view.

3.5.3 Suma Park Reservoir

Two sites were sampled on the reservoir adjacent to the location where the Discharge Structure would be located. This area of the reservoir is surrounded by rural and residential land with mixed native and exotic riparian vegetation.

3.5.3.1 Site 1

Site 1 was located adjacent to the boat ramp on the reservoir (Plate 12a, b). The maximum water depth was approximately 1.2 m. Visibility was good. The substratum was heavily silted, but stable. No snags were seen..

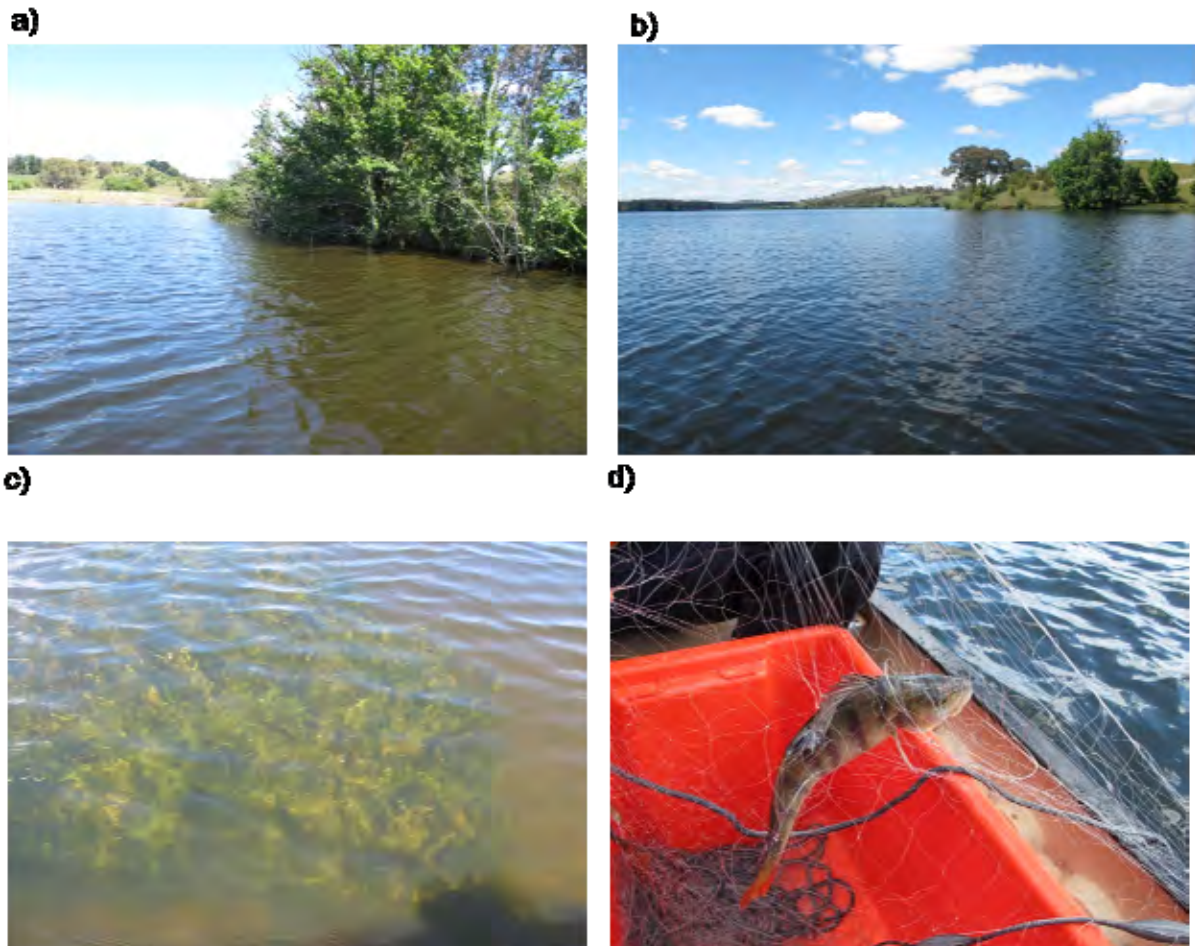


Plate 12: Suma Park Reservoir, Site1: (a) Upstream view; (b) Downstream view; (c) Ribbon weed (*Vallisneria* sp.); (d) Redfin perch (*Perca fluviatilis*) caught in the gill net.

Sparse patches of the Spike Rush (*Eleocharis* sp.) were present among the native and exotic grasses on the bank. Ribbon weed (*Vallisneria* sp.) was the only submerged macrophyte species observed (Plate 12c).

This site contained significant fish habitat. Redfin Perch (Plate 12d) were abundant near the dam wall, in close proximity to the study site. Ten Redfin Perch with fork lengths ranging from 231 to 420 mm were caught in the gill nets. No fish or invertebrates were caught using the electrofisher or baited traps.

The macroinvertebrate sample contained 26 taxa and was dominated by physid pond snails, stick caddis flies, copepods, cladocera, water boatmen, baetid mayflies, atyid shrimps, oligochaetes and coenagrionid damselflies (Appendix 3). The SIGNAL2 score (3.0) indicated severe degradation.

3.5.3.2 Site 2

Site 2 was located opposite the boat ramp (Plate 13a, b). The maximum water depth was approximately 1 m. Water visibility was good. The substratum was heavily silted, but the sediment was stable. No snags were observed.

The substrata in shallow sections of the water body were covered in green filamentous algae (Plate 13c). Ribbon weed was distributed throughout the study site. Patches of Spike Rush were present on the reservoir bank (Plate 13d).

The macroinvertebrate sample contained 25 taxa and was dominated by physid pond snails, stick caddis flies, copepods, cladocera, water boatmen, baetid mayflies, hydracarinid mites, oligochaetes, chironomids, hawk dragonflies (Aeshnidae) and coenagrionid damselflies (Appendix 3). The SIGNAL2 score (2.9) indicates severe degradation.

This site contained significant fish habitat. Five Redfin Perch all with fork lengths <30 mm long were caught by electrofishing along the edge of the water body. No fish or invertebrates were caught using gill nets or bait traps.

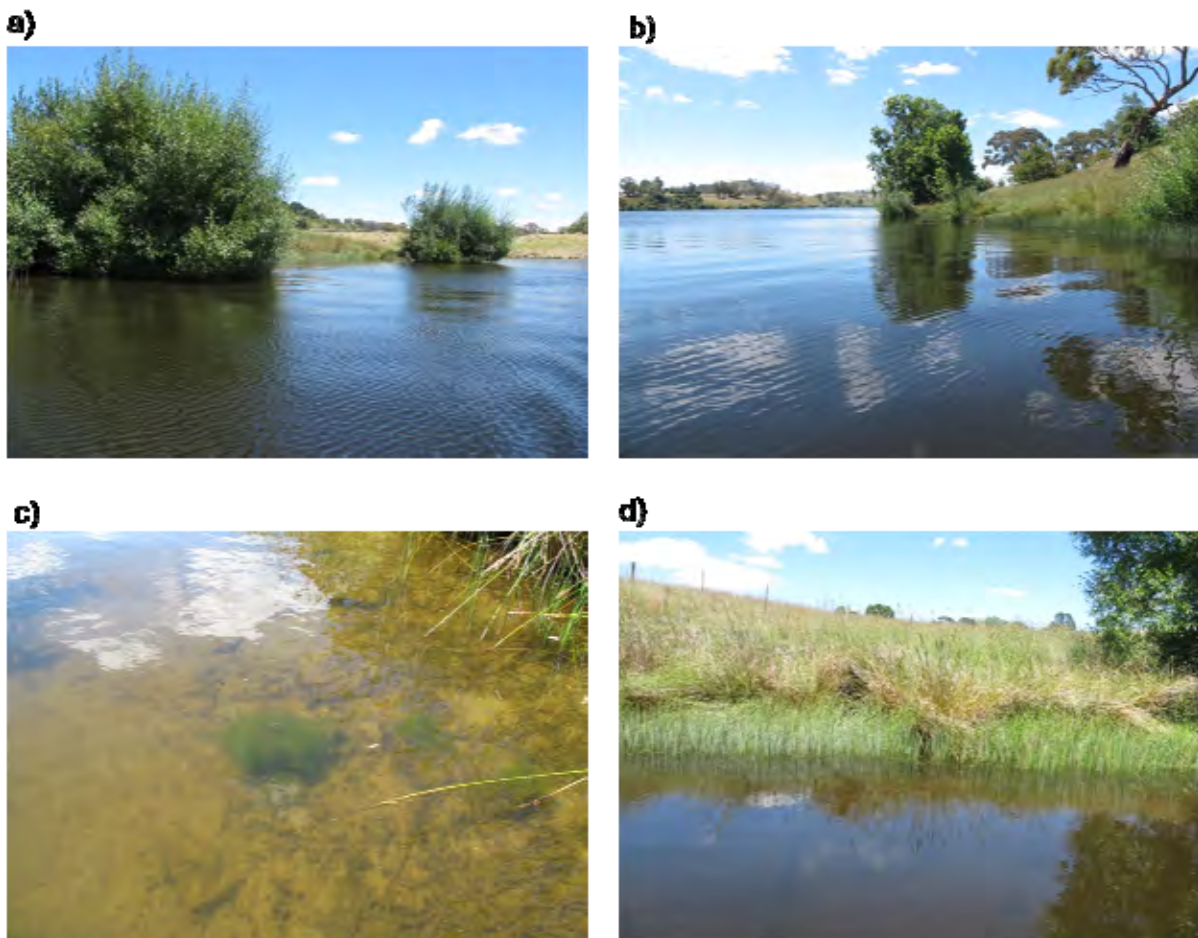


Plate 13: Suma Park Reservoir, Site 2: (a) Upstream view; (b) Downstream view; (c) Green filamentous algae growing on benthic substratum; (d) Spike Rush (*Eleocharis* sp.) fringing the reservoir edge.

3.6 Conclusions

The aquatic plant, macroinvertebrate and fish assemblages that were observed and/or sampled are unlikely to have recovered from the flooding that took place two weeks previously. The data obtained are consequently unlikely to be representative of the waterways under the sort of flow conditions that would prevail during construction and operation of the pipeline. The high water levels during the field survey undertaken in

December 2011 also may have affected some of the sampling, particularly that for fish and the AUSRIVAS and SIGNAL scores for the macroinvertebrates. Despite this, the field study was considered to be suitable to describe the aquatic habitats present and sample a range of biota sufficient to make an assessment of the likely effects of the proposed pipeline.

4 Proposed Works and Potential Impacts

The components of the project that could potentially affect instream ecology are the Offtake Structure/Pump Station, Water Pipeline and Discharge Structure. This section describes the construction and operation of each of these components and their potential impacts on aquatic habitats, water quality and aquatic biota in general. The various measures that could be used to minimise such impacts are described in Chapter 5. Potential impacts on threatened species and populations and key threatening processes and the measures to minimise these are described in Section 6

4.1 Offtake Structure and Pump Station

4.1.1 Proposed Works and Operation

The Offtake Structure would be built adjacent to Gardiners Hole on the south side of the Macquarie River immediately upstream of the confluence with Boshes Creek at Latitude 32° 59' 55" S, Longitude 149° 13' 58" and approximately 380 m RL. The site is approximately 4.6 km downstream of the flow gauge near Long Point. The Offtake Structure would consist of either a precast concrete structure or a structural steel trash rack enclosure and would be embedded into the bedrock of the river bed below the water level (Figure 3). The structure would be equipped with a trash screen consisting of bars spaced 25 mm apart to prevent ingress of large floating debris and aquatic biota (e.g. platypus, turtles and fish). A finer screen with a 2 mm mesh would be placed in front of the suction manifold to prevent fouling by smaller objects and entrainment of smaller organisms (GHD 2011b) (Figure 3). The Offtake Structure in the river would be 5.4 m long x 3.3 m wide x 3.7 m high. The building housing the motor/compressor on the top of the bank would be 6 m long x 4 m wide x 3.5 m high. The Offtake Structure would be surrounded by rock armouring to prevent river bank erosion. The construction of this structure would require clearing of vegetation, removal and stockpiling of soil, the installation of a coffer dam, excavation and possibly blasting of the river bank, and construction of an all weather access road (GHD 2011b).

The Offtake Structure would be connected to the Pumping Station by a manifold. The Pump Station would comprise a vertical shaft approximately 3 m in diameter and vertical turbine pumps, set back from the river bank. The foundations of the Pump Station would be situated 5 m below the invert level of the river.

The offtake would draw in raw water from the river at a design flow rate of 177 litres per second. Up to 12 ML of water would be extracted from the river over a 19 hour period each day, when flows at the extraction point exceed 38 ML/d and the storage volume of Suma Park Reservoir is less than 90%. This would result in the transfer of 1,616 ML of water over 135 days each year on average, with the range varying from 0 to 3,804 ML/y over 0 to 317 pumping days per year (Geolyse 2012). The quality of the water within the river also needs to be acceptable for extraction (i.e. should not have a high sediment load).



Figure 3: Diagram showing the proposed Pump Station and Offtake Structure.

4.1.2 Potential Construction Impacts

Construction activities that take place in the vicinity of the river bank and bed have the potential to impact on aquatic ecosystems in the following ways:

- The disturbance of soils and sediments by construction equipment and runoff from the all-weather access road and areas where vegetation has been cleared and soils have been stockpiled could increase the sediment load in the river which, in turn, could have indirect impacts on water quality;
- The installation of the coffer dam would result in temporary loss of a small area of aquatic habitat, displacement of associated aquatic biota and changes in hydraulic conditions;
- The installation of the gabions and Offtake Structure would result in loss and/or degradation of riparian and aquatic habitats;
- Accidental release of lubricating oils, hydraulic fluids and fuel from construction equipment could result in the input of hydrocarbon and metal contaminants into the river;
- The modification of riparian and aquatic habitats and changes in water quality could have indirect impacts on abundance, distribution and health of aquatic and riparian biota.

The installation of the gabions and Offtake Structure is unlikely to alter the stability of the river bed and banks, because these are composed of bedrock.

4.1.2.1 Impacts on Aquatic Habitat

Aquatic fauna utilise a variety of habitats, including overhanging and trailing vegetation on the river bank, logs, tree roots and instream woody debris, beds of instream plants, deep pools, rock ledges, boulders, pebbles, gravel, sand and detritus. These habitats provide shelter and refuge areas, food for aquatic invertebrates, which in turn provide food for fish, birds and aquatic mammals, camouflage, spawning sites and sites for attachment of aquatic plants (NSW Fisheries 1999).

The clearing of vegetation on the river banks and earthworks involved in the installation of the gabions and the Offtake Structure would reduce or degrade the habitat available for aquatic fauna and flora. The cutting back of the embankment and installation of the gabions would result in permanent loss of a small area of riparian habitat and disturbance to adjoining areas of this habitat. The disturbance of the riparian zone would be localised, temporary and addressed by rehabilitation works undertaken after the construction work is completed. The impact on aquatic habitat due to installation of the coffer dam would be localised and temporary. The construction of the Offtake Structure would lead to permanent loss of approximately 12 m² of underlying benthic substratum which is equivalent to approximately 0.02% of the area within the deep pool (hole). This structure would be exposed when water levels are low. Similar deep pool habitats are available nearby and at other locations in the upper Macquarie River, hence the loss of this habitat is considered to be comparatively small. Despite this, measures to ensure that the remaining habitats within the pool are maintained should be considered (see below).

The deposition of sediments mobilised by runoff or through construction works has the potential to alter the nature of the benthic substratum (e.g. replace sand with mud) and smother some aquatic habitats (e.g. gravel beds). There is also a possibility that sections of the river bed and banks that have been re-profiled may be more prone to erosion during flood events. As the concrete pit would be constructed where there is bedrock just below the surface, such impacts would be minimal.

4.1.2.2 Impacts on Surface Water Quality

Dissolved oxygen, pH (acidity), turbidity, temperature, salinity, nutrient and contaminant levels are the most important water quality parameters from an aquatic ecology perspective.

Runoff from cleared areas and stockpiles of soil, disturbance of the riverbed and banks by construction works within and adjacent to the watercourse, the installation, dewatering and dismantling of the coffer dam could lead to short-term increases in sediment loading and transfer of sequestered nutrients, organic matter and contaminants into the river. The clearing of vegetation and use of fertilisers during landscaping or rehabilitation works could lead to the input of organic matter and nutrients, respectively.

Accidental spillage of fuels, hydraulic fluids and lubricating oils used in the operation of construction equipment could result in the input of hydrocarbons and metals. Fuel is more likely to enter the river if it is spilt along the access route or the bank. The significance of the impact would depend on the type of fuel or oil used, the quantity spilt, the prevailing weather conditions and rate of flow of the river (i.e. dilution effect).

4.1.2.3 Impacts on Aquatic Fauna and Flora

The suspension of sediment particles in the water column load would increase the turbidity levels within the river, which could in turn potentially decrease the amount of light available for photosynthesis by aquatic plants, clog the gills and feeding apparatus of aquatic fauna and reduce the visual acuity of some predators. Mobile animals, such as fish and shrimps, are capable of moving away from sediment plumes and are therefore likely to be less susceptible to disturbance than sessile or sedentary species. The aquatic flora and fauna that occur within and in the vicinity of Gardiners Hole are likely to be fairly tolerant of natural increases in sediment load that occur during periodic rainfall events. The sediment plumes that form would be dispersed downstream, with rate of dispersion depending on the prevailing flow within the river. Temporary, localised increases in sediment load are consequently unlikely to have any significant effects on aquatic flora or fauna.

The input of nutrients, organic carbon and contaminants could have an impact on aquatic biota. The addition of excessive amounts of nutrients to rivers can lead to the formation of algal and macrophyte blooms. The effects of additional nutrient inputs would depend on whether fertilisers are being used on the surrounding land, nutrient inputs from further upstream and the rate of flow within the river. Impacts resulting from accidental inputs of fuel and oil would depend on their composition and properties, the quantities spilt, prevailing weather conditions and rate of flow of the river (i.e. dilution effect). Low concentrations of petroleum hydrocarbons are toxic to aquatic biota. The input of organic matter in the form of leaves, wood, bark and detritus may be beneficial to many small aquatic animals that feed on this resource or use it for shelter. The addition of large quantities of organic matter, however, can be problematic if it is retained and decomposed within pools. In these environments, decomposition of organic matter can result in a reduction in oxygen levels, changes in pH and increases in nutrient levels, which in turn, may have adverse effects on the biota living within the pool.

The installation of a coffer dam has the potential to hinder the movements of fish species that undertake either localised or more extensive migrations, downstream drift of aquatic macroinvertebrates and feeding excursions of platypus, if present. This effect would be restricted to a small area adjacent to the river bank and limited to the period of construction (expected to be about one month) and construction footprint. It would not prevent downstream movements of fish and other organisms in the adjoining part of the river.

4.1.3 Potential Operational Impacts at the Offtake Site

Potential impacts on aquatic habitats and biota that may occur during the operation of the Offtake and Pump Station include:

- Alteration of habitat;

- Disturbance of aquatic fauna resulting from noise and/or vibration;
- Entrainment and impingement of aquatic macroinvertebrates, invertebrate plankton, fish eggs and larvae and plant fragments by screens within the Offtake Structure;
- Small aquatic organisms that pass through the screen would be subject to mortality or physical injury due to collision with impellers in the pump and wall of the pipeline and exposure to changes in pressure;
- Increased risk of predation due to stress and/or provision of novel habitat for fish and bird predators (Blackley 2003);
- Transfer of small aquatic biota to Suma Park Reservoir;
- Exposure of organisms in the Macquarie River downstream of the Offtake Structure to changes in flow regime and a maximum change in water level of 23 mm in Gardiners Hole.

4.1.3.1 Impacts on Aquatic Habitat

Impacts on aquatic habitat may arise as a result of the presence and operation of the Offtake Structure.

The Offtake Structure would provide an artificial substratum that could be colonised by aquatic flora and fauna, with some animals potentially using it as a spawning site. Mobile aquatic animals may seek shelter inside the wet sump behind the trash rack. The structure would be designed to minimise its suitability as potential fish habitat. During prolonged periods of low flows the structure could serve as a roosting site for birds. Woody debris that collects on the trash rack could provide a temporary habitat for aquatic flora and fauna, such as microscopic plants and aquatic macroinvertebrates, until it is dislodged by floods. The wet sump would be an obstacle to the flow of water and could therefore result in erosion of the adjacent river bed and bank, which in turn could lead to changes in habitat quality. The Offtake Structure has a relatively small footprint and it is therefore unlikely that it will have a significant impact on the availability of aquatic habitat. The location of the Offtake Structure on an area of the bank where there is bedrock just below the surface would minimise erosion.

Gardiners Hole is an approximately 1 km long pool with a maximum depth of 3 m through which the river flows relatively slowly. If the flows are not strong enough to mix the entire water column, the pool may become thermally stratified with a warmer, less dense, better oxygenated surface layer overlying the colder, denser, less oxygenated deep water which is favourable as a habitat for many aquatic organisms. The operation of the Offtake Structure is unlikely to have any effect on thermal stratification (if it exists), because of the small footprint of the structure relative to Gardiners Hole (0.02% of the surface area), its location adjacent to the river bank and intake of surface water.

The extraction would decrease the river level at Gardiners Hole by an average of 1-4 mm during moderate to high flows and by 6-9 mm during low to moderate flows (Geolyse 2012). The water that is removed would be replenished by flows from upstream, so the impact on the availability of pool habitat per day would be transient and small. The decrease in the volume of the pool would, in turn, lead to a small and temporary reduction in the depth of water and rate of flow over the riffle structure retaining the pool. The duration of these changes would depend on the prevailing flow rate upstream of the offtake site and number of consecutive extraction days. A maximum reduction in water level of 23 mm is expected to occur when extraction coincides with a flow of 38 ML/day and flow is reduced to the equivalent of 22.8 ML/day. This is likely to happen on 0.11% of pump days.

4.1.3.2 Impacts on Surface Water Flows and Quality

The average amount of water that would be extracted from the Macquarie River per year (1,616 ML) is equivalent to 0.52% of the annual flow in the river past the offtake site (Geolyse 2012). The average and maximum amounts extracted per day would be 1.6% and 31.5% of the flows in the river, respectively. Figure 4 shows that there would on average be no pumping on 230 days per year and that pumping at 30% to 31.5% of flows would occur on 2 days per year. As pumping will be limited to 19 hours per day, there will be a 5 hour period each day during which there will be no change to the prevailing flows at the extraction site. Hydrological modelling indicates that extraction would result in a 5-8 ML/d decrease in low to moderate flows and 0-6 ML/d reduction in moderate to high flows, but would have no effects on the amplitude or frequency of low flow events (i.e. those below 22ML/d). The water balance modelling shows that the transfer of water from the Macquarie River will increase the average annual volume of spills from Suma Park Dam. This will lead to an increase in average annual flows in Summer Hill Creek which will in turn flow through to the Macquarie River and offset the long-term average annual extraction from the river (Geolyse 2012). These flow-on effects would reduce the average annual extraction from the Macquarie River system to around 325 ML/year, which represents 0.11% of the average annual river flow at the proposed offtake point. The maximum amount of water extracted in any one year would be 3,804 ML, which is equivalent to 6.0% of the total annual flow past the extraction site.

The extraction of water from the river could result in mobilisation and dispersion of benthic sediments. As the pump would be located within a wet sump and the extraction rate is relatively small, the effects are unlikely to be significant. The use of a sealed pump would prevent contamination due to loss of lubricants. The erosion of benthic sediments from the upstream side of the Offtake Structure, however, could result in an increase in sediment plume. The dispersal of this plume would depend on the prevailing river flows.

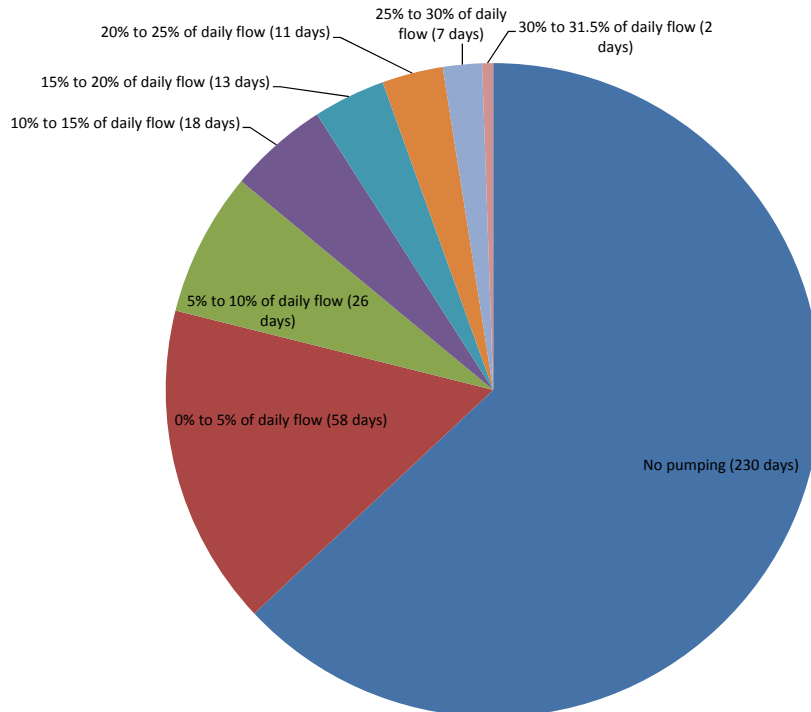


Figure 4: Pie chart showing the average days per year operation and proportion of river flow extracted.

4.1.3.3 Impacts on Aquatic Biota

The operation of the pump has the potential to disturb nearby aquatic fauna in the vicinity that are sensitive to noise and vibrations. The impact would be localised and more acute for sessile or sedentary species. Mobile organisms such as shrimps, yabbies and fish would be capable of moving away from the disturbance.

The most commonly used type of pump has rotating impellers which are known to damage certain species and size classes of fish. A study of the effects of high (150 ML/d) and low-volume (36 ML/d) pumps in the Namoi River showed that some native and alien fishes were susceptible to entrainment in the flows (Baumgartner *et al.* 2009). Less than 5% of the fish entrained, however, were injured or killed during entrainment. The fish that were entrained by the high volume pump system suffered the most injuries and mortalities. The proportions of deaths and injuries varied among species and size of fish, with carp being the most susceptible species and more small fish (<50 mm) killed or injured than medium (100 to 200 mm) or large ones (>200 mm). In the low-volume pump system, only one fish (Spangled Perch) was killed, but three species (Spangled Perch, Carp and Goldfish) were injured. The susceptibility of aquatic biota to extraction depends on the size, capacity and location of the pump, presence of barriers to exclude aquatic biota from the pump system and swimming ability of fish.

At the proposed Offtake Structure, the risk of injury or mortality is likely to be very low given the proposed pumping rate is less than 12 ML/d, trash screens and a fine-mesh screen situated in front of the suction manifold would be used to minimise entrainment of large and small biota, respectively. Small organisms that pass through the screen may be injured or killed elsewhere in the pipeline as result of shear stress (i.e. collision with exclusion screens and the walls of the pipe and passage through pump stations) or exposure to sudden changes in pressure, if other control measures are not implemented. These organisms would effectively be lost from the population within the river. For mobile biota, small-bodied species and juveniles are likely to be more vulnerable to entrainment than those with larger bodies. Eggs and planktonic life cycle stages that rely on passive dispersion would be unable to avoid entrainment, but such organisms would be a small proportion of the total number passing the offtake site, given the proposed pumping plan and fine screen (Section 4.1.1). As the fish species likely to occur in the vicinity of the offtake have a relatively large geographic range, the impact of extraction on their populations is likely to be relatively small.

Some fish may aggregate at the offtake and become more susceptible to predation. The use of the Offtake Structure as a roost by predatory birds when it is exposed during periods of low flows could also increase the risk of predation on fish.

4.1.4 Potential Operational Impacts between the Offtake Site and Burrendong Dam

The hydrological modelling shows extraction would reduce the inflows to the section of the river between the offtake site and Burrendong Dam by 1,616 ML/year on average (Geolyse 2012). Extraction would take place on 135 days per year on average and lead to the removal of 1.6% of flows in the river. The proportion of the flows extracted on average per day would vary from 0 to 31.5%, with 0-10%, 10-20% and 20-30% of the daily flow in the river at the extraction point being removed on 84, 31 and 18 days, respectively (Figure 4). The proportion of the flows removed from the river would exceed 30% on 2 days per year on average and reach a maximum level of 31.5% when 12 ML/day is extracted during a river flow of 38 ML/day. As pumping will be limited to 19 hours per day, there will be a 5 hour period each day during which there is no change to the prevailing flow within the river. The annual extraction will vary between 0 and 3,804 ML which is equivalent to 0 and 6% of the annual flows, respectively, with extraction occurring on 0-317 days per year (Geolyse 2012).

The cessation of extraction when flows at the extraction point fall below 38 ML/day means the Project would have no effect on the low and very low flow regimes in the unregulated section of the Macquarie River between the proposed offtake point and Burrendong Dam.

The hydrological modelling indicates that low and very low flows would also be preserved under drought conditions (Geolyse 2012). The Project would consequently not affect the availability of aquatic habitat or have any impacts on aquatic or riparian biota, including upstream and downstream movement of threatened fish species, during low or very low flows.

During extraction, the volume of low to moderate flows and moderate to high flows in the section of the river between the offtake site and Burrendong Dam would on average be reduced by 5-8 ML/d and 0-6 ML/d, respectively. The reductions would therefore be proportionally greater during low to moderate than moderate to high flows. The reduction in the volume of these flows would lead to decreases in wetted perimeter, depth of water and rate of flow over riffles and cascade habitats downstream of Gardiners Hole and hence a reduction in the availability of aquatic habitat. Reductions in depth and velocity of water over riffles and cascades during low flows could also impede movement of fish, particularly in shallow areas of the river. As the water extracted would be replenished by flows from upstream, the impact on the availability of habitat on any one day is likely to be minor and transient and within the range of natural variability. Extraction over a number of consecutive days, however, could potentially have a cumulative effect. The magnitude of this is difficult to assess, because of the lack of information on aquatic habitats in this section of the river and the uncertainty about when and for how long extraction would take place and the magnitude of flows likely to prevail at that time. The reduction in availability of aquatic habitat would be relatively small and would diminish with distance downstream, with its geographic extent depending on inflows from downstream tributaries.

The reduction in the volume of low to moderate and moderate to high flows would result in less sediment, leaf litter, woody debris, plankton and aquatic macroinvertebrates being transported downstream. The likelihood of aquatic biota being damaged as a result of contact with mobilised sediment, debris and rocks would also be reduced. The reduction in volume of moderate to high flows may result in fewer flow-sensitive aquatic plants and macroinvertebrates being dislodged from their habitats and transported downstream. The reduction in low to moderate flows could lead to greater accumulation of sediment and debris in riffles and pools. The reduction in flows would also result in less exchange of oxygen with the atmosphere, so the dissolved oxygen levels in the water may decline. The changes in aquatic ecology associated with the decreased volumes of low to moderate and moderate to high flows, however, are expected to be within the range of natural variability and much smaller than those that would occur periodically during droughts. They are consequently unlikely to have a significant impact on quality of aquatic habitat or the biota in this section of the river.

The temporal variability in the various components of the flow regime (i.e. floods, high, medium and low flows) is expected to be similar to that at present (Geolyse 2012). The proposed extraction is consequently unlikely to result in loss of cues for migration, spawning or recruitment of threatened fish species or loss of cues that prompt reproduction of other aquatic organisms or the emergence of some organisms from their resting stages.

4.1.5 Impacts on Groundwater-Dependent Ecosystems

Extraction of water from the Macquarie River would result in a slight reduction in the level of the water table in aquifers situated adjacent to the river and downstream of the Offtake Structure (Pells Consulting 2012 in Cardno 2012). The change in the water table would be smaller than the change in height of the river and would decrease with distance away from the river and be maximal when the river flow is close to 38 ML/day. Under these conditions, it is estimated that the groundwater levels would decrease by 10 mm at a site 20 m away from the river, but decline to < 0.1 mm at a point 100 m away from the river. The minor changes in river levels that are likely to occur downstream of the Offtake Structure are not expected to alter the patterns of groundwater recharge from the river (Cardno 2012). Given the above, it is unlikely that there would be any measurable impacts on GDEs adjacent to the river downstream of the offtake site.

4.2 Water Pipeline

4.2.1 Proposed Works and Operation

The Water Pipeline between the Macquarie River Offtake Structure and the Discharge Structure at Suma Park Reservoir would be approximately 37 km long. The project description indicates the Water Pipeline would be constructed within a 20 m wide corridor and that creek crossings would be installed below ground using the open trench excavation method, with trenches being 1.2-2.0 m deep (GHD 2011b). The construction of open trench crossings would require clearing of vegetation, soil and rocks, the installation of temporary coffer dams, use of a diesel pump and associated piping and excavation of the stream bed and bank (GHD 2011b). The soil removed from the trench would be stockpiled and either used for backfilling or disposed of. If environmental considerations or detail design indicate open trench methodology is not appropriate, the crossings may be constructed using a trench-less technique, such as Horizontal Directional Drilling (HDD), which involves the use of a self-propelled drilling machine, an excavator, a drilling mud plant and extraction of water from the stream or a water tank. Small catch pits would be excavated on either side of the waterway at the beginning and end of the bore to capture drilling mud returns. The construction of each watercourse crossing is expected to take a week.

The Pipeline would incorporate:

- Two booster pumping stations to provide the lift necessary to transfer the water over the required distance;
- Section valves so that sections of the pipeline could be isolated and dewatered;
- Scour valves so that the pipeline could be dewatered for emergency repairs and during decommissioning, if required. The water would be released to scour pits and then either discharged to the nearest watercourse, if it meets water quality requirements, or transferred to the stormwater holding pond or Council's sewage treatment plant by a suction tanker truck.
- Air valves that would allow air to enter and leave as water either leaves or enters the pipeline.

Section valves would be installed on either side of major road and watercourse crossings.

The Water Pipeline would be cleaned approximately once every 10 years to:

- Reduce the build-up of bacterial growths within the pipe, that could potentially cause a reduction in water quality and carrying capacity of the pipeline; and
- Remove sediment that may accumulate within the balance tanks.

Bacterial growths would be controlled by chlorination and using a pipeline pig to scrape the internal walls. The water from this cleaning would be removed and gradually discharged to Council's sewage treatment plant, where it would be treated (GHD 2012). The sediment in the break tanks would be removed by divers while that in pump out scours would be removed with a suction pipe connected to a tanker truck. The sediments in the pipeline would be sent to a treatment plant.

4.2.2 Potential Construction Impacts

The type and severity of the impact of pipeline crossings on aquatic ecosystems depends on the construction method used (Levesque and Dube 2007). Open cut construction that does not involve diversion of flows has greater impacts than methods involving isolation of the stream channel, which in turn have a greater potential for impact than installing a pipeline in a tunnel drilled below the stream channel. The installation and removal of construction infrastructure can also affect aquatic ecosystems. The susceptibility of watercourses to impacts will also vary, with sites that have fine-grained bank and bed sediments (e.g. Oaky Creek) likely to be more severely impacted than those with pebble, cobble or bedrock

substrata (3rd and 4th crossings on Summer Hill Creek). The amount of aquatic and/or riparian habitats that would be lost or degraded during construction works would depend on the construction methodology adopted.

4.2.2.1 Impacts on Aquatic Habitats and their Biota

Instream construction activities that involve disturbance of the stream bed and banks could potentially have the following effects on aquatic ecosystems:

- Direct impacts on channel morphology, hydrological characteristics and aquatic habitat;
- Indirect impacts on water quality, particularly turbidity, dissolved oxygen, total dissolved and suspended solids, nutrient, total organic carbon and contaminant levels, associated with increased sedimentation;
- Indirect impacts on water quality as a result of accidental release of drilling fluids from horizontal directional drilling;
- Indirect impacts on abundance, distribution and health of aquatic and riparian biota associated with the modification of aquatic habitat and changes in water quality;
- Indirect effects on behaviour (e.g. avoidance response and foraging) and physiology (e.g. respiration, gill damage, loss of equilibrium) of fish associated with increased suspended sediment concentrations and changes in stream bed substratum (Levesque and Dube 2007).

These impacts would be generally localised and short-term in nature and are thus not considered to be significant at the scale of the watercourse. Impacts are also likely to be less significant if the species inhabiting the watercourses are subject to high sediment loads periodically during flood events. There are, however, reports of the construction of pipeline crossings leading to changes in the substratum and downstream drift of benthic invertebrates that persisted for several years until high magnitude flows scoured the stream bed (Armitage and Gunn 1996; Anderson *et al.* 1998). This implies that the effects of construction are likely to last longer in systems that are subject to low or variable flows.

In Summer Hill Creek, there is a potential for cumulative impacts due to the occurrence of multiple crossings. Mobile species, such as fish, that pass through several crossing constructions with elevated sediment concentrations may be more vulnerable to cumulative impacts.

4.2.2.2 Impacts on Groundwater-Dependent Ecosystems

The Australian Natural Resource Atlas (ANRA) indicates that the groundwater within fractured rock aquifers in the Lachlan Fold Belt GMA occurs at a depth of 40 m. This is well below the 1-2 m depth level to which pipe trenching would extend, so it is highly unlikely that the construction of the pipeline crossings would have any impact on these groundwater resources. Significant shallower aquifers are not believed to be present in the area (Pells Consulting 2012 in Cardno 2012). The linear nature and hence small total area covered by the pipeline suggests that it is also unlikely to alter the recharge or water balance of existing aquifer systems. There is a possibility that the groundwater resources in the Lachlan Fold Belt could become contaminated by spillages of fuels and hydraulic fluids during construction. The groundwater vulnerability map for the Macquarie catchment indicates the risk of impacts due to spillages of contaminants is low to low-moderate for the Project Area (Piscopo 2001). Given the above, and that control measures would be used to contain spillages, the construction of the pipeline is expected to have no or only minor impacts on any nearby groundwater-dependent ecosystems.

4.2.3 Potential Operational Impacts

The major source of impact during operation of the pipeline would be potential leakage of water and sediment into the streams. The water released from the scour valves is unlikely to

result in impacts to the aquatic environment, as it would be released in accordance with a scour management plan and would have to meet minimum water quality standards. The water removed during the periodic cleaning of the pipeline would be of poorer quality as it would contain material scoured from the wall of the pipe. This water would be treated prior to discharge.

4.3 Discharge Structure

4.3.1 Proposed Works and Operation

The Discharge Structure would be located at the saddle dam at Suma Park Reservoir (GHD 2011b). The pipeline would terminate at an outlet cast into the centre of a 2-5 m long reinforced concrete head wall adjacent to the saddle dam wall at Suma Park Reservoir (GHD 2012b) (Figure 5). The construction of the head wall would require part of the dam embankment to be removed by an excavator and a reinforced concrete slab to be built on the ground. The head wall would be between 1 m and 2 m high and would be a three-sided enclosure with an opening facing into the reservoir. The structure would be constructed of pre-cast concrete or be cast *in situ*. A valve would be installed in the outlet to control back pressure on the pipeline.

Rock rip rap would be installed downstream of the headwall in order to reduce the energy contained in the discharge and spread the flow across a wider area. Water would be discharged into the dam from the saddle dam wall when the dam level falls below 90%, based on the current proposed operating rules.

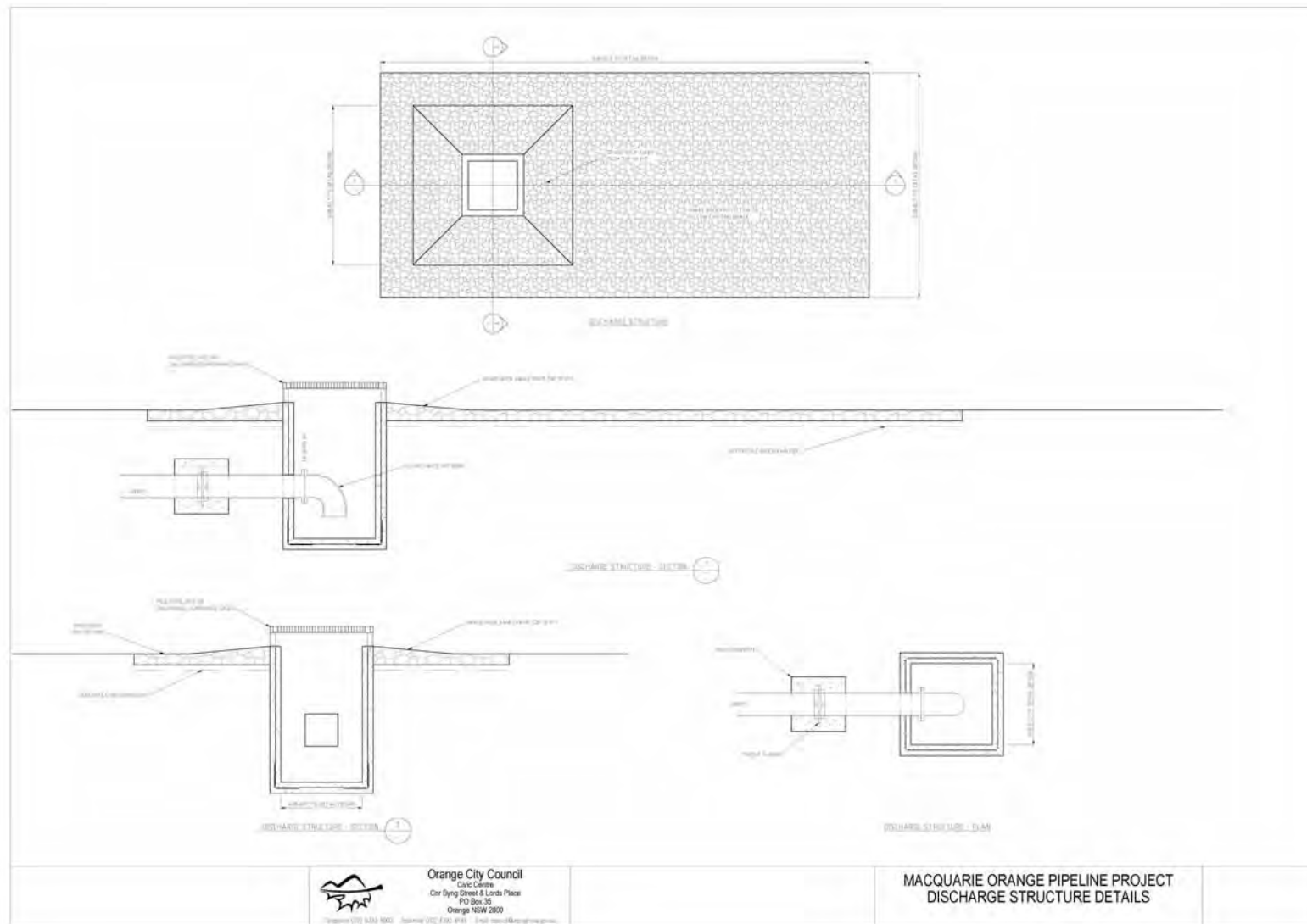


Figure 5: Diagrams showing the proposed Discharge Structure.

4.3.2 Potential Construction Impacts

The construction activities that take place at the reservoir have the potential to affect aquatic ecosystems in the following ways:

- The removal of part of the dam embankment and installation of rock rip rap could result in transient, localised increases in the sediment load in the adjacent section of the reservoir which, in turn, could have impacts on water quality;
- *In situ* construction of the Discharge Structure could lead to accidental release of wet concrete into the dam;
- Accidental release of lubricating oils, hydraulic fluids and fuel from construction equipment could result in the input of hydrocarbon and metal contaminants into the reservoir.

The construction of the Discharge structure would have no effects on Groundwater Dependent Ecosystems.

4.3.3 Potential Operational Impacts

4.3.3.1 Suma Park Reservoir

The potential impacts on the aquatic ecology of the storage that may arise during discharge of water include:

- Transfer of eggs, spores and propagules of aquatic biota, including aquatic weeds, that survive the passage from the Macquarie River to Suma Park Dam;
- Transfer of pathogens from livestock, wildlife and people that access the river and urinate and defecate on the banks or instream;
- Periodic transfer of additional nutrients and contaminants resulting from application of fertilisers and pesticides on land adjoining the river, seepage from abandoned mines and septic tanks, stormwater runoff from urban centres and sewage treatment plants located upstream (iConneXX 2011);
- Localised changes in water quality including turbidity, dissolved oxygen, total dissolved and suspended solids nutrient and total organic carbon levels and temperature;
- Periodic exposure of aquatic biota to changes in water quality during the discharge of extracted water.

The discharge of water that has higher nutrient levels than the reservoir could facilitate the development of algal blooms within the reservoir.

The operation of the Discharge structure would have no effects on Groundwater Dependent Ecosystems.

4.3.3.2 Summer Hill Creek

The extraction of water from the Macquarie River would result in the storage being maintained at a higher supply level, so natural runoff is more likely to result in spills (Geolyse 2012). At present, spill events occur once every 1.9 years on average and release 8,022 ML/year into the creek over 49 days. The Project would result in spill events occurring once every 1.6 years on average and release of 9,100 ML/year over 57 days. The pattern of the spillages would be the same as at present, with the greatest volume of spills occurring between June and October and peaking in July-August. The water balance modelling shows that the average volume of the spill from Suma Park Dam into Summer Hill Creek would increase by 1,298 ML/year (Geolyse 2012). It is important to note that changes in the flow regime are unlikely to occur during dry periods, as there would be insufficient natural runoff into the dam to produce spills.

In the section of the creek immediately downstream of the dam, the increase in spillages would on average result in a 40% increase in the volume of flows in the 10th percentile, but there would be no change in the volume of the other flows, as these are controlled by the environmental releases. The hydraulic modelling for the 10th percentile indicates this would increase flows by 0.117 m³, flow depth by 64 mm, channel velocity by 0.11m/s, flow area by 0.41 m² and flow top width by 3.06 m (Geolyse 2012).

In the creek downstream of the Second Crossing, there would be proportionally greater increases in the volume of low flows (26-57%) than low to moderate flows (7-10%) and moderate to high flows (4-10%) (Percentages are derived from flow deciles for existing and with project scenarios presented in Table 4.11 of Geolyse 2012). The greatest changes in hydraulic characteristics would occur during low flows, with maximum increases of 0.010 m³ in flows, 30 mm in depth, 0.25 m/s in channel velocity, 0.31 m² in flow area and 1.8 m in flow top width and maximum decreases in channel velocity of 0.28 m/s. The corresponding maximum increases during moderate to high flows would be 0.046 m³ in flows, 18 mm in depth, 0.076 m/s in channel velocity, 0.24 m² in flow area and 0.31 m in flow top width and a maximum decrease in channel velocity of 0.13 m/s (Geolyse 2012). During low to moderate flows the maximum increases would be 0.009 m³ in flows, 13 mm in depth, 0.22 m/s in channel velocity, 0.13 m² in flow area and 0.32 m in flow top width and maximum decrease in flow velocity would be 0.06 m/s. Decreases in flow velocity are likely to occur when the increased flow has to generate more head to get conveyed along flat areas of the creek.

The small changes in hydraulic characteristics during low to moderate and moderate to high flows would result in small increases in the availability of aquatic habitat and small improvements in the connectivity of aquatic habitats and biota along the creek and their connection with adjoining riparian and floodplain habitats. The increase in flows would enhance downstream transport of sediment, leaf litter, woody debris, rocks and plankton. The mobilisation of sediment and debris that accumulates in riffles and pools may improve the quality of these habitats for aquatic biota. However, the sediment, debris and rocks that are mobilised by the increased flows could damage aquatic biota, either through direct physical impact, smothering or clogging of their feeding or respiratory appendages. The higher flows may also increase the likelihood of aquatic plants and macroinvertebrates that can not tolerate strong flows being dislodged from their habitats and transported downstream.

The changes in hydraulic characteristics during low flows would result in a proportionally greater increase in the availability of shallow aquatic habitats and connectivity of aquatic habitats and biota along the creek. The increased longitudinal and lateral connectivity would be beneficial to mobile species (e.g. fish, platypus and turtles, enabling them to move through the stream network more freely than at present and access additional foraging and spawning areas. The increase in volume of low flows could potentially provide the cues necessary to stimulate spawning migrations and recruitment of native fish. Exotic fish species (e.g. Eastern Gambusia, Carp and Redfin Perch) that prefer slow-flowing streams may be disadvantaged by the increase in volume of low flows.

The general increase in volume of flows is likely to improve water quality, by increasing dissolved oxygen levels, reducing temperature and resulting in further dilution of the effluent from the sewage treatment plant and runoff from the adjacent agricultural land. The general increase in availability of water within the creek system may also reduce die-back of riparian vegetation and improve their reproductive success.

As the changes in flows would not have a significant effect on the hydraulic characteristics of the stream (i.e. flow depth, channel velocity, flow area or top width), it is unlikely that the changes in availability of aquatic habitats would be significant. Inflows from tributaries would reduce the effects of changes in hydraulic characteristics further downstream. The changes in aquatic ecology associated with the increased volume of moderate to high flows would be minor and of relatively short duration (i.e. occurring primarily between July and August) and much smaller than those that occur periodically during floods. The changes in aquatic

habitats and biota, including any threatened species that may be present, due to the increased volume of flow flows would be small to moderate in scale, but of relatively short duration.

4.4 Conclusions

The key impacts on instream ecology associated with the construction works are likely to be:

- Changes in water quality due to an increase in the sediment load of the waterways associated with disturbance of soils and sediments by construction equipment and runoff from the all-weather access road and areas where vegetation has been cleared and soils have been stockpiled;
- Direct impacts on channel morphology, hydrological characteristics and aquatic habitat;
- Indirect impacts on water quality due to increased sedimentation, accidental release of lubricating oils, hydraulic fluids, drilling fluids, fuel from construction equipment and wet concrete;
- Temporary loss of aquatic habitat, displacement of aquatic biota and changes in hydraulic conditions while coffer dams are in place;
- Changes in the abundance, distribution, behaviour and physiology of aquatic fauna and health of aquatic and riparian biota due to degradation of riparian and aquatic habitats and reduction in water quality.

The key impacts on instream ecology associated with the operational phase of the Project are likely to be:

- Alteration of habitat;
- Disturbance of aquatic fauna resulting from noise and/or vibration;
- Entrainment or impingement of aquatic macroinvertebrates, invertebrate plankton, fish larvae and plant fragments by screens within the Offtake Structure;
- Changes in the flow regime downstream of the Offtake Structure in the Macquarie River due to the extraction of water (i.e. small decreases in the volume of low to moderate and moderate to high flows, but no change in low flows);
- Changes in the flow regime of Summer Hill Creek (i.e. an increase in the low to moderate flows and average annual flow).

Within the reservoir, there would be localised changes in water quality due to periodic transfer of silt, organic material, dissolved nutrients and contaminants in the river water.

5 Avoidance, Mitigation and Offset Measures

This section describes the measures that could be used to prevent, minimise and offset the potential impacts of the construction and operation of the Offtake Structure, Water Pipeline and Discharge structure on aquatic habitats, and aquatic biota in general. The measures that could be used to avoid, minimise and offset potential impacts on threatened species and populations are described in Section 6.

5.1 Offtake Structure

5.1.1 Construction Phase

Control measures to avoid, minimise and/or mitigate impacts on aquatic habitats, water quality and aquatic biota that may arise during construction works are described in Table 8. Measures to avoid impacts include:

- Implementation of a Sediment and Erosion Control Plan to protect aquatic habitats and biota immediately downstream of the construction area;
- Translocation of aquatic fauna from the construction area to the river prior to dewatering of coffer dams;
- Establishment of a bunded area for storage of fuels, oils, refuelling and appropriate maintenance of vehicles and mechanical plant.

The impacts of construction works would be minimised by:

- Limiting the area of riparian zone and aquatic habitat disturbed;
- Screening the pump inlet used to dewater the coffer dam;
- Limiting construction work during critical life cycle stages of fish (i.e. spring and early summer when threatened fish species spawn and recruit).

The loss of aquatic habitat could be offset by rehabilitating other areas of habitat within the Project Area. This could be done by adding instream woody habitat in the form of snags to adjacent sections of the Macquarie River;

Loss of riparian habitat could be offset by removing weeds, replanting with appropriate native plants and installing fences to manage or exclude stock.

It should also be noted that NSW I and I (2011) have required:

- the preparation of a detailed management plan outlining how the offtake pump station and infrastructure would be constructed to ensure free passage of fish is not blocked whilst work is conducted;
- implementation of a vegetation or revegetation management plan to ensure that riparian buffer zones at the offtake site are carefully managed.

The construction works are also expected to be done in accordance with the NSW DPI Policy and Guidelines for Aquatic Habitat Management and Fish Conservation (See Section 2.1.3) (NSW Fisheries 1999) (David Ward, email communication 13 March 2011). This indicates that:

- free passage should be maintained for migratory fish species;
- mesh fences should not be deployed across waterways as they may obstruct fish passage;
- 50 m wide riparian buffer zones with natural features and vegetation preserved should be established and maintained and increased to a width of 100 m or more adjacent to ecologically sensitive areas.

Table 8: Potential Impacts and Mitigation Measures for Construction of the Pipeline Offtake Structure

Potential Impact	Mitigation Measures
Loss or degradation of riparian habitat	Select a location for the end of the access road and Offtake Structure that minimises disturbance of the riparian zone. Locate ancillary infrastructure (i.e. Pump Station) outside the riparian corridor. Revegetate disturbed areas with local native species immediately after construction works are completed and monitor rehabilitated areas to ensure that revegetation is successful and the integrity of the riparian corridor is restored.
Loss or degradation of aquatic habitat	Minimise the footprint of the Offtake Structure. The Offtake Structure would be located within the embankment of the Macquarie River to minimise the extent of disturbance on the hydrologic, hydraulic and geomorphic functions of the river and by association aquatic habitat. Adopt construction methods that minimise disturbance to aquatic habitats.. Avoid construction within likely fish habitat and removal of large woody debris.
Increased sediment load and turbidity Addition of nutrients	Develop and implement a Sediment and Erosion Control Plan prior to the commencement of construction work that includes the following provisions: Restriction of vegetation clearing and construction works to no rainfall periods to reduce the risk of sediment runoff. Deployment of erosion control matting in the riparian zone and silt curtains along the river bank to prevent sediment entering the river channel and provision of protection against scouring and erosion of the river bed. Inspect these control measures regularly during the course of construction to ensure they are functioning properly. Installation of a coffer dam made of appropriate materials (e.g. that provide impermeable walls and base) around the offtake site to isolate the construction works and minimise downstream impacts. A silt curtain deployed around the coffer dam would also minimise spread of suspended sediment. Monitor turbidity, pH and oxygen levels of the water within and downstream of the construction area and, if a decline in water quality is detected, stop or scale back further works and revise control measures. If the sediment load of the water within the coffer dam is unacceptable, allow it to settle or transfer it to a settlement trap prior to its discharge into the river. Stabilisation and rehabilitation of disturbed/eroded areas of the river bed and bank, riparian zone and instream aquatic habitat.
Addition of organic matter	Minimise the construction footprint and extent to which soil and vegetation within the riparian zone are disturbed.
Contamination from accidental spillages of fuel and oil	Minimise direct access to the river by construction vehicles and mechanical plant. Inspect construction vehicles and mechanical plant for leakage of fuel and /or oils. Establish a bunded area for storage of fuel and oils, refuelling and maintenance of vehicles and mechanical plant. Prohibit re-fuelling, washing and maintenance of vehicles and plant within 30 m of the river. Report spillages to the appropriate officer and immediately deploy spill containment kits to restrict their spread to or within the river.
Disturbance of aquatic biota by increased sediment load and elevated turbidity	Deploy erosion control matting in the riparian zone and silt curtains along the river bank to prevent sediment entering the river channel and provide protection against scouring and erosion of the river bed.
Injury or mortality of aquatic biota contained within coffer dams	Translocate fish, turtles and platypi from the coffer dam to flowing water within the river. Screen the pump to minimise entrainment of fish when the water is pumped out.
Disruption to movements of fish by coffer dams	Limit construction works during critical fish migration and spawning periods (i.e. spring and summer). Limit the period for which the coffer dam is installed.

A permit may also be required under s.219 of the *FM Act* for any works, which may result in the temporary or permanent blockage of fish passage within a waterway. This applies to blockages associated with the deployment of silt fencing across waterways for sediment, erosion control, bunding and dewatering works during construction of crossings (NSW DPI undated).

5.1.2 Operational Phase

Control measures to avoid, minimise and/or mitigate impacts on aquatic habitats, water quality and aquatic biota that may arise during the operation of the Offtake Structure are described in Table 9. Mortality and injury of juvenile, sub-adult and adult fish, turtles and platypus would be avoided by:

- Installing screens at the pump inlet;
- Starting the pump up slowly and then ramping up its velocity to a level that reduces the likelihood of aquatic biota in the vicinity of the Offtake Structure being drawn into the pump.

The entrainment of fish eggs and larvae during operation of the offtake and pumping station would be minimised by:

- Screening the pump inlet;
- Limiting the extraction period to 19 hours per day and by blasting air through the screen at the end of each day's extraction to dislodge any organisms trapped on the screen.

It should also be noted that the operating rule prevents pumping during low and very low flows and that it will also not result in the creation of low flows (i.e. those below 22 ML/d) (Geolyse 2012).

An additional control measure that could be considered is the installation of devices that deflect fish and other organisms away from the Offtake Structure. The extraction of water from the river could result in mobilisation and dispersion of benthic sediments. The location of the pump within a wet sump and the relatively small extraction rate suggest that mobilisation of sediments would be limited. The impact of this on aquatic biota is consequently expected to be negligible.

There is a possibility that water and sediments could become contaminated if lubricants are lost from the pump. The use of a sealed pump would minimise the risk of such contamination.

The loss of aquatic organisms could be offset by improving the likelihood of native fish populations surviving elsewhere within the Project Area. This could be done by adding additional instream woody habitat (i.e. snags). It should also be noted that Orange City Council has secured an option on an existing 640 ML/year irrigation licence on the upper Macquarie River for the Project (Orange City Council 2011) and that this would offset some of the water extracted.

5.1.2.1 Screening

Successful fish screening at water intakes requires the following conditions (Turnpenny *et al.* 1998):

- A structure or stimulus that the fish can use to detect its approach to the intake.
- The escape velocity of the water must be within the swimming ability of the fish, and
- A suitable escape route or bypass must be available.

Fish are less likely to be drawn into pump intakes if the water velocity is within their prolonged or sustained swimming speeds. If the intake velocity is below the maximum sustainable swimming speed of fish, they should be able to swim ahead of the screen for

several hours. Turnpenny *et al.* (1998) recommended that the sustained swimming speed of fish should be used to set the approach velocity at intakes. As length of fish is a major factor affecting swimming performance, prolonged and sustained swimming speeds vary both among and within species. The advice on preliminary operating rules given to OCC by GHD (2011c) indicates that the initial start-up velocity needs to be below 0.05 m/sec or no greater than the passing flow velocity to avoid sudden entrainment and that native fish less than 80 mm in length are unable to negotiate flows in excess of 0.15m/sec and that flows in excess of 0.05 m/sec would be problematic for turtles.

Table 9: Potential Impacts and Mitigation Measures for Operation of the Offtake Structure, Water Pipeline and Discharge Structure.

Component	Potential Impact	Mitigation Measures
Offtake Structure	Alteration of habitat.	The location of the pump within a wet sump and the relatively small extraction rate would minimise changes in habitat due to mobilisation of sediments.
	Disturbance of aquatic fauna resulting from noise and/or vibration.	Starting the pump up slowly and then ramping up its velocity to a level that reduces the likelihood of aquatic biota in the vicinity of the Offtake Structure being drawn into the pump.
	Entrainment and impingement of aquatic macroinvertebrates, invertebrate plankton, fish eggs and larvae and plant fragments by screens within the Offtake Structure.	Screening the pump inlet with 2 mm mesh; Limiting the extraction period to 19 hours per day and flows above 38 ML/d and purging the screen with air at the end of each day's operation.
	Mortality and/or physical injury of small aquatic organisms that pass through the screen and collide with impellers in the pump or wall of the pipeline and exposed to changes in pressure.	Using an appropriately-designed offtake pump; Installing screens at the pump inlet; Starting the pump up slowly and then ramping up its velocity to a level that reduces the likelihood of aquatic biota in the vicinity of the Offtake Structure being drawn into the pump.
	Increased risk of predation due to stress and/or provision of novel habitat for fish and bird predators.	Design the Offtake Structure in a way that minimises its suitability as novel habitat.
	Transfer of small aquatic biota to Suma Park Reservoir.	Screening the pump inlet with 2 mm mesh;
	Exposure of organisms in the Macquarie River downstream of the Offtake Structure to small changes in flow regime and a maximum change in water level of 23 mm in Gardiners Hole.	Limiting the extraction period to 19 hours per day and flows above 38 ML/d.
	Contamination of water and sediments due to loss of lubricants from the pump.	The use of a sealed pump would minimise the risk of such contamination
Water Pipeline	Leakage of water and sediment into the streams.	Undertaking routine inspections of the pipeline to ensure early detection of leaks; Prompt repair of leaks; Prohibiting direct discharge of water contained within the pipeline into watercourses via scour valves, except in emergencies providing the quality of the water is acceptable.
Discharge Structure	Transfer of eggs, spores and propagules of aquatic biota, including aquatic weeds that survive the passage from the Macquarie River to Suma Park Dam.	Screening the pump inlet at the Offtake Structure with 2 mm mesh; Controlling algal blooms by ensuring adequate mixing of the water within the reservoir (i.e. de-stratification) or addition of algicides.
	Transfer of pathogens from livestock, wildlife and people that access the river and urinate and defecate on the banks or instream.	Ensuring that the water discharged into the reservoir is of appropriate quality and quantity.

Component	Potential Impact	Mitigation Measures
	Periodic transfer of additional nutrients and contaminants resulting from application of fertilisers and pesticides on land adjoining the river, seepage from abandoned mines and septic tanks, stormwater runoff from urban centres and sewage treatment plants located upstream.	Ensuring that the quality and quantity of the water discharged into the reservoir is of appropriate quality and quantity.
	Localised changes in water quality including turbidity, dissolved oxygen, total dissolved and suspended solids nutrient and total organic carbon levels and temperature;	Ensuring that the quality and quantity of the water discharged into the reservoir is of appropriate quality and quantity. Installing rock rip rap downstream of the Discharge Structure to dissipate the energy contained in the discharge over a greater area and thereby reduce the risk of erosion and creation of a sediment plume.
	Periodic exposure of aquatic biota to changes in water quality during the discharge of extracted water.	Using a valve in the Discharge Structure to control discharge pressure. Installing rock rip rap downstream of the Discharge Structure to dissipate the energy contained in the discharge over a greater area and thereby reduce the risk of erosion and creation of a sediment plume.

Excluding fish from water intakes and diversions has been achieved by using barriers which may be structural (referred to as positive barrier screens) or behavioural. Fish protection screeds are designed to protect the weakest swimming species in their most vulnerable stages of development (Blackley 2003). The letter from NSW Industry and Investment (2011) to DoP re: Orange Drought Relief Pipeline (10_0235) - Director General's Requirements dated 18 March 2011 indicated that fish exclusion screens should be designed, located and operated in such a way that pumping cannot occur unless adequate fish screen/filters are *in situ* surrounding the pump within the off-take well. The optimal screen size depends on many factors, including the species and size of organisms to be protected, water flow, location in the river, sediment and debris load of the river and time of year water will be extracted. A screen that prevents entrainment of fish eggs and larvae would need a very small mesh size and strict operating protocols (Baumgartner *et al.* 2007). The mesh of the screen used to prevent entrainment of fish eggs and larvae should reflect the size of these objects. As the size of eggs and larvae varies among species it is recommended that screening be based on measurements for threatened species as their populations are the most vulnerable to impacts. The information that is presented in Table 10 about the size of eggs and length of larvae of the threatened fish species that are most likely to occur in the Project Area (See Sections 5.1.2 and 5.2.1) indicates that no eggs of these species would be entrained if a mesh size was adopted. An assessment of the effects of this screen on entrainment of larvae is not possible because of the lack of information on body depth of fish larvae.

An important consideration in mitigating the possibility of entrainment is the ability of native fish to swim against currents. Cotterell (1998) stated that water velocities of ≤ 0.3 m/s would facilitate passage of all native fish, but velocities > 1 m/s would not. Harris and Mallen-Cooper (1994) recommended a mean water velocity of 0.3 m/s, but not exceeding 0.8 m/s for catadromous fish in south eastern Australia. A velocity of 0.3 m/s is within the range of widely accepted fish escape criteria (Turnpenny *et al.* 1998). Reducing the flow into intake pipes or across screens would clearly help to reduce entrainment and/or impingement. In addition, the possibility of fish being drawn into the pump at start-up may be reduced if pumps are designed to start slowly and reach operational speed gradually. Devices that induce the movement of fish away from the pump could also be installed.

Table 10: Sizes of egg and lengths of larvae at hatching of the threatened fish species most likely to occur in the Project Area (see Sections 5.1.2 and 5.2.1)

Threatened Fish Species	Size of egg	Length of larvae at hatching	Source
Trout Cod	Fertilised eggs are 2.5-3.6 mm in diameter	6.-8.8 mm	Trout Cod Recovery Team (2008b)
Murray Cod	Diameter of 2.5-3 mm for unfertilised eggs and 3-4 mm when fertilised and water hardened	9.5 -15 mm	National Murray Cod Recovery Team (2010b)
Macquarie Perch	Diameter of 2 mm for unfertilised eggs and 4 mm for fertilised eggs that are water hardened	4.4-6.5 mm	DSEWPAC (2010)
Silver Perch	Fertilised eggs are about 2.8 mm in diameter	3-6 mm	NSW DPI (2005)
Freshwater Catfish	3 mm	7 mm	Lintermans (2007)

5.1.2.2 Timing of extraction

The risk of entrainment of eggs and fish larvae and impingement of larger individuals could potentially be reduced further by pumping at times of day when fish are less active and/or pumping at times of year when there is minimal spawning and recruitment activity. Baumgartner *et al.* (2009), however, found no difference in fish entrainment rates between day and night and concluded that little would be gained by modifying pumping regimes over the day/night cycle. The seasonal adjustment of pumping regimes to achieve the same secure yield is not considered feasible, because larger pumps would be required to extract more water at certain times of the year. Unfortunately the use of larger pumps is not feasible due to power restrictions.

5.2 Water Pipeline

5.2.1 Construction Phase

The letter from NSW Office of Water to DoP re: Orange Drought Relief Pipeline (10_0235) - Director General's requirements dated 23 March 2011 indicated that the design and construction of crossings within 40 m of watercourses, including temporary and permanent vehicle crossings, must be done in accordance with their guidelines on controlled activities (See Section 2.1.2). The relevant guidelines are:

- Laying pipes and cables in watercourses (NSW Office of Water 2010a);
- Riparian corridors (NSW Office of Water 2011a);
- In-stream works (NSW Office of Water 2010b).

The guidelines for laying pipes and cables in watercourses indicate that directional boring methodology is preferred to trenching. The NSW Office of Water (2011b) has indicated that directional drilling techniques should be used on watercourses with significant hydrological or hydraulic characteristics or that are highly sensitive due to their ecological or stability characteristics. The guidelines for trenching indicate:

- The pipe should be laid across the watercourse on the downstream side of channel bedrock outcrops and along straight section of the watercourse;
- Infrastructure should be placed below calculated bankfull flow scour depths plus a safety margin;

- The installation of concrete caps and casings which may become exposed by bed lowering should be avoided;
- Backfilling should be undertaken to restore the channel shape and bed level to its preconstruction condition.

The guidelines for directional drilling specify:

- Disturbance of banks and channel bed should be minimised;
- Risks associated with cave-ins, bed collapse or frac-outs during boring should be avoided;
- The depth of drilling should not lead to exposure of assets if the channel or bank are degraded;
- Bore entry and exit points should be located outside designated riparian corridors and existing vegetation;
- Recovery and removal of construction plant and materials, including drilling mud, should be addressed.

Control measures designed to avoid, minimise and/or mitigate impacts on aquatic habitats, water quality and aquatic biota that may arise during construction works are described in Table 11. These measures have been derived from the guidelines specified above.

Impacts on aquatic and/or riparian habitat would be avoided by:

- Using existing cleared easements for the pipeline;
- Ensuring the alignment of the pipeline does not disturb locations containing significant aquatic or riparian habitat;
- Using the measures specified in the Sediment and Erosion Control Plan to protect aquatic habitats and biota immediately downstream of the construction area.

Impacts would be minimised by

- Selecting construction methods that have a smaller construction footprint and result in less disturbance of the stream bed and banks and any associated vegetation;
- Maintaining the existing hydraulic, hydrological, geomorphic and ecological function of the watercourses;
- Using appropriate protection measures to minimise scour and impacts on water quality;
- Minimising the duration of in-stream activities;
- Limiting construction of crossings during times that are important for completion of life cycles (e.g. in spring and summer when threatened fish species spawn and recruit);
- Rehabilitating disturbed areas of stream bed and banks;
- Implementing a management plan to remove or lockdown equipment in the event that high flows are forecast during instream activities.

NSW DPI has indicated that crossings should be constructed in accordance with their Policies and Guidelines on Fish-Friendly Waterway Crossings and Policy and Guidelines: Aquatic Habitat Management and Fish Conservation (David Ward, email communication 13 March 2012). Waterway crossing design and construction must also be consistent with the Habitat Protection Plans gazetted under the *FM Act*, particularly HPP No. 1 which outlines requirements for the management of 'snags' (large woody debris or boulders).

Degradation of riparian vegetation is a key threatening process listed under the *FM Act* (See Section 2.1.1.2) and NSW DPI recommend that the following management strategies should

be used to minimise impacts of the degradation on native flora and fauna and enhance habitat quality and availability for fish:

- The health of existing native riparian vegetation should be maintained, recruitment of juvenile trees and shrubs should be encouraged and weeds should be controlled;
- Areas where little or no riparian vegetation remains should be rehabilitated by replanting or natural regeneration;
- The access of stock to riparian habitat should be controlled; and
- Exotic riparian vegetation should be replaced by native vegetation.

The amount of riparian vegetation that would need to be maintained will vary among the crossing locations, so an assessment for each crossing will need to be undertaken once the crossing construction footprints and methodology are finalised.

The letter from NSW Industry and Investment (2011) to DoP re: Orange Drought Relief Pipeline (10_0235) - Director General's Requirements dated 18 March 2011 indicated a vegetation or revegetation management plan should be implemented to ensure that riparian buffer zones along the pipeline corridor are carefully managed.. A riparian buffer zone with natural features and vegetation preserved that is at least 50 m wide should be established and maintained. The width of this zone should be increased to 100 m or more adjacent to ecologically sensitive areas. The NSW Office of Water (2011a) recommends that the core riparian zone, vegetated buffer and asset protection zone should be considered when determining the width of a riparian corridor and the quantity of riparian vegetation that should be protected or re-established at a site. The width of the core riparian zone should be determined by the type of watercourse as follows:

- First order watercourse with intermittent flows in a defined channel and any 'river' not identified on a topographic map - 10 m;
- First order watercourses with permanent flow and second order watercourses with a defined channel and either intermittent or permanent flow – 20 m;
- Third order or greater watercourse with a defined channel and either intermittent or permanent flow – 20-40 m.

It should be noted that a number of potential pipeline routes were considered by Orange City Council and that the final alignment chosen is that which would have the least impact on fauna and flora. It also minimises the need to cross sensitive waterways.

Impacts on aquatic habitat could be offset by rehabilitating disturbed areas and/ or similar habitats elsewhere within the streams of similar size. This could be done by adding instream woody habitat in the form of snags.

Loss of riparian habitat could be offset by removing weeds, replanting with appropriate native plants and installing fences to manage or exclude stock.

Table 11: Potential Impacts and Mitigation Measures for Construction of the Pipeline Crossings

Potential Impact	Mitigation Measures
Loss or degradation of riparian habitat	Select locations and construction methods for pipeline crossings that minimise or avoid disturbance of the riparian zone (e.g. existing cleared or disturbed areas adjacent to easements such as roads). Locate directional bore entry and exit points outside designated riparian corridors and existing vegetation. Revegetate disturbed areas with local native species immediately after construction works are completed and monitor rehabilitated areas to ensure that revegetation is successful.
Loss or degradation of aquatic habitat	Select construction methods that minimise or avoid disturbance of stream banks and beds (e.g. directional boring is preferred to trenching and open cut trenching with diversion of flows is preferable to open cut trenching without flow diversion). In the case of directional boring, minimise cave-ins and bed collapse by selecting an appropriate boring depth below the watercourse. In open cut trenching, the pipeline should be laid across the watercourse on the downstream side of channel bedrock outcrops or along straight sections of the watercourse. Impacts on flows should be reduced by staging the trench across the channel or minimising the time that flows are stopped or intercepted. Once the pipeline is laid, scouring and erosion should be prevented by restoring the channel shape and bed level to its preconstruction condition by backfilling the trench with appropriate material. Avoid the removal of large woody debris situated instream.
Increased sediment load and turbidity	Develop and implement a Sediment and Erosion Control Plan that includes the same provisions as for construction of the Offtake Structure. In addition: Minimise the time open cut trenches remain open. Stockpile the material removed from the trench outside the riparian zone to prevent runoff into the watercourse during rainfall events.
Addition of nutrients	As for construction of the Offtake Structure.
Addition of organic matter	As for construction of the Offtake Structure.
Contamination from accidental spillages of fuel and oil	As for construction of the Offtake Structure, except that the equipment used for site preparation and construction of the crossing should wherever possible be operated from the top of the stream bank or an existing easement.
Contamination from accidental frac out (i.e. release of drilling fluids) during directional boring	Minimise frac-out by selecting an appropriate depth below the watercourse for directional boring to take place. Develop and implement an Emergency Frac-out Response Plan that includes measures such as stopping boring, containment and clean-up of released drilling muds, prevention of their further migration into the watercourse and notification of appropriate authorities. Construct a settling basin for drilling muds at the drilling exit site to prevent sediment and other deleterious substances from entering the watercourse. Transfer excess drilling muds, cuttings and other waste materials to a disposal facility located well away from the watercourse.
Disturbance of aquatic biota by increased sediment load and elevated turbidity	As for construction of the Offtake Structure.
Injury or mortality of aquatic biota contained within coffer dams	As for construction of the Offtake Structure.
Disruption to movements of fish by coffer dams	As for construction of the Offtake Structure.

5.2.2 Operational Phase

Control measures to avoid, minimise and/or mitigate impacts on aquatic habitats, water quality and aquatic biota that may arise during the operation of the Water Pipeline are described in Table 9. Potential impacts on instream ecology due to leakage of water and residual sediment within the pipeline would be avoided by:

- Undertaking routine inspections of the pipeline to ensure early detection of leaks;
- Prompt repair of leaks;
- Prohibit direct discharge of water contained within the pipeline into watercourses via scour valves, except in emergencies and providing the quality of the water is acceptable.

The operation of the pipeline would have no effects on Groundwater Dependent Ecosystems.

5.3 Discharge Structure

5.3.1 Construction Phase

Control measures to prevent, minimise and/or mitigate impacts on aquatic habitats, water quality and aquatic biota that may arise during construction works are described in Table 12. Appropriate erosion and sediment control measures would be used to avoid impacts on aquatic habitats and biota outside the immediate construction footprint. The potential for other impacts would be minimised by:

- Limiting the construction footprint;
- Adopting a construction method for the Discharge Structure that reduces the risk of increased sediment load and accidental release of wet concrete.

Table 12: Potential Impacts and Mitigation Measures for the Construction of the Discharge Structure

Potential Impact	Mitigation Measures
Loss or degradation of aquatic habitat	Select a construction footprint and method for the Discharge Structure that minimises disturbance. Minimise the extent of disturbance of the dam embankment.
Increased sediment load and turbidity	Development and implementation of a Sediment and Erosion Control Plan that includes the following provisions: Restriction of the excavation of the dam embankment to the dry period to reduce the risk of sediment runoff; Deployment of silt curtains to prevent the excavated sediment from entering the reservoir; Monitoring of turbidity, pH and oxygen levels of the water adjacent to and downstream of the excavation area. If a decline in water quality is detected, stop or scale back further works and revise control measures. Stabilisation of the excavated area of the embankment; Use rock rip rap to minimise the erosive force of the discharge and creation of sediment plumes.
Contamination from accidental spillage of concrete	Deploy silt curtains around the Discharge Structure to prevent spillages entering the reservoir
Disturbance of aquatic biota by increased sediment load and elevated turbidity	Deploy silt curtains around the Discharge Structure to prevent sediment entering the reservoir.

5.3.2 Operational Phase

Control measures to avoid, minimise and/or mitigate impacts on aquatic habitats, water quality and aquatic biota that may arise during discharge of extracted water are described in Table 9 and include:

- Using a valve in the Discharge Structure to control discharge pressure;
- Installing rock rip rap downstream of the Discharge Structure to dissipate the energy contained in the discharge over a greater area and thereby reduce the risk of erosion and creation of a sediment plume;
- Ensuring that the water discharged into the reservoir is of appropriate quality;
- Controlling algal blooms by ensuring adequate mixing of the water within the reservoir (i.e. de-stratification) or addition of algicides.

5.4 Monitoring

The effectiveness of the mitigation measures adopted during construction works and operation of the pipeline should be assessed by:

- Monitoring water quality, particularly turbidity, total suspended solids, dissolved oxygen, nutrient and total organic carbon levels upstream and downstream of the potential impact sites and comparing measurements with the ANZECC/ARMCANZ (2000) Water Quality Guidelines for slightly disturbed streams;
- Comparing stream bed morphology, the particle size of the substratum, stream bed and bank stability, aquatic habitat availability and quality at sites upstream and downstream of the potential impact sites before and after construction and operation.

If significant changes in water quality and stream bed characteristics are detected their effects on key aquatic biological indicators at sites upstream and downstream of the impact sites should be assessed.

5.5 Conclusions

The potential for impacts associated with construction works would be avoided or minimised by:

- Limiting the disturbance of riparian zone and aquatic habitat;
- Rehabilitating disturbed areas;
- Implementing sediment and erosion control measures;
- Establishing a bunded area for storage of fuels, oils, refuelling and maintenance of construction vehicles and mechanical plant;
- Excluding biota from the construction area using coffer dams and translocating aquatic fauna contained therein;
- Screening the pump inlet used to dewater coffer dams; and
- Avoiding instream construction work during the spawning and recruitment phases of the threatened fish species.

The potential for impacts associated with operation of the water transfer system would be avoided or minimised by:

- Using a 2 mm mesh screen located in front of the suction manifold to minimise entrainment of fish eggs and larvae into the pump offtake;
- Starting the pump up slowly and then ramping up its velocity to a level that reduces the chances of aquatic biota being drawn into the pump;
- Limiting the extraction period to 19 hours per day and to flows above 38 ML/d;
- Prohibiting direct discharge of water contained within the pipeline into watercourses via scour valves, except in emergencies and providing the water quality is of an acceptable standard;

- Installing rock rip rap downstream of the Discharge Structure to dissipate the energy contained in the discharge over a greater area and thereby reduce the risk of erosion of the dam invert;
- Controlling algal blooms by using the existing mixer at the reservoir (i.e. de-stratification) or addition of algicides.

Loss of aquatic habitat could be offset by adding instream woody habitat in the form of snags to adjacent sections of the Macquarie River. Loss of riparian habitat could be offset by removing weeds, replanting with appropriate native plants and installing fences to manage or exclude stock.

The various measures that would be taken to avoid, minimise, mitigate and offset impacts associated with the Offtake Structure, Water Pipeline and Discharge Structure indicate the Project is likely to have minor effects on biodiversity values. Conclusions about the overall effects of the Project on other key thresholds (i.e. threatened species and populations of fish and the Macquarie Marshes) are presented in Section 6.0.

6 Conservation Issues

In this section, threatened aquatic species, populations and communities of national and state significance that may occur in the Project Area are identified, the potential impacts of the proposed construction works and operation of the pipeline on these assets are outlined and the significance of these impacts are assessed. In the case of threatened species that are highly mobile and may only be present occasionally, numerous surveys would need to be undertaken to confirm their presence. Even if this was done there is no guarantee that all of these threatened species would be caught. In view of this assessments of significance have been prepared for all the threatened species listed in appropriate databases as likely to occur or suitable habitat for them is likely to be present in the Project Area.

6.1 Matters of National Environmental Significance

6.1.1 Methods

The Protected Matters Search Tool, a database maintained by the Department of Sustainability, Environment, Water, Population and Communities (DSEWPAC), was used to identify threatened aquatic species, populations and communities of national environmental significance and wetlands of international significance that occur or may occur in the Orange and Cabonne Local Government Areas (LGAs) and the NRM Central West. Note that a search was undertaken over the latter area in order to take into consideration mobile, threatened species that may periodically move up the Macquarie River system into the Project Area. Note that searches for threatened terrestrial fauna and flora, including migratory bird species were undertaken by another specialist consultant and that assessments of significance for these are reported in BIOSIS (2012).

A survey of fish occurring at nine sites within the Project Area was undertaken from 9-12 December 2011. The objective of this survey was to identify and estimate the relative abundance of native and alien fish species and confirm the presence of any threatened species. The study sites, sampling conditions and survey methods are described in Sections 3.2, 3.3 and 3.4, respectively. Targeted surveys using the specific sampling methods recommended for the threatened species identified as potentially occurring in the Project Area were not undertaken. The methodologies used in the survey are considered appropriate for large freshwater perches, but were not necessarily the best method for the species of interest (DSEWPAC 2011). It should also be noted that the surveys could not be undertaken at the most appropriate time of day (i.e. dawn, dusk and at night) because access to the sites on the Macquarie River was restricted by the landowner. DSEWPAC has confirmed that the fish survey effort is adequate for EPBC assessment purposes (Email communication from Mark Jenkins of DSEWPAC to Jeremy Pepper of GHD dated 13 March 2012).

6.1.2 MNES Identified

The Protected Matters Search Tool indicates that three species of fish listed as threatened under the *EPBC Act* may occur or suitable habitat for them may occur within the Orange and Cabonne LGAs. These species are:

- Murray Cod (*Maccullochella peelii peelii*) –listed as vulnerable;
- Macquarie Perch (*Macquaria australasica*) - endangered;
- Trout Cod (*Maccullochella macquariensis*) - endangered.

No additional aquatic MNES were listed within these LGAs, however, three Wetlands of International Significance (RAMSAR) were found in South Australia.

A wider search for MNES based on the Central West Natural Resource Management (NRM) region, which extends from the central tablelands around Oberon, Bathurst and Rylstone to

the western plains around Nyngan, Brewarrina and Coonamble, indicates that a fourth species of fish, the Australian grayling (*Prototroctes maraena*) may occur in this area. The Australian Grayling is a diadromous species and requires access to freshwater, estuarine and marine habitats for its survival. Australian grayling are now restricted to the coastal rivers of southern New South Wales (Morris *et al.* 2001), and are therefore highly unlikely to occur in the upper Macquarie River. As there are no records of this species occurring in the Macquarie River, it has not been considered further.

Macquarie Perch have been recorded in the Macquarie River (Trueman 2007), but are now presumed to be extinct, because none have been collected from there since the species original description, nor have any been reported ethnographically for many decades (Faulks *et al.* 2010). It should, however, be noted that the fish surveys that have been undertaken are limited in frequency, spatial extent, duration and intensity, so the possibility of the species still being present cannot be discounted.

The search based on the Central West NRM identified a fourth Wetland of International Significance, the Macquarie Marshes, situated on the Macquarie River over 500 km downstream of the Project Area.

None of the EPBC-listed threatened species were recorded during the field survey (see Section 3.5.1). However, fry of both Trout Cod and Murray Cod have been released at Gardiners Hole and other nearby locations in the upper Macquarie River in recent years and it is possible that local populations have become established at or in the vicinity of the offtake site (See Section 2.2.1.5).

The proposed construction of the pipeline was referred to DSEWPAC for approval in November 2011. On the basis of the information presented in the referral, the department decided that the proposed construction constituted a controlled action and that an assessment and a decision on its approval under the *EPBC Act* was required before the project could proceed.

6.1.3 Proposed Construction and Operation Works

A description of the proposed construction works and operation of the Offtake Structure in the vicinity of Gardiners Hole in the Macquarie River is presented in Section 4.1.1.

6.1.4 Potential Impacts on Threatened Species

6.1.4.1 Construction Phase

The potential impacts on the threatened fish species associated with the construction phase of the Project include:

- Loss and modification of habitat;
- Exposure to increased sediment load and/or turbidity;
- Reduction in water quality due to accidental release of contaminants;
- Disruption to movements and injury resulting from use of a coffer dam.

The construction of the Offtake Structure would lead to permanent loss of approximately 12 m² of underlying benthic substratum within a deep pool (hole). As similar deep pool habitats are available nearby and at other locations in the upper Macquarie River, the loss of this habitat would not be significant.

The deposition of sediments mobilised by runoff or through construction works has the potential to alter the nature of the benthic substratum (e.g. replace sand with mud) and smother some aquatic habitats (e.g. gravel beds). There is also a possibility that sections of the river bed and banks that have been re-profiled may be more prone to erosion during flood events. The construction works could also increase the sediment load and/or turbidity of the water. The suspension of sediment particles in the water column load could clog the

gills of the fish and reduce their ability to locate prey by eye. It should, however, be noted that fish are capable of moving away from sediment plumes and those that occur within or in the vicinity of the offtake site (Gardiners Hole) are likely to be fairly tolerant of natural increases in sediment load that occur during periodic rainfall events. The sediment plumes that form would be dispersed downstream, with rate of dispersion depending on the prevailing flow within the river. Increases in sediment load are consequently likely to have only minor, temporary effects on the threatened fish species.

Impacts resulting from accidental inputs of fuel and oil would depend on their composition and properties, the quantities spilt, prevailing weather conditions and rate of flow of the river (i.e. dilution effect). Low concentrations of petroleum hydrocarbons are toxic to aquatic biota, so there is a possibility of impacts on the threatened fish species. The likelihood of such events is low and would be reduced even further if appropriate control measures are implemented.

The installation of a coffer dam could hinder movements and/or migration of the fish species and injure fish retained within. This structure would not block fish passage in the river, only the streams. These impacts would be localised, limited to the period of construction and consequently of only minor significance to the three threatened fish species.

6.1.4.2 Operation Phase

The potential impacts on the threatened fish species associated with the operational phase of the Project include:

- Modification of habitat;
- Disturbance from noise and/or vibration;
- Entrainment and impingement of fish eggs and larvae by screens within the Offtake Structure;
- Physical injury or mortality of small larvae that pass through the screen and collide with impellers in the pump and wall of the pipeline and are exposed to changes in pressure;
- Increased risk of predation due to stress and/or provision of novel habitat for fish and bird predators;
- Alteration of the flow regime downstream of the offtake site;
- Exposure to contaminants due to leakage of lubricants from the pump.

The Offtake Structure would provide an artificial substratum that could potentially be used as a spawning site by Trout Cod. There is also a possibility that individuals of some of the threatened fish species may seek shelter inside the wet sump behind the trash rack. There is a possibility that some individuals may aggregate at the offtake site and become more susceptible to predation if the Offtake Structure is used as a perch by predatory birds or fishermen when exposed during periods of low flows. The wet sump would be an obstacle to the flow of water, but is unlikely to result in erosion of the adjacent river bed and bank as these are composed of bedrock. As the Offtake Structure has a relatively small footprint, the above impacts are likely to be of minor significance to the threatened fish species.

Pumps with rotating impellers are known to damage certain species and size classes of fish. The susceptibility of fish to such damage depends on their size and swimming ability and on the capacity and location of the pump and installation of exclusion screens (See Section 4.1.2.2). Eggs and planktonic life cycle stages that rely on passive dispersion would be unable to avoid entrainment. At the proposed Offtake Structure, the risk of injury or mortality of eggs and larvae is likely to be very low given the proposed pumping rate is less than 12 ML/d and a fine-mesh screen situated in front of the suction manifold would be used to prevent entrainment of eggs and minimise entrainment of larvae. Small fish larvae that pass through the screen may be injured or killed elsewhere in the pipeline as result of shear stress

(i.e. collision with exclusion screens and the walls of the pipe and passage through pump stations) or exposure to sudden changes in pressure, if other control measures are not implemented. These larvae would effectively be lost from the population within the river, but would represent only a small proportion of the total number passing the offtake, given the proposed pumping plan and fine screen (Section 4.1.1). As the fish species likely to occur in the vicinity of the offtake site have a relatively large geographic range, the impact of extraction on their populations is likely to be relatively small.

Flow has significant effects on several aspects of the lives of fish, with critical life phases such as spawning and recruitment of some species being linked with stable low flows (Bunn and Arthington 2002). The overall hydrological modelling indicates that extraction would decrease the amplitude of some medium and moderate to high flows, but have no effects on the amplitude or frequency of low flows (i.e. those within the 80th to 95th flow percentiles) which are ≤ 22 ML/day (Geolyse 2012). Given the lack of any impacts on low flow events and that large proportion of flows (12 ML/day from 38 ML/day) would only be extracted on 0.2% of pump days, it is unlikely that changes in flows as a result of extraction would have any measurable effects on the spawning and recruitment of the threatened fish species.

The use of a sealed pump would prevent contamination of water and sediments due to loss of lubricants. The extraction of water from the river could result in mobilisation and dispersion of benthic sediments. The location of the pump within a wet sump and the relatively small extraction rate suggest that mobilisation of sediments would be limited. The impact of this on threatened fish species is consequently expected to be negligible.

The volume of low to moderate flows and moderate to high flows would on average be reduced by 5-8 ML/d and 0-6 ML/d, respectively. The reduction in these flows would lead to decreases in wetted perimeter, depth of water and rate of flow over riffles and cascade habitats in the section of the river between the offtake site and Burrendong Dam and hence a reduction in the availability of habitat for threatened fish species. These reductions would be proportionally greater during low to moderate than moderate to high flows. Reductions in depth and velocity of water over riffles and cascades during low flows could also impede the movement of threatened fish species, particularly in shallow areas of the river. As the water extracted would be replenished by flows from upstream, the impact on the habitat of these fish on any one day is likely to be minor and transient and within the range of natural variability. The cumulative effect of extraction over a number of consecutive days is difficult to assess, because of the lack of information on aquatic habitats in the river downstream of the extraction site and the uncertainty about when and for how long extraction would take place and the magnitude of flows likely to prevail at that time. The geographic extent of the reductions in these characteristics would depend on inflows from downstream tributaries.

The reduction in volume of flows would result in less sediment, leaf litter, woody debris and plankton being transported downstream. The likelihood of threatened fish species being damaged as a result of contact with mobilised sediment, debris and rocks would also be reduced. The general reduction in flows would result in less exchange of oxygen with the atmosphere, so the amount of dissolved oxygen available to threatened fish species may decline. The changes in the aquatic environment associated with the decreased volumes of low to moderate and moderate to high flows, however, are expected to be within the range of natural variability and much smaller than those that would occur periodically during droughts. They are consequently unlikely to have a significant impact on the threatened fish species that frequent this section of the river.

The temporal variability in the various components of the flow regime (i.e. floods, high, medium and low flows) is expected to be similar to that at present (Geolyse 2012). The proposed extraction is consequently unlikely to result in loss of cues for migration, spawning or recruitment of threatened fish species.

6.1.5 Safeguards, Mitigation and Offset Measures for Threatened Species

The control measures that could be used to safeguard and mitigate potential impacts on the three threatened fish species arising from the construction of the Offtake Structure are outlined in Table 13 and include:

- Implementation of a Sediment and Erosion Control Plan to protect any individuals of the threatened fish species occurring immediately downstream of the construction area;
- Translocation of threatened fish from the construction area to the river prior to dewatering;
- Establishment of a bunded area for storage of fuels, oils, refuelling and appropriate maintenance of vehicles and mechanical plant.

The impacts of construction works would be minimised by:

- Limiting the area of aquatic habitat disturbed;
- Screening the pump inlet used to dewater the coffer dam;
- Limiting construction work during critical life cycle stages of fish (i.e. spring and summer when the threatened fish species spawn and recruit).

The loss of a small area of aquatic habitat for Trout Cod and Murray Cod could be offset by adding more instream woody habitat (i.e. snags) to the Macquarie River, either adjacent to or within the vicinity of the Project Area. The quality of existing habitat could also be improved by removing weeds from the riparian zone, replanting with appropriate native plants and using fences to manage or exclude stock.

The measures used to minimise operational impacts on the threatened fish species would include:

- Installing screens with a 2 mm mesh size that would prevent intake of fish eggs and larvae at the pump inlet;
- Starting the pump up slowly and then ramping up its velocity to a level that reduces the likelihood of any fish in the vicinity of the Offtake Structure being drawn into the pump;
- Limiting the extraction period to 19 hours per day and flows above 38 ML/d when the storage volume in the Suma Park Reservoir is below 90%
- At the end of each day's extraction blasting air through the screen to dislodge any organisms trapped on the screen;

It should also be noted that the operating rule not only prevents pumping during low flows (i.e. those below 22 ML/d) it will also not create low flows (Geolyse 2012).

An additional control measure that could be considered is the installation of a device that would return fish to the river or deflect them away from the Offtake Structure.

The adoption of these control measures would reduce the potential impact of the construction and operational phases of the Project on Murray Cod, Trout Cod and Macquarie Perch to minor levels.

Table 13: Potential Impacts of the Construction of the Offtake Structure on EPBC—Listed Threatened Species and Proposed Safeguards and Mitigation Measures.

Potential Impact	Proposed Safeguards and Mitigation Measures
Loss or degradation of aquatic habitat	Avoid construction within critical fish habitat and removal of large woody debris. Minimise the construction footprint of the Offtake Structure. Location of the Offtake Structure within the embankment of the Macquarie River would minimise the amount of aquatic habitat disturbed. Adoption of construction methods that minimise disturbance to aquatic habitats.
Changes in habitat quality, damage to the gills and reduction in visual acuity of threatened fish associated with increased sediment load and/or turbidity	Implement a Sediment and Erosion Control Plan prior to the commencement of construction work that includes the following control measures: Restrict necessary vegetation clearing and construction works to no rainfall periods to reduce the risk of sediment runoff; Deploy erosion control matting in the riparian zone and silt curtains along the river bank to prevent sediment entering the river channel and provide protection against scouring and erosion of the river bed. Inspect these control measures regularly during the course of construction to ensure they are functioning properly. Install a coffer dam with impermeable walls and base around the offtake site to isolate the construction works and minimise downstream impacts. A silt curtain deployed around the coffer dam would also minimise spread of suspended sediment. Monitor turbidity, pH and oxygen levels of the water within and downstream of the construction area and, if a decline in water quality is detected, stop or scale back further works and revise control measures. If the suspended sediment load of the water within the coffer dam is unacceptable, allow the sediment more time to settle or pass it through a sediment trap prior to its discharge into the river. Stabilise and rehabilitate disturbed/eroded areas of the river bed and bank, riparian zone and instream aquatic habitat, as soon as possible after construction is completed.
Reduction in water quality due to contamination from accidental spillages of fuel and oil	Limit access to the river by construction vehicles and mechanical plant. Inspect construction vehicles and mechanical plant for leakage of fuel and /or oils. Establish a bunded area for storage of fuel and oils, refuelling and maintenance of vehicles and mechanical plant. Prohibit re-fuelling, washing and maintenance of vehicles and plant within 30 m of the river. Report spillages to the appropriate officer and immediately deploy spill containment kits to restrict its spread to or within the river.
Injury or mortality of threatened species contained within coffer dams	Translocate fish from the coffer dam to flowing water within the river. Screen the pump to minimise entrainment of fish when the water is pumped out.
Disruption to movements of fish by coffer dams	Limit construction works during critical fish migration, spawning and recruitment periods of threatened fish species (i.e. spring and summer). Limit the period for which the coffer dam is installed.

6.1.6 Assessments of the Significance of Impacts on Threatened Species

The assessments of the significance of impacts on threatened fish species listed under the *EPBC Act* presented in Table 14 have been prepared in accordance with the Significant Impact Criteria specified in the MNES Significant Impact Guidelines 1.1 (Commonwealth of Australia 2009). These criteria are to determine whether the Project would:

- Lead to a long-term decrease in the size of a population;
- Reduce the area of occupancy of the species;
- Fragment an existing population into two or more populations;
- Adversely affect habitat critical to the survival of a species;
- Disrupt the breeding cycle of a population;
- Modify, destroy, remove, 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 critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat;
- Introduce disease that may cause the species to decline; and
- Interfere with the recovery of the species.

The objective of these assessments is to determine whether the Project is likely to have a significant impact on the threatened fish species identified in Section 5.1.1. The assessment takes into consideration potential direct and indirect impacts of the pre-construction, construction and operational phases of the project and off-site impacts. The assessments presented in Table 14 indicate there is a possibility of local Murray Cod, Macquarie Perch and Trout Cod populations being impacted during the construction and operation of the Offtake Structure. The adoption of the mitigation and management measures recommended in Section 4.1.3.2, however, would reduce the potential for impact to minor levels.

Table 14: Assessments of the Potential for Significant Impact (EPBC)

(a) Trout Cod (*Maccullochella macquariensis*) (Source: NSW DPI 2006a; Trout Cod Recovery Team 2008a and b)

Assessment Criteria	Response
<i>Conservation status under EPBC Act</i>	Endangered species
<i>Long-term decrease in the size of local and regional populations</i>	Trout Cod are endemic to the southern Murray-Darling river system, including the Murrumbidgee and Murray Rivers, and upper Macquarie River. This species has undergone a dramatic decline in its distributional range and abundance over the past century, with the only known natural population being restricted to the Murray River from below Yarrawonga Weir to Strathmerton. There are two historic reports of this species occurring naturally in the Macquarie River, one of which is unconfirmed, but no recent records. In 2009, hatchery-bred Trout Cod were released at Gardiners Hole (the proposed offtake site), two nearby sites (i.e. Boat Hole and Dixons Hole) and three other sites on the upper Macquarie River. Three sites further upstream were stocked in 2010. Trout Cod were also released at sites in the upper Macquarie River in December 2011 and are known to have been released into the Turon River, a tributary of the Macquarie River, in 1991 and 1993. It is not known whether any of these individuals have survived and, if so, whether local populations have been established at or in the vicinity of Gardiners Hole. The extraction of water from the river could result in the impingement and entrainment of eggs and larval Trout Cod within the Offtake Structure and their loss from the river. The greater swimming abilities of juveniles, sub-adults and adults would make them less susceptible to impingement and entrainment. Losses of eggs and larvae would be minimised by screening the offtake, slowly ramping up the pump velocity, restricting offtake to a maximum of 12 ML over a period of 19 hours per day when flows upstream of the offtake site are equal to or greater than 38 ML/day and the storage volume of Suma Park Dam is below 90%. After daily extraction operations, air would be passed through the screen to dislodge animals trapped in the screen. Devices that deflect fish away from the vicinity of the pump could also be installed.
<i>Reduced area of occupancy</i>	Trout Cod have been recorded in several aquatic habitats. The existing self-sustaining populations are found in deep, flowing rivers with sand, silt or clay substrata and numerous snags and in relatively narrow streams with rock, gravel and sand substrata, and shallow pools interspersed with rapids and cascades. The Macquarie River and Summer Hill Creek both contain suitable habitat, but that in the creek is unlikely to be accessible. The construction and operation of the Offtake Structure is likely to disturb any Trout Cod that occur in the vicinity. Their most likely response to disturbance from noise, loss of habitat and increased sediment load would be to move to suitable habitat elsewhere in the river. The installation of the Offtake Structure would lead to permanent loss of approximately 12 m² of underlying benthic substratum, which is equivalent to approximately 0.02% of the pool habitat. Adjoining areas of habitat are also likely to be disturbed by the works. Given the small footprint of the Offtake Structure and presence of alternative habitat nearby and elsewhere in the upper Macquarie River, the reduction in area of occupancy would be localised and of minor significance. The extraction of water would on average reduce the water level in Gardiners Pool by 1-4 mm during moderate to high flows and by 6-9 mm during low to moderate flows. A maximum decrease in water level of 23 mm would occur on the 0.11% of extraction days when 12 ML/day is extracted from a river flow of 38 ML/day (Geolyse 2012).

	As the water that is removed would be replenished by flows from upstream, the impact on the availability of habitat per day would be transient and minor.
<i>Fragmentation of an existing population into two or more populations.</i>	The limited spatial extent of the Offtake Structure, availability of potential habitat for Trout Cod nearby and elsewhere in the upper Macquarie River and the mobility of this species suggest that fragmentation of an existing population into two or more populations is highly unlikely.
<i>Adverse effects on habitat that is critical to the survival of the species</i>	Trout Cod use a variety of aquatic habitats, including deep, flowing rivers with sand, silt or clay substrata and numerous snags and relatively narrow streams with rock, gravel and sand substrata, and shallow pools interspersed with rapids and cascades. Information on habitat that is critical to the survival of this species is limited. In the Murray River, Trout Cod frequent areas where there are large amounts of large woody debris, close to deep water and high surface flows. In narrow river sections, they frequented areas where large wood was abundant, but in other areas they use large wood that occurred in deep scour pools (Nicol <i>et al.</i> 2007). Trout Cod in the Murrumbidgee River have a small home range and prefer to move along outer river bends where there is deeper water and more structural woody habitat (Thiem <i>et al.</i> 2008). As similar habitats to that at the proposed Offtake Structure are present nearby and elsewhere in the upper Macquarie River, it is unlikely that the effects of the Project on habitat would be critical to the survival of this species.
<i>Disrupt the breeding cycle of a population</i>	It is not known whether any of the Trout Cod that have been released into the upper Macquarie River have survived to sexual maturity. Trout Cod are believed to pair up prior to spawning which takes place in late October to early November, when water temperatures reach about 16° C. Spawning does not appear to be dependent on flow conditions, so the small reductions in amplitude of medium, and moderate to high flows resulting from extraction of water are unlikely to have any effects. Trout Cod are believed to deposit adhesive eggs on hard surfaces on or near the stream bottom. The likelihood of intake of eggs during extraction is consequently low. The inclusion of a screen at the pump intake with a 2 mm mesh would prevent entrainment of the fairly large eggs (2.5-3.6 mm in diameter) produced by this species. There is a possibility that some female Trout Cod may deposit their eggs on the surface of the Offtake Structure. The larvae are 6.0-8.8 mm long at hatching and are thought to disperse downstream in the drift for a short distance, with peak dispersal occurring in November (Koehn and Harrington 2006). Small larvae would be vulnerable to impingement and entrainment during their dispersal, but the risk would be minimised by screening. The environmental conditions favouring successful recruitment are not known. Given the above, the Project is unlikely to disrupt the breeding cycle of a Trout Cod population, if present.
<i>Modify, destroy, remove, isolate or decrease the availability and or quality of habitat to the extent that the species is likely to decline.</i>	Potential temporary impacts on the quality of habitat resulting from increased sediment loading during construction would be avoided or minimised by application of appropriate erosion and sediment control measures. The area of habitat that would be lost, modified or degraded as a result of the installation of the Offtake Structure is small relative to that available nearby and within the upper Macquarie River. It is consequently highly unlikely that the Project would change habitat availability and/or quality to such an extent that the species would decline.
<i>Result in invasive species that are harmful becoming established in the</i>	Populations of six invasive fish species, Brown Trout, Eastern Gambusia, European Carp, Goldfish, Rainbow Trout and Redfin

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<i>threatened species habitat</i>	Perch are known to occur in the upper Macquarie River. Redfin Perch, Eastern Gambusia and European Carp have been recorded in the vicinity of the proposed site of the Offtake Structure. The construction and operation of the proposed pipeline does not include any mechanisms for establishment of additional invasive species.
<i>Introduce disease that may cause the species to decline</i>	The construction and operation of the proposed pipeline does not include any mechanisms that would introduce disease. The noise, vibrations, and increase in sediment loading during the construction work and operation of the Offtake Structure could potentially stress Trout Cod and, in turn, increase their susceptibility to disease. The effects, however, would be localised and therefore unlikely to cause the species to decline.
<i>Interfere with the recovery of the species</i>	The overall objective of the National Recovery Plan for Trout Cod (Trout Cod Recovery Team 2008a) is to minimise the probability of extinction in the wild, and increase the likelihood of important populations becoming self-sustaining. in the long term. The following activities associated with the Project could pose a threat to the recovery of this species: • Removal of habitat including large woody debris from the vicinity of the Offtake Structure • Reduction in water quality and increased sediment load associated with construction works; • Construction of barriers to movement (e.g. coffer dams) • Extraction of water The threats posed by most of the above activities would be localised and transient and therefore unlikely to interfere with the recovery of the species. Extraction, however, could potentially have a cumulative effect on local populations, particularly if it results in periodic impingement and entrainment of eggs and larval fish. The likelihood of this depends on whether stocking of Trout Cod at Gardiners Hole and nearby sites has led to the establishment of self-sustaining populations and the efficacy of mitigation measures (i.e. low pump velocities, screening, limited extraction periods and purging of the screen) that would be used to minimise impingement and entrainment. The overall objective of the NSW Recovery Plan for Trout Cod is to ensure the recovery and natural viability of this species throughout its former range. The specific objectives of this plan that are pertinent to the Project are: • Establishing and protecting stocked populations at selected locations throughout the species former range; • Identifying management actions to minimise threats to populations. The recovery actions specified in the NSW Plan that are relevant to the Project are: • Minimising habitat degradation and improving protection and rehabilitation of key habitat; and • Reducing the impact of incidental capture. The proposed site for the Offtake Structure is adjacent to one of the sites in the Macquarie River (Gardiners Hole) where large numbers of hatchery-bred Trout Cod have been released as part of the NSW Recovery Plan. The stocking that has been undertaken to date is unlikely to be compromised by the proposed Project if the proposed mitigation measures are implemented.
<i>Conclusion</i>	There is a possibility of the local Trout Cod population, if one exists, being impacted during the construction and operation of the offtake. The adoption of the mitigation and management measures recommended in Section 4.1.3.2, however, would reduce impacts to minor levels.

(b) Macquarie Perch (*Macquaria australasica*) (Source: NSW DPI 2006a; DSEWPAC 2010)

Assessment Criteria	Response
Conservation status under EPBC Act	Endangered species
Long-term decrease in the size of local and regional populations	Macquarie Perch are found in the Murray-Darling Basin, particularly the upstream reaches of the Lachlan, Murrumbidgee and Murray Rivers, and parts of south-eastern coastal NSW, including the Hawkesbury and Shoalhaven catchments. They have also been recorded in the upper reaches of the Macquarie River system. There has been a marked decline in the distribution and abundance of Macquarie Perch in NSW. Natural populations are now thought to be restricted to the upper reaches of the Lachlan and Murrumbidgee Rivers in southern NSW. This species is presumed to be extinct in the Macquarie River catchment, as it has not been collected from there since its original description, nor been reported ethnographically for many decades (Faulks <i>et al.</i> 2010). It should, however, be noted that the fish surveys that have been undertaken are limited in frequency, spatial extent, duration and intensity, so the possibility of the species still being present cannot be discounted. This species has been stocked at numerous sites within and outside its natural range, but no records have been found of any recent stockings in the upper Macquarie River. If this species is present, the extraction of water could result in the impingement and entrainment of eggs and larval fish within the pipeline and their loss from the river. The greater swimming abilities of juvenile, sub-adults and adults would make them less susceptible to impingement and entrainment. Losses of eggs and larvae would be minimised by screening the offtake, slowly ramping up the pump velocity and restricting offtake to a maximum of 12 ML over a period of 19 hours per day, when flows upstream of the offtake site are equal to or greater than 38 ML/day and the storage volume of Suma Park Dam is below 90%. Air would be blasted through the screen after daily extraction operations to dislodge animals trapped in the screen. Devices that deflect fish away from the vicinity of the pump could also be installed.
Reduced area of occupancy	Macquarie Perch is a schooling species that prefers clear water and deep, rocky holes with lots of cover in the form of aquatic vegetation, large boulders, debris and overhanging banks. Potential habitat for this species is present at the proposed offtake site. The construction and operation of the Offtake Structure is likely to disturb any Macquarie Perch that may occur in the vicinity. The most likely response of these fish to disturbance from noise, loss of habitat and increased sediment load would be to move to suitable habitat elsewhere in the river. The installation of the Offtake Structure would lead to permanent loss of approximately 12 m² of underlying benthic substratum which is equivalent to approximately 0.02% of the pool habitat. Adjoining areas of habitat are also likely to be disturbed by the works. Given the small footprint of the Offtake Structure and presence of alternative habitat nearby and elsewhere in the upper Macquarie River, the reduction in area of occupancy would be localised and of minor significance. As extraction would not take place when flows fall below 38 ML/day there would be no change in the availability of aquatic habitat during low or very low flows. The extraction of water would on average reduce the water level in Gardiners Pool by 1-4 mm during moderate to high flows and by 6-9 mm during low to moderate flows. A maximum decrease in water level of 23 mm would occur on the 0.11% of extraction days when 12 ML/day is extracted from a river flow of 38 ML/day (Geolyse 2012). As the water that is removed would be replenished by flows from upstream, the impact on the availability of habitat per day would be transient and minor.

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<i>Fragmentation of an existing population into two or more populations.</i>	The limited spatial extent of the Offtake Structure, availability of potential habitat for Macquarie Perch nearby and elsewhere in the upper Macquarie River and the mobility of this species suggest that fragmentation of an existing population into two or more populations is highly unlikely.
<i>Adverse effects on habitat that is critical to the survival of the species</i>	As similar habitats to that at the proposed Offtake Structure are present nearby and elsewhere in the upper Macquarie River, it is unlikely that the effects of the Project on habitat would be critical to the survival of this species. Macquarie Perch generally release their eggs in shallow, fast-flowing water over gravel beds. The limited spatial extent of the Offtake Structure, availability of similar habitat nearby and elsewhere in the Upper Macquarie River suggest that effects on this habitat would not be critical to the survival of this species.
<i>Disrupt the breeding cycle of a population</i>	Macquarie Perch is known to migrate from impoundments into rivers to spawn in areas with small boulders, pebbles and gravel. Spawning generally takes place in spring and early summer in shallow, fast-flowing water over gravel beds. The eggs produced are adhesive and stick to gravel. The risk of the entrainment of eggs during extraction would consequently be low. The inclusion of a screen at the pump intake with a 2 mm mesh would also prevent entrainment of the large fertilised eggs (4.0 mm in diameter) produced by this species. Suitable spawning habitat for this species is present in the vicinity of the offtake site. If a self-sustaining Macquarie Perch population is present in the vicinity, it is possible that larvae that hatch from eggs deposited at or upstream of this site would be entrained. Newly-hatched larvae are 4.0-6.5 mm long and could be vulnerable to impingement and entrainment during their dispersal. The proposed screening of the pump would minimise these risks. Given the above, the Project is unlikely to disrupt the breeding cycle of a Macquarie Perch population, if present.
<i>Modify, destroy, remove, isolate or decrease the availability and or quality of habitat to the extent that the species is likely to decline.</i>	Potential temporary impacts on the quality of habitat resulting from increased sediment loading during construction would be minimised by application of appropriate erosion and sediment control measures. The area of habitat that would be lost, modified or degraded as a result of the installation of the Offtake Structure is small relative to that available nearby and within the upper Macquarie River. It is consequently highly unlikely that the Project would change habitat availability and/or quality to such an extent that the species would decline.
<i>Result in invasive species that are harmful becoming established in the threatened species habitat</i>	Populations of six invasive fish species, Brown Trout, Eastern Gambusia, European Carp, Goldfish, Rainbow Trout and Redfin Perch are known to occur in the upper Macquarie River. Redfin Perch, Eastern Gambusia and European Carp have been recorded in the vicinity of the proposed site of the Offtake Structure. The construction and operation of the proposed pipeline does not include any mechanisms for establishment of additional invasive species.
<i>Introduce disease that may cause the species to decline</i>	The construction and operation of the proposed pipeline does not include any mechanisms that would introduce disease. The noise, vibrations, and increase in sediment loading during the construction work and operation of the Offtake Structure could potentially stress Murray Cod and, in turn, increase their susceptibility to disease. The effects, however, would be localised and therefore unlikely to cause the species to decline.
<i>Interfere with recovery of the species</i>	There is no Recovery Plan for Macquarie Perch.
<i>Conclusion</i>	There is a possibility of the local Macquarie Perch population, if one exists, being impacted during the construction and operation of the offtake. The adoption of the mitigation and management measures recommended in Section 4.1.3.2, however, would reduce impacts to minor levels.

(c) Murray Cod (*Maccullochella peelii peelii*) (Source: National Murray Cod Recovery Team 2010a)

Assessment Criteria	Response
<i>Conservation status under the EPBC Act</i>	Vulnerable species
<i>Long-term decrease in the size of local and regional populations</i>	Murray Cod are endemic to the Murray-Darling River system and historically were present throughout most of this system, except for the upper reaches of tributaries. This species is still present throughout most of its historic range, so natural populations may still occur in the Macquarie River. This species has not been caught during recent itinerant surveys, but this may reflect inappropriate sampling methodology and low sampling intensity rather than absence of the species. The NSW DPI fish stocking records show that Murray Cod fry were released at Gardiners Hole (i.e. the proposed offtake site) in 2008, 2010 and 2011 and at several nearby localities (i.e. Jumbo Hole, Dixons Long Point and Noisy Hole) on the upper Macquarie River. Fry have also been released into Burrendong Dam. It is not known whether any of the individuals released at Gardiners Hole have survived or whether any of those released at the other sites have dispersed to and established local populations at Gardiners Hole. If this species is present, the extraction of water could result in the impingement and entrainment of eggs and larval fish within the pipeline and their loss from the river. The greater swimming abilities of juveniles, sub-adults and adults would make them less susceptible to impingement and entrainment. Losses of eggs and larvae would be minimised by screening the offtake, slowly ramping up the pump velocity and restricting offtake to a maximum of 12 ML over a period of 19 hours per day, when flows upstream of the offtake site are equal to or greater than 38 ML/day and the storage volume of Suma Park Dam is below 90%. Air would also be blasted through the screen after daily extraction operations to dislodge any animals trapped in the screen. Devices that deflect fish away from the vicinity of the pump could also be installed.
<i>Reduced area of occupancy</i>	Murray Cod have been found in a variety of habitats, including clear rocky streams, slow flowing, turbid rivers, and billabongs. This fish is usually found in sheltered areas, where there is extensive cover in the form of large rocks, snags, overhanging vegetation or other woody structures. Juveniles have been found in the main river channel. Murray Cod are thought to be sedentary species, remaining in a specific hole, snag or area of the river until spring-summer, when they undertake extensive upstream spawning migrations. After spawning, the adults return to their territory downstream. The construction and operation of the Offtake Structure is likely to disturb any Murray Cod that may occur in the vicinity. The most likely response of these fish to disturbance from noise, loss of habitat and increased sediment load would be to move to suitable habitat elsewhere in the river. The installation of the Offtake Structure would lead to permanent loss of approximately 12 m² of underlying benthic substratum, which is equivalent to approximately 0.02% of the pool habitat. Adjoining areas of habitat are also likely to be disturbed by the works. Given the small footprint of the Offtake Structure and presence of alternative habitat nearby and elsewhere in the upper Macquarie River, the reduction in area of occupancy would be localised and of minor significance. As extraction would not take place when flows fall below 38 ML/day there would be no change in the availability of aquatic habitat during low or very low flows. The extraction of water would on average reduce the water level in Gardiners Pool by 1-4 mm during moderate to high flows, by 6-9 mm during low to moderate

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	flows. A maximum decrease in water level of 23 mm would occur on the 0.11% of extraction days when 12 ML/day is extracted from a river flow of 38 ML/day (Geolyse 2012). As the water that is removed would be replenished by flows from upstream, the impact on the availability of habitat per day would be transient and minor.
<i>Fragmentation of an existing population into two or more populations.</i>	The limited spatial extent of the Offtake Structure, availability of potential habitat for Murray Cod nearby and elsewhere in the upper Macquarie River suggest that fragmentation of an existing population into two or more populations is highly unlikely.
<i>Adverse effects on habitat that is critical to the survival of the species</i>	As similar habitats to that at the proposed Offtake Structure are present nearby and elsewhere in the upper Macquarie River, it is unlikely that the effects of the Project on habitat would be critical to the survival of this species.
<i>Disrupt the breeding cycle of a population</i>	Murray Cod spawn in late spring and early summer. Spawning has been reported to occur in the vicinity of submerged rocks and in depressions excavated in clay banks. The eggs are adhesive and are deposited as a large mat on the spawning surface. The risk of the entrainment of eggs during extraction would consequently be low. The inclusion of a screen at the pump intake with a 2 mm mesh would also prevent the 2.5 -3.0 mm diameter eggs produced by this species being entrained. Larvae drift downstream and fry settle out in suitable protected habitat. Newly-hatched larvae are 9.5-15.0 mm long and would be vulnerable to entrainment if they pass through the area where the Offtake Structure is located. The proposed screening of the pump would minimise these risks. Given the above, the Project is unlikely to disrupt the breeding cycle of a Murray Cod population, if present
<i>Modify, destroy, remove, isolate or decrease the availability and or quality of habitat to the extent that the species is likely to decline.</i>	Potential temporary impacts on the quality of habitat resulting from increased sediment loading during construction would be minimised by application of appropriate erosion and sediment control measures. The area of habitat that would be lost, modified or degraded as a result of the installation of the Offtake Structure is small relative to that available nearby and within the upper Macquarie River. It is consequently highly unlikely that the Project would change habitat availability and/or quality to such an extent that the species would decline.
<i>Result in invasive species that are harmful becoming established in the threatened species habitat</i>	Populations of six invasive fish species, Brown Trout, Eastern Gambusia, European Carp, Goldfish, Rainbow Trout and Redfin Perch are known to occur in the upper Macquarie River. Redfin Perch, Eastern Gambusia and European Carp have been recorded in the vicinity of the proposed site of the Offtake Structure. The construction and operation of the proposed pipeline does not include any mechanisms for establishment of additional invasive species.
<i>Introduce disease that may cause the species to decline</i>	The construction and operation of the proposed pipeline does not include any mechanisms that would introduce disease. The noise, vibrations, and increase in sediment loading during the construction work and operation of the Offtake Structure could potentially stress Murray Cod and, in turn, increase their susceptibility to disease. The effects, however, would be localised and therefore unlikely to cause the species to decline.
<i>Interfere with recovery of the species</i>	The overall objective of the National Recovery Plan for Murray Cod is to have self-sustaining populations managed for conservation, fishing and culture. The following activities associated with the Project could pose a threat to the recovery of this species: Habitat degradation, including removal of any large woody debris present in the vicinity of the Offtake

	Structure • Reduction in water quality and increased sediment load associated with construction works; • Construction of barriers to movement (e.g. coffer dams); • Extraction of water. The threats posed by most of the above activities would be localised and transient and therefore unlikely to interfere with the recovery of the species. Extraction, however, could potentially have a cumulative effect on local populations, particularly if it results in periodic entrainment of eggs and larval fish. The likelihood of this depends on whether stocking of Murray Cod at Gardiners Hole and nearby sites has led to the establishment of self-sustaining populations and the efficacy of the mitigation measures (i.e. low pump velocities, screening, limited extraction periods and purging of the screen) that would be used to minimise entrainment. The Project is unlikely to compromise the stocking of Murray Cod that has been undertaken to date at this and nearby sites. There is no NSW Recovery Plan for Murray Cod.
<i>Conclusion</i>	There is a possibility of the local Murray Cod population, if one exists, being impacted during the construction and operation of the offtake. The adoption of the mitigation and management measures recommended in Section 4.1.3.2, however, would reduce the potential for impact to minor levels.

6.1.7 Assessments of the Significance of Impacts on the Macquarie Marshes

An assessment of the significance of impacts on the ecological character of the Macquarie Marshes has been prepared in accordance with the Significant Impact Criteria for Ramsar wetlands specified in the MNES Significant Impact Guidelines 1.1 (Commonwealth of Australia 2009). These criteria are whether the Project would result in:

- Areas of the wetland being destroyed or substantially modified;
- A substantial and measurable change in the hydrological regime of the wetland;
- Adverse effects on the habitat or life cycle of native species dependent upon the wetland;
- A substantial and measurable change in the quality of water within the wetland;
- The establishment of an invasive species within the wetland that is harmful to its ecological character.

The objective of this assessment is to determine whether the Project is likely to have a significant impact on the ecological character of the Macquarie Marshes, as described in Sections 6.1.7.1 to 6.1.7.2. The assessment takes into consideration potential direct and indirect impacts of the pre-construction, construction and operational phases of the project and off-site impacts.

6.1.7.1 General Description

The Macquarie Marshes is a large (> 200,000 ha) floodplain wetland situated at the lower end of the Macquarie River in the Macquarie-Castlereagh region (CSIRO 2008). The Marshes are of national significance because it is one of the largest inland, semi-permanent wetlands in South-east Australia, an outstanding example of the lower floodplain wetlands characteristic of the Darling Riverine Plain and a relatively unmodified part of the Northern Alluvial Fans, a major land system in NSW (DEWHA 2000). Approximately 10% of the Marshes have been declared a Ramsar site (Wetland of International Importance) (Kingsford *et al.* 2007). The Ramsar site includes the northern and southern sections of the Macquarie Marshes Nature Reserve (18,143 ha) and the Wilgara wetland on the Gum Cowl - Terrigal Creek system (583 ha).

6.1.7.2 Ecological Character

The ecological character of the Ramsar site is the sum of all the ecosystem components, processes and benefits/services of the wetland at the time of its designation for a Ramsar Site. The description of the ecological character of the Ramsar site within the Marshes presented below focuses on the key ecosystem components, processes, benefits and services of the area and is based primarily on the Ramsar Information Sheet for this wetland. It should be noted that the key ecological components of the marshes are well documented, but relatively little is known about their ecological processes and functions, and how the different parts interact and change over time (NSW DECCW, 2010).

The description of the ecological character of the Macquarie Marshes Ramsar site prepared prior to its designation is intended to serve as a baseline against which changes in its ecosystem components, processes, services and benefits are measured. It is important to note that marked changes in the flow regime and reductions in inundation frequency have occurred since the designation of the Ramsar site in 1986 and that these have led to declines in the health, diversity and distribution of key vegetation communities in the southern and northern section of the Nature Reserve and the Wilgara wetland and reductions in the numbers of colonial breeding waterbirds (NSW DECCW, 2010). CSIRO (2008) indicates the average period between important inundation events in the Marshes has increased by 114 % as a result of the development of water resources within the Macquarie - Castlereagh catchment. Extremely low rainfall and flows during the last decade have also contributed to the reduction in the amount of available water (Ren *et al.* 2010). An assessment of the effects of river regulation and extraction on the Macquarie Marshes based

on the LOESS model has shown that median natural flows and area of inundation have been reduced by 52% and 59%, respectively relative to the natural flows that would have prevailed prior to the construction of Burrendong Dam, the most significant regulatory structure on the Macquarie River (Ren *et al.* 2010). It is understood that the description of the ecological character of the Macquarie Marshes has recently been updated, but has yet to be released (Alison Curtin, Water and Wetlands Strategy Division, NSW Office of Environment and Heritage pers. comm.).

6.1.7.2.1 Ecosystem components

The Marshes are situated on early Tertiary alluvium in the Great Artesian Basin, within the Northern Alluvial Fans land system. The soils are fairly uniform and consist of grey-brown soils to black organic loams over grey clays. Several different wetland forms are represented, including braided swamps, ephemeral lagoons, overflow depressions, channel country and gilgaied floodplain. The Ramsar site supports a diverse range of vegetation types, including extensive areas of River Red Gum woodland, reed swamp and water couch grassland. Black Box, Lignum, Cumbungi and River Cooba are also present. This vegetation in turn supports a diverse range of animals and plants, including 211 bird species, 8 species of native mammal, 15 frog species, 56 reptile species and 24 native fish species (Brock 1997).

The Nature Reserve and Wilgara Wetland are of international significance because they provide temporary habitat for migratory bird species listed under the Japan-Australia and China-Australia Migratory Bird Agreements (JAMBA and CAMBA), support permanent populations of several threatened bird species (e.g. Australasian Bittern and Brolga), and are two of the few places in NSW where Magpie Geese breed. Other threatened bird species, including Freckled Duck, Blue-billed Duck and Painted Snipe, are also present. The Ramsar site provides significant habitat for colonially-breeding waterbirds and is also one of the few places in Australia, where large colonies of Straw-necked Ibis occur, and one of the few sites in NSW, where Magpie Geese breed. It also supports large breeding colonies of Intermediate Egret, Rufous Night Heron and Royal Spoonbill and provides habitat for other waterbirds that breed there. The Ramsar site supports at least one threatened plant species (*Lepidium hyssopifolia*), the most southerly population of Coolibah, northernmost population of Black Box and westernmost population of Gould's Long-eared Bat.

6.1.7.2.2 Ecosystem processes

The term ecosystem processes refers to the dynamic forces within an ecosystem and includes processes that occur between organisms, within and between populations and communities and their interactions with the non-living environment and bring about changes in ecosystems over time (Australian Heritage Commission 2002).

Primary production, nutrient cycling, decomposition, carbon cycling and oxidation-reduction are considered to be key dynamic processes in wetlands. The animal and plant populations within the wetland are maintained by processes such as reproduction, regeneration, dispersal, migration, pollination, competition, predation, succession and herbivory (DEWHA 2008). Information on both sets of processes is lacking.

The key processes that determine the character of the Marshes and hence the Ramsar site are the frequency, duration, extent of inundation and quality of the water (Poff *et al.* 1997; Puckridge *et al.* 1998). The Nature Reserve receives water from the Macquarie River, Monkeygar Creek and Bora Channel systems, while the Wilgara Wetland is supplied by the Gum Cowal - Terrigal Creek systems (DEWHA 2000). The inundation of the area by flooding is a highly variable natural process and is dependent on flows from the upper catchment of the Macquarie River more than 460 km to the southeast (Kingsford and Thomas 1995). Over the last 50 years, the total amount of inundation and the frequency, area and duration of flooding has been reduced by regulation of flows by dams and weirs, levees and banks and by extraction of water further upstream for irrigation, stock and domestic water supply.

6.1.7.2.3 Ecosystem Benefits and Services

The term ecosystem benefits and services refers to the direct and indirect benefits and services that people receive from ecosystems (Ramsar Convention 2005). The direct ecosystem benefits and services associated with the Ramsar site are limited to:

- The use of Wilgara Wetland for grazing beef cattle and its management for conservation through the application of sustainable grazing management practices;
- Public access to the Nature Reserve, which takes the form of educational visits by schools and universities and open days held in October each year during which guided walks and talks are provided by NPWS staff;
- The use of the habitats and associated fauna, particularly waterbirds, for scientific research.

The Ramsar site provides the following indirect benefits:

- It supports a diverse range of wetland-dependent animals and plants, particularly birds;
- It is part of the main sediment trap within the Macquarie catchment and by intercepting nutrients, salt and chemical contaminants derived from agricultural and urban activities helps to maintain water quality in the Murray-Darling Basin;
- It supports agricultural activities such as grazing of beef cattle and sheep, production of wheat, oats, sorghum, and irrigated cropping (cotton) on surrounding private land.

6.1.7.3 Potential Impacts on Ecological Character

Information on the relationship between flows and the condition of the key ecological components is needed to assess the impacts of changes in the flow regime on the ecological character of the Macquarie Marshes. This information is not available for all the components and in some cases it is not even known whether there is a linear relationship between flow and ecological condition or a threshold beyond which their condition deteriorates. Factors such as seasonality, catchment health and antecedent conditions may also influence responses to flow events (Rayner *et al.* 2009). The flows that occur downstream of Marebone Weir over five successive months between June and April/May, however, are known to determine the area of the floodplain and extent to which vegetation communities, such as common reed, mixed marsh, water couch and cumbungi, river cooba and lignum and river red gum, are inundated (MDBA 2012). The relationships between river flows and breeding of colonial waterbirds and flooding in the Macquarie Marshes have also been documented (Kingsford and Auld 2005). Breeding of most colonial waterbirds was positively related to flow in the three months before breeding and triggered when flows were usually above 200 GL.

The environmental water requirements of some of the key ecological components within the Macquarie Marshes have also recently been assessed (MDBA 2012). The following inflows are thought to be required to maintain the condition of the main flood dependant vegetation types:

- 100 GL over a 5 month period to maintain semi-permanent wetlands and other lower elevation vegetation communities, including some river red gum forest;
- 250 GL over a 5 month period to inundate a larger proportion of the marshes, including the majority of river red gum forest and wetland communities;
- 400 GL and 700 GL over periods of 7 and 8 months to inundate the broader Marshes, including woodland communities.

These flows are required to occur on 80%, 40%, 30% and 17% of years respectively and over five successive months between June to April or May.

The breeding success of colonial nesting waterbirds is dependent on floods that are of sufficient volume and duration to inundate colony sites and feeding areas for at least five consecutive months between August and March (NSW DECCW 2010). According to MDBA (2012), an inflow of around 250 GL to 300 GL at Marebone Weir is required for successful waterbird breeding.

Flows that connect the river channel to the floodplain and in-channel flow variability are considered to be important for sustaining native fish populations. The native fish species in the Macquarie Marshes and lower Macquarie River typically recruit during spring and early summer. Appropriate flows are needed during this period to ensure that eggs, larval and juvenile fish are protected (NSW DECCW 2010). The flow requirements of flood-dependent vegetation communities and waterbirds are expected to support the life-cycle and habitat requirements of such fish and provide them with cues for spawning and migration and enable them to access food resources. They are also likely to benefit the life-cycle and habitat requirements of amphibians, and water-dependent reptiles and invertebrates and enhance key ecosystem functions associated with river and floodplain connectivity.

The assessment of the potential impact of the proposed extraction on the ecological character of the Marshes also needs to take into consideration the factors that influence the extent to which the area is inundated with water, including:

- The effects of extraction on inflows to Burrendong Dam, the major regulatory structure on the Macquarie River, which is situated upstream of Wellington;
- The provisions of the Water Sharing Plan for the Macquarie and Cudgegong Regulated Rivers Water Source 2003 (Macquarie-Cudgegong WSP) which specify how the flows in the regulated section of the Macquarie River are allocated (NSW Government, 2006); and
- General water security entitlements purchased by the NSW and Australian governments.

Burrendong Dam has a storage capacity of 1,154 GL and regulates 91% of inflows from the Macquarie and Cudgegong Rivers (CSIRO 2008). The IQQM modelling indicates the extraction of 1.665 GL/year of water on average via the Macquarie River to Orange pipeline would reduce the combined long-term average inflows from these rivers by 0.16% (Geolyse 2012). The water balance modelling shows that the project would increase the average annual flow in Summer Hill Creek by around 1.30 GL/year. The additional inflow from this tributary would reduce the average net extraction from the Macquarie River to 0.33 GL/year, which represents 0.03% of the long term average annual inflow to Burrendong Dam. During dry periods, the reduction in inflows would increase, but would still constitute only a small proportion of the total inflows, with estimates of reductions varying from 0.32% to 0.67% for the three dry periods modelled. It is important to note that the IQQM modelling referred to in this section was based on an annual average extraction of 1.665 GL/y rather than 1.616 GL/y. The impacts would consequently be marginally less than reported below.

The provisions of the Macquarie-Cudgegong WSP affect the management of water access licences, water accounts, water trading, dam operations and management of follows, including release of water for environmental needs. The plan indicates there an environmental release into the Macquarie River of up to 160 GL/year would be made from Burrendong Dam when the storage is full. Part of this would be released between 1 June and 30 November, and between 15 March and 31 May to provide more natural flows downstream. The other part of the environmental component would be released when needed to enhance opportunities for native fish recruitment and dispersal in the Macquarie River and Macquarie Marshes and to ensure completion of colonial water bird breeding and alleviate severe, prolonged drought conditions in the Macquarie Marshes. The Macquarie Cudgegong WSP also indicates approximately 73% of the long-term average yearly flows in the system are reserved for the protection of environmental health (DIPNR 2004). Additional water for environmental purposes is purchased each year by the NSW and Commonwealth Governments from holders of general security access licences. In June 2010, the total

regulated environmental share available to the Macquarie Marshes was 262.15 GL and comprised:

- 160 GL environmental share provided in the Macquarie-Cudgegong WSP
- A general security entitlement of 46.275 GL purchased by the NSW government; and
- A general security entitlement of 55.873 GL held by the Commonwealth Environmental Water Holder.

This represents 41% of the total general security entitlement downstream of the dam. The IQQM modelling indicates the proposed extraction of water would reduce the long-term average general security diversions downstream of the dam by 0.6 GL/year and those of the Marshes by 0.25 GL/year, which is approximately 0.10% of the available regulated environmental share (Geolyse 2012). For the three dry periods modelled, the total percentage change in general security diversions was also small, ranging from -0.57% to +0.49%. The corresponding changes in the Macquarie Marshes share range from a loss of 5.2 GL to an increase of 1.3 GL.

IQQM modelling was also used to assess the effects of extraction on flows downstream of Marebone Weir less downstream irrigation diversions, as this is believed to be the best indicator of flows to the Marshes. The modelling showed that extraction would lead to a 0.5 GL/year decrease in the average annual flow, which is 0.12% of the long-term average annual flow in the river at that point (Geolyse 2012). The reduction in the total inflow resulting from extraction during the three dry periods modelled was also small, ranging from 0.07% to 0.83%. The flow duration curves for the three dry periods indicate that extraction would have a small effect on moderate to high flows, but no effect on low flows at the weir.

The use of long-term average measures of water availability is questionable in a highly variable river system like the Macquarie River and also when considering impacts on aquatic biota, most of which have relatively short life spans (NSW DECCW 2010). It is therefore important to also assess the impact of the maximum annual extraction rate on the ecological character of the Marshes. The IQQM modelling indicates flows in the river downstream of Marebone Weir would be reduced by 1.766 GL/year when the maximum annual extraction occurs and losses would be greatest between February and August and maximal in June. The reduction in inflows due to maximal extraction represents only a small fraction (0.4%) of the average annual flows (426.4 GL/year) in the Marshes and an even smaller fraction (0.11%) of their maximum annual flows (1582.4 GL/year) (Geolyse 2012). Given the above, it is highly unlikely that the reduction in flows due to extraction will have a detectable effect on the ecological character of the Macquarie Marshes. Note that the proportional loss during minimum flows (33.9GL/year) or drought periods is not considered relevant, as maximal extraction is unlikely to occur at such times.

It should also be noted that Orange City Council has secured an option for the purchase of a 640 ML/year unregulated water access licence that would be transferred from an upstream location on the Macquarie River to the proposed offtake point if the Project is approved. This would offset some of the proposed extraction.

The IQQM modelling shows that the proposed extraction of water would have only a minor impact on flow in the regulated section of the Macquarie River and that its impact on the flow regime within the Macquarie Marshes is likely to be even smaller (i.e. negligible) due to flow regulation and the management of flows in accordance with the Macquarie-Cudgegong WSP. As the proposed extraction would have a negligible impact on the hydrological regime of the Macquarie Marshes Ramsar site even during drought, it is highly unlikely that the Project would result in:

- Destruction or substantial modification of areas of the wetland;
- Adverse effects on the habitat or lifecycle of the native species that are dependent upon the wetland;
- Substantial or measurable changes in the water quality of the wetland;

- Establishment of additional or spread of existing invasive species that are harmful to the ecological character of the wetland.

On the basis of the above, the proposed extraction is unlikely to have a significant impact on the ecological character of the Macquarie Marshes Ramsar site.

6.2 Matters of State Environmental Significance

6.2.1 Matters Identified

6.2.1.1 Threatened Species

The natural distribution ranges of threatened fish species listed under the *FM Act* indicate that the following could potentially occur in the Project Area:

- Flathead Galaxias (*Galaxias rostratus*) – listed as critically endangered;
- Macquarie Perch (*Macquaria australasica*) - endangered;
- Trout Cod (*Maccullochella macquariensis*) - endangered;
- Southern purple-spotted gudgeon (*Mogurnda adspersa*) – endangered; and
- Silver perch (*Bidyanus bidyanus*) – vulnerable.

Flathead Galaxias is endemic to the southern tributaries of the Murray-Darling River System (i.e. the Murray, Murrumbidgee and Lachlan Rivers and their tributaries). It has also been reported from the upper Macquarie River (Fisheries Scientific Committee 2008a). There are very few recorded recent sightings of this species. Although they are now considered to be locally extinct in the Macquarie River, an assessment of significance has been prepared as a precautionary measure.

6.2.1.2 Threatened Populations

A review of the distribution ranges of threatened populations listed under the *FM Act* legislation indicates that one endangered fish population, Murray River Basin Population of the Freshwater Catfish (*Tandanus tandanus*) could potentially occur in the vicinity of the offtake site. Juvenile Freshwater Catfish have recently been caught at the upstream offtake site on the Macquarie River (GHD 2011a; Cardno this study). DPI NSW has caught this species further upstream in the river at Bruinbun and at Sofala on the Turon River (See Table 3).

The western NSW population of the Olive Perchlet (*Ambassis agassizii*), which is listed as endangered under the *FM Act*, used to occur in the lower and mid Macquarie River Basin, but is now believed to be restricted to a few localities in the Darling drainage upstream from Bourke (Fisheries Scientific Committee 2009). It is consequently not considered relevant to the current project.

6.2.1.3 Threatened Communities

None of the threatened aquatic communities listed under the *FM Act* occur in the upper Macquarie River.

6.2.1.4 Protected Species

The platypus (*Ornithorhynchus anatinus*) is protected under the NSW National Parks and Wildlife Act 1974 and may not therefore be harmed by any person. Platypus are known to occur in the Upper Macquarie River and Summer Hill Creek. Potential habitat for this species has been identified in the vicinity of the proposed offtake site and there are anecdotal reports of the occurrence of platypus in this section of the river (GHD 2011a).

None of the protected freshwater fish species listed under the *FM Act* are relevant.

6.2.1.5 Key Threatening Processes

The following KTPs listed under the *FM Act* may be relevant to the construction and operation of the proposed pipeline:

- Installation and operation of instream structures and other mechanisms that alter natural flow status;
- Removal of large woody debris from NSW rivers and streams;
- Degradation of native riparian vegetation along New South Wales water courses;

Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands” is a KTP listed on Schedule 3 of the TSC Act

6.2.1.6 Critical Habitat

. None of the critical aquatic habitats listed under the TSC Act or *FM Act* occur in the Project Area.

6.2.1.7 Records of Conservation Assets

Six fish species predicted to occur in the upland zone of the Macquarie River prior to significant human intervention (Davies *et al.* 2008) are now considered to be threatened (Table 3). None of these species was recorded during surveys of sites within the upper Macquarie catchment undertaken by Davies *et al.* (2008), GHD (2011a), Cardno Ecology Lab (this study) or DPI NSW, except for Murray Cod which have been caught in the Cudgegong River. It should, however, be noted that intensive targeted sampling of these species has not been undertaken.

Flat-head Galaxias and Macquarie Perch, species listed as critically endangered and vulnerable, respectively under the *FM Act*, have previously been reported from the upper Macquarie River (FSC 2008a; Trueman 2007). It should also be noted that NSW DPI has released Murray Cod and Trout Cod at various sites in the upland zone of the Macquarie River and stocked Murray Cod and Silver Perch into Lake Burrendong (Section 2.2.1.4).

The potential impact of the Project on each of these conservation assets is considered in the next section. The impact assessments have been prepared in accordance with the Guidelines for Threatened Species Assessment, which identify important factors that must be considered when assessing potential impacts on threatened species, populations, or ecological communities, or their habitats for development applications assessed under Part 3A of the NSW Environmental Planning and Assessment Act, 1979 (DEC and DPI, 2005). The use of these guidelines was specified in the Director-Generals Requirements issued on 24 March 2011.

6.2.2 Assessments of the Significance of Impacts on Threatened Species

The assessments of the significance of impacts on threatened fish species and populations listed under the *FM Act* presented in Tables 15 and 16, respectively have been prepared in accordance with the Draft Guidelines for Threatened Species Assessment that are applicable to development proposals that are to be assessed under Part 3A of the NSW Environmental Planning and Assessment Act, 1979 (DEC and DPI, 2005). These guidelines specify the important factors that must be taken into considered when assessing potential impacts on threatened species, populations, or ecological communities. The factors requiring consideration are:

- How is the Project likely to affect the lifecycle of a threatened species and/or population?
- How is the Project likely to affect the habitat of a threatened species, population or ecological community?

- Does the Project affect any threatened species or populations that are at the limit of its known distribution?
- How is the Project likely to affect current disturbance regimes?
- How is the Project likely to affect habitat connectivity?
- How is the Project likely to affect critical habitat?

The assessments that have been prepared are based on the Project Description (GHD 2011b) and our understanding of the likely impacts of the Project on instream ecology. Issues raised in the DGRs have also been taken into consideration. The objective of these assessments is to determine whether the Project is likely to have a significant impact on the threatened species and population identified in Sections 5.2.1.1 and 5.2.1.2. The assessment considers the potential direct and indirect impacts of the construction and operational phases of the project.

The potential for adverse effects on the lifecycle of threatened fish species depends on whether the Project is likely to cause loss or degradation of habitat, reduction in water quality, limit their foraging activities and disrupt their reproduction and recruitment.

The disturbance regime that is likely to be most relevant to threatened fish species in the upper Macquarie River is the natural variation in flow rates. Bunn and Arthington (2002) identified four key principles that highlight the linkage between flows and aquatic biota:

1. Flow is a major determinant of physical habitat in streams, which in turn has a major effect on the presence and abundance of flora and fauna.
2. The life history strategies of aquatic species have evolved in response to natural flow regimes.
3. Flows are important in maintaining natural patterns of longitudinal and lateral connectivity that are essential to the viability of populations of many riverine species;
4. Changes in the flow regime have facilitated the invasion and success of exotic and introduced species.

The life history of fish is influenced by several features of the flow regime, including the seasonality and predictability of the overall pattern, the timing of particular flow events, (principle 2). Some flow events trigger longitudinal dispersal of migratory aquatic organisms and other large events.

The other disturbance regimes that may be relevant are:

- Addition of ash and nutrients to the river if bushfires are followed by heavy storms (iConneXX 2011); and
- Addition of contaminants and nutrients from a variety of other sources, including urban and rural runoff, discharges from sewage treatment plants, seepage from abandoned mines and septic tanks.

Table 15: NSW Threatened Species Assessments

(a) Flathead Galaxias (*Galaxias rostratus*)(Source: FSC 2008a; Lintermans 2006)

Assessment Criteria	Response
<i>How is the proposal likely to affect the life cycle of the threatened species?</i>	Little is known about the ecology of Flathead Galaxias. They spawn in spring, with the females laying slightly adhesive, demersal eggs. Fecundity is relatively low with females releasing 3000-7000 eggs. The construction of the pipeline could potentially have adverse effects on the availability and quality of spawning habitat. The potential impacts include direct loss and degradation of habitat (e.g. smothering with silt) and changes in water quality due to increased sediment load and accidental releases of drilling fluids, fuels or lubricants. These impacts would be localised and generally short-term in nature, except for loss of habitat. The potential for such impacts would be minimised by limiting the construction footprint, using construction methods that limit disturbance of the stream bed and bank, using appropriate sediment and erosion control measures and translocating animals, if necessary. The limited spatial extent of the pipeline crossings, availability of potential spawning habitat for this species elsewhere in the creeks and suggested mitigation measures suggests that the Project would have a limited effect on the life cycle of Flathead Galaxias, if the species was present.
<i>How is the proposal likely to affect the habitat of this threatened species?</i>	The Flathead Galaxias is a small shoaling fish found in still and gently flowing waters in small streams, lakes, lagoons, billabongs and backwaters. It is consequently more likely to occur in the streams along the pipeline route and Suma Park Reservoir than in the upper Macquarie River, where the proposed Offtake Structure would be constructed. This species is found in habitats with rocky and sand bottoms and aquatic vegetation. If this species is present in the streams along the pipeline route, the availability and quality of its habitat would be affected by the construction work. The potential impacts include loss or modification of physical habitat and changes in water quality due to increased sediment load and accidental releases of drilling fluids, fuels or lubricants. These impacts would be localised and generally short-term in nature, except for loss of habitat. The potential for such impacts would be minimised by limiting the construction footprint, using construction methods that limit disturbance of the stream bed and bank, using appropriate sediment and erosion control measures and translocating animals, if necessary. There is a potential for cumulative impacts to occur in Summer Hill Creek, due to multiple pipeline crossings. The limited spatial extent of the pipeline crossings and availability of potential habitat for this species elsewhere in the creeks indicate the Project is unlikely to result in fragmentation or isolation of potential Flathead Galaxias habitat.
<i>Does the proposal affect a threatened species at the limit of its known distribution</i>	Flathead Galaxias is endemic to the southern tributaries of the Murray-Darling River System and has been reported to occur in the Murray, Murrumbidgee, Lachlan and their tributaries. It has also been reported from the upper Macquarie River. The historical records indicate this species had an intermittent distribution. There has been a significant decline in the distribution and abundance of Flathead Galaxias in NSW rivers and it is

	thought that it may now be locally extinct from the lower Murray, Murrumbidgee, Macquarie and Lachlan Rivers. The Project Area is a considerable distance from the downstream and upstream limits of the upper Macquarie River, so there would be no effects on distribution limits.
<i>How is the proposal likely to affect current disturbance regimes?</i>	The major processes that affect aquatic habitats and their biota in the Project area are surface water flows, runoff during rainfall events and fire. The transfer of water from the Macquarie River will increase the spills from Suma Park Dam and lead to beneficial increases in low to moderate flows and a greater average annual flow in Summer Hill Creek.
<i>How is the proposal likely to affect habitat connectivity?</i>	If flathead Galaxias are present in the streams along the pipeline route, the installation of coffer dams may result in a temporary reduction in habitat connectivity. The impact of this could be minimised by transferring any fish trapped within the coffer dam to adjacent sections of the creek. Increased flows within Summer Hill Creek would improve habitat connectivity within that system.
<i>How is the proposal likely to affect critical habitat?</i>	There are no critical habitats for Flathead Galaxias listed under the <i>FM Act</i>. The recommended and declared critical habitats listed on the NSW Critical Habitat Register (OEH, 2012) and DSEWPAC Register of Critical Habitat (2009) do not occur within the Project area or its surrounds.

(b) Trout Cod (*Maccullochella macquariensis*) (Source: NSW DPI 2006a)

Assessment Criteria	Response
<i>How is the proposal likely to affect the life cycle of the threatened species?</i>	The Trout Cod is a large, deep-bodied opportunistic predator which feeds on yabbies, crayfish, shrimp, fish and aquatic insects. Little is known about its biology or ecology. This species was initially thought to undertake significant upstream migrations, possibly for spawning. Studies undertaken in the Murray River, however, indicate that it may have a small home range. Spawning occurs in late October to early November. Trout Cod do not appear to be dependent on flow conditions, so are unlikely to be affected by the small reduction in flows resulting from extraction of water. Trout Cod produce relatively small numbers (1,200 to 11,000) of adhesive eggs at a time and are believed to deposit these on hard surfaces on or near the stream bottom. The Offtake Structure could potentially provide a hard surface for the deposition of eggs, particularly if it is constructed of precast concrete. The larvae disperse downstream in the flow for a short distance, with peak dispersal occurring in November. The environmental conditions favouring successful recruitment are not known. The noise and vibration of the pump during offtake operations could potentially disturb any Trout Cod present nearby. The offtake of water could also potentially result in the impingement and entrainment of eggs and larval Trout Cod. The greater swimming abilities of juveniles, sub-adults and adults would make them less susceptible to entrainment and impingement. Losses would be minimised by screening the offtake, slowly ramping up the pump velocity, restricting offtake to a maximum of 12 ML/d over a maximum of 19 hours when river flows are ≥ 38 ML/day and purging the screen at the end of the extraction period. Impacts could be minimised further by installing devices that deflect fish away from the pump.
<i>How is the proposal likely to affect the habitat of this threatened species?</i>	Trout Cod utilise several types of aquatic habitat. Existing self-sustaining populations occur in deep, flowing rivers with sand, silt or clay substrata and numerous snags as well as relatively narrow streams with rock, gravel and sand substrata, and shallow pools interspersed with rapids and cascades. The Macquarie River and Summer Hill Creek would both appear to contain suitable habitat for this species. The construction of the Offtake Structure is likely to disturb any Trout Cod that occur in the vicinity of Gardiners Hole. Their most likely response to disturbance from noise, loss of habitat and increased sediment load would be to move to suitable habitat elsewhere in the river. As the footprint of the development is relatively small and there is suitable habitat for this species nearby, the impact of construction work is likely to be localised and of minor significance. The construction of the Offtake Structure would lead to permanent loss of approximately 12 m² of underlying benthic substratum which is equivalent to approximately 0.02% of the pool habitat. Adjoining areas of habitat are also likely to be disturbed by the works. The disturbance to these areas would be localised and transient in nature. The limited spatial extent of the construction and availability of potential habitat for this species nearby and elsewhere in the upper Macquarie River, suggests that fragmentation and isolation of habitat are unlikely to occur. If Trout Cod were present in the larger streams along the pipeline route, the availability and quality of its habitat would be affected by

	the construction work. The potential impacts include loss or modification of physical habitat and changes in water quality due to increased sediment load and accidental releases of drilling fluids, fuels or lubricants. These impacts would be localised and generally short-term in nature, except for loss of habitat. The potential for such impacts would be minimised by limiting the construction footprint, using construction methods that limit disturbance of the stream bed and bank, using appropriate sediment and erosion control measures and translocating animals, if necessary. The extraction of water would reduce the water level in Gardiners Pool by an average of 1-4 mm during moderate to high flows and 6-9 mm during low to moderate flows. As the water that is removed would be replenished by flows from upstream, the effect of this reduction on the availability of habitat between the extraction site and the backed up waters of Burrendong Dam would be relatively small and transient. The decline in availability of aquatic habitat would also diminish with distance downstream. The impact on aquatic habitat would be most significant when 12 ML/day is extracted from a river flow of 38 ML/day. This would result in a decrease in water level of 23 mm, but would be a rare event, occurring on 0.11% of extraction days (Geolyse 2012). There would be no effect on the availability of aquatic habitat during low and very low flows, because extraction would not occur under these conditions.
<i>Does the proposal affect a threatened species at the limit of its known distribution</i>	Trout Cod are endemic to the southern Murray-Darling river system, including the Murrumbidgee and Murray Rivers, and upper Macquarie River. There are, however, only two reports of this species occurring naturally in the Macquarie River, one of which is unconfirmed. This species has undergone a dramatic decline in its distributional range and abundance over the past century. The only known natural population is restricted to the Murray River from below Yarrawonga Weir to Strathmerton. Hatchery-bred Trout Cod have been released at ten sites on the upper Macquarie River on several occasions between 1991 and 2011. Three release sites (Boat Hole, Gardiners Hole and Dixons Hole) are close to the proposed site for the Offtake Structure. It is not known whether any of these individuals have survived and if so whether they have dispersed to and established local populations in the vicinity of the proposed Offtake Structure. The Project Area is situated towards the downstream end of the stocking sites on the upper Macquarie River, but a considerable distance from their upstream limits. Effects on downstream distribution limits are consequently more likely than on upstream limits within the upper Macquarie River.
<i>How is the proposal likely to affect current disturbance regimes?</i>	The major processes that affect aquatic habitats and their biota in the Project area are surface water flows, runoff during rainfall events and fire. The average amount of water that would be extracted from the Macquarie River per year (1616 ML) is equivalent to 0.11% of the annual flow in the river past the offtake site (Geolyse 2012). The average and maximum amounts extracted per day would be 1.6% and 31.5% of the flows in the river, respectively. Hydrological modelling indicates that extraction would result in a 5-8 ML/d decrease in low to moderate flows and 0-6 ML/d reduction in moderate to high flows, but would have no effects on the amplitude or frequency of low flow events (i.e. those below 22 ML/d). The hydrological modelling indicates that extraction of 31.5% of the flows within the river is likely to occur on only 0.2% of extraction days. The Project would consequently have only a minor effect on surface water flows.
<i>How is the proposal likely to affect habitat connectivity?</i>	As the Project Design Criteria indicate that extraction would cease when flows drop below a threshold of 38 ML/d, which is in excess of those categorised as low flows, it is unlikely that loss of habitat

	connectivity within the upper Macquarie River would occur.
<i>How is the proposal likely to affect critical habitat?</i>	There are no critical habitats for Trout Cod listed under the <i>FM Act</i> . The recommended and declared critical habitats listed on the NSW Critical Habitat Register (OEH, 2012) and DSEWPAC Register of Critical Habitat (2009) do not occur within the Project area or its surrounds.

(c) Macquarie Perch (*Macquaria australasica*) (Source: FSC 2008b; DSEWPAC 2010).

Assessment Criteria	Response
<i>How is the proposal likely to affect the life cycle of the threatened species?</i>	Macquarie Perch are known to migrate from impoundments into rivers to spawn in areas with small boulders, pebbles and gravel. Spawning generally occurs during spring and early summer in shallow, fast-flowing water over gravel beds or riffles. The eggs are adhesive and stick to gravel. Newly-hatched larvae shelter amongst pebbles. The construction of the Pipeline Intake is likely to disturb any Macquarie Perch that occur in the vicinity of Gardiners Hole. The noise and vibration of the pump during offtake operations could potentially disturb any Macquarie Perch present nearby. Their most likely response to disturbance from noise, loss of habitat and increased sediment load would be to move to suitable habitat elsewhere in the river. If the Offtake Structure is constructed over gravel or pebble habitat, it could result in localised loss of these potential spawning and larval habitats. The offtake of water could also potentially result in the impingement and entrainment of eggs and larvae. Juvenile, sub-adults and adults would be less susceptible to entrainment, due to their greater swimming abilities. Losses of eggs and larvae would be minimised by screening the offtake, slowly ramping up the pump velocity, restricting offtake to a maximum of 12 ML/d over 19 hours when river flows are ≥ 38 ML/day and purging the screen at the end of the extraction period. Impacts could be minimised further by installing devices that deflect fish away from the pump.
<i>How is the proposal likely to affect the habitat of this threatened species?</i>	Macquarie Perch is a schooling species that prefers clear water and deep, rocky holes with lots of cover in the form of aquatic vegetation, large boulders, debris and overhanging banks. Potential habitat for this species is present at the proposed Intake site, but is unlikely to occur in the streams along the pipeline route. The construction of the Offtake Structure would lead to permanent loss of approximately 12 m² of underlying benthic substratum, which is equivalent to approximately 0.02% of the pool habitat. Adjoining areas of habitat are also likely to be disturbed by the works and operation of the Offtake Structure. The disturbance is likely to be localised and periodic. The extraction of water would reduce the water level in Gardiners Pool by an average of 1-4 mm during moderate to high flows and 6-9 mm during low to moderate flows. As the water that is removed would be replenished by flows from upstream, the effect of this reduction on the availability of habitat between the extraction site and the backed up waters of Burrendong Dam would be relatively small and transient. The decline in availability of aquatic habitat would also diminish with distance downstream. The impact on aquatic habitat would be most significant when 12 ML/day is extracted from a river flow of 38 ML/day. This would result in a decrease in water level of 23 mm, but would be a rare event, occurring on 0.11% of extraction days (Geolyse 2012). There would be no effect on the availability of aquatic habitat during low and very low flows, because extraction would not occur under these conditions.
<i>Does the proposal affect a threatened species at the limit of its known distribution</i>	Macquarie Perch are found in the Murray-Darling Basin, particularly the upstream reaches of the Lachlan, Murrumbidgee and Murray Rivers, and parts of south-eastern coastal NSW, including the Hawkesbury and Shoalhaven catchments. This species has been recorded in the upper reaches of the Macquarie River system, but is now presumed to be extinct, because it has not been collected from this river since its original description, nor has it been reported ethnographically for many decades (Faulks <i>et al.</i> 2010). It should, however, be noted that the fish surveys that

	have been undertaken are limited in frequency, spatial extent, duration and intensity, so the possibility of the species still being present cannot be discounted. The Project area is a considerable distance from the downstream and upstream limits of the upper Macquarie River.
<i>How is the proposal likely to affect current disturbance regimes?</i>	The major processes that affect aquatic habitats and their biota in the Project area are surface water flows, runoff during rainfall events and fire. The average amount of water that would be extracted from the Macquarie River per year (1616 ML) is equivalent to 0.11% of the annual flow in the river past the offtake site (Geolyse 2012). The average and maximum amounts extracted per day would be 1.6% and 31.5% of the flows in the river, respectively. Hydrological modelling indicates that extraction would result in a 5-8 ML/d decrease in low to moderate flows and 0-6 ML/d reduction in moderate to high flows, but would have no effects on the amplitude or frequency of low flow events (i.e. those below 22 ML/d). The hydrological modelling indicates that extraction of 31.5% of the flows within the river is likely to occur on only 0.2% of extraction days. The impact of the Project on the current flow regime would consequently be minor.
<i>How is the proposal likely to affect habitat connectivity?</i>	The limited spatial extent of the construction, availability of potential habitat for this species nearby and elsewhere in the upper Macquarie River and proposed extraction regime indicate the Project is unlikely to result in fragmentation or isolation of Macquarie Perch habitat. As the Project Design Criteria indicate that extraction would cease when flows drop below 38 ML/d, it is unlikely that loss of habitat connectivity within the upper Macquarie River would occur. The Offtake Structure is unlikely to prevent the movement of Macquarie Perch within the Macquarie River, because of its small size relative to available instream habitat. It may, however, pose an obstacle to their movement, particularly if exposed during periods of low flow.
<i>How is the proposal likely to affect critical habitat?</i>	No critical habitats for Macquarie Perch are listed under the <i>FM Act</i>. The recommended and declared critical habitats listed on the NSW Critical Habitat Register (OEH, 2012) and DSEWPAC Register of Critical Habitat (2009) do not occur within the Project area or its surrounds.

(d) Purple-Spotted Gudgeon (*Mogurnda adspersa*) (Source: Fisheries Scientific Committee 2008c)

Assessment Criteria	Response
<i>How is the proposal likely to affect the life cycle of the threatened species?</i>	Females deposit small numbers of adhesive eggs in a single batch a rock, log or aquatic plants. They may produce several batches of eggs each spawning season. The males guard and fan the eggs (Lintermans 2009). Newly hatched larvae are approximately 4 mm long. The construction of the pipeline could have adverse effects on the availability and quality of potential spawning habitat in the creeks. The potential impacts include direct loss and degradation of habitat (e.g. smothering with silt) and changes in water quality due to increased sediment load and accidental releases of drilling fluids, fuels or lubricants. These impacts would be localised and generally short-term in nature, except for loss of habitat. The potential for such impacts would be minimised by limiting the construction footprint, using construction methods that limit disturbance of the stream bed and bank, using appropriate sediment and erosion control measures and translocating animals, if necessary.
<i>How is the proposal likely to affect the habitat of this threatened species?</i>	Purple-Spotted Gudgeon are slow-moving ambush predators. They are benthic species and usually found in areas with good cover such as cobble and rocks or aquatic vegetation. This species occurs in slow moving or still waters of creeks, rivers, wetlands and billabongs, but appears to prefer slower flowing, deeper habitats. It is consequently more likely to occur in the creeks than in the Macquarie River. If this species is present in the streams along the pipeline route, the availability and quality of its habitat would be affected by the construction work. The potential impacts without mitigation measures include loss or modification of physical habitat and temporary changes in water quality due to increased sediment load and accidental releases of drilling fluids, fuels or lubricants. These impacts would be localised and generally short-term in nature, except for loss of habitat at crossings. The potential for such impacts would be minimised by limiting the construction footprint, using construction methods that limit disturbance of the stream bed and bank, using appropriate sediment and erosion control measures and translocating animals, if necessary. There is a potential for cumulative impacts to occur in Summer Hill Creek, due to multiple pipeline crossings.
<i>Does the proposal affect a threatened species at the limit of its known distribution</i>	There are two populations of Purple-Spotted Gudgeon in NSW: the eastern population is found in coastal drainages to the north of the Clarence River catchment and a western population that was historically disjunct but present throughout the Murray-Darling system. The distribution of the western population has declined significantly in recent years and is now restricted to three areas west of the dividing range in the coastal drainage of NSW. This species was predicted to occur in the upper Macquarie River prior to human intervention (Davies <i>et al.</i> 2008). A new population has recently been discovered in the Macquarie catchment near Wellington (NSW DPI 2008). If a population is present in the Project Area it would not be at or close to the limit of their distribution range.
<i>How is the proposal likely to affect current disturbance regimes?</i>	The major processes that affect aquatic habitats and their biota in the Project area are surface water flows, runoff during rainfall events and fire. The transfer of water from the Macquarie River will increase the spills from Suma Park Dam and lead to beneficial increases in low to moderate flows and a greater average annual flow in Summer Hill Creek.
<i>How is the proposal likely to affect habitat</i>	The limited spatial extent of the pipeline crossings and availability

<i>connectivity?</i>	of potential habitat for this species elsewhere in the creeks indicate the Project is unlikely to result in fragmentation or isolation of potential Purple-Spotted Gudgeon habitat. The use of coffer dams in the construction of the pipeline crossings would result in a temporary loss of connectivity. The impact of this would be minimised by limiting the period for which the coffer dam is installed and translocating any fish contained within the dam to adjacent areas of the streams.
<i>How is the proposal likely to affect critical habitat?</i>	No critical habitats for Purple-Spotted Gudgeon are listed under the <i>FM Act</i>. The recommended and declared critical habitats listed on the NSW Critical Habitat Register (OEH, 2012) and DSEWPAC Register of Critical Habitat (2009) do not occur within the Project area or its surrounds.

(e) Silver Perch (*Bidyanus bidyanus*) Source (NSW DPI 2006b)

Assessment Criteria	Response
<i>How is the proposal likely to affect the life cycle of the threatened species?</i>	Silver perch is a moderate to large omnivorous species that consumes insects, molluscs, small crustaceans, worms, microscopic animals and algae. Adults migrate upstream from November to February while older juveniles do so between October and April. These movements appear to be stimulated by increases in water temperature above 20°C and water level and, in the case of adults, may be for spawning. Females release non-adhesive, floating eggs which hatch within a few days. The larvae develop into juvenile fish within three weeks. This species has a relatively slow growth rate but appears to be long-lived, with individual fish reaching 27 years in age. The construction of the Offtake Structure is likely to disturb any Silver Perch that occur in the vicinity of Gardiners Hole. The noise and vibration of the pump during extraction operations could potentially disturb any Silver Perch present nearby. Their most likely response to disturbance from noise, loss of habitat and increased sediment load would be to move to suitable habitat elsewhere in the river. As the footprint of the development is relatively small and there is suitable habitat for this species nearby, the impact of the construction work on the life cycle would be limited. The offtake of water could potentially result in the impingement and entrainment of eggs and larvae. Juvenile, sub-adults and adults would be less susceptible to entrainment, due to their greater swimming abilities. Losses of eggs and larvae would be minimised by screening the offtake, slowly ramping up the pump velocity, restricting offtake to a maximum of 12 ML/d over 19 hours and purging the screen at the end of the extraction period. Impacts could be minimised further by installing devices that deflect fish away from the pump.
<i>How is the proposal likely to affect the habitat of this threatened species?</i>	Silver perch occupy a variety of habitats across the Murray-Darling Basin, including cool, clear, gravel-bed streams in the upper reaches. They could consequently occupy habitats in the vicinity of the proposed Intake site. Little is known about the specific habitat requirements of this species, particularly the extent to which they may depend on structural habitat components. NSW DPI sampling records show that they are usually caught near snags in rivers. The construction of the Offtake Structure would lead to permanent loss of approximately 12 m² of underlying benthic substratum, which is equivalent to approximately 0.02% of the pool habitat. Adjoining areas of habitat are also likely to be disturbed by the works. The disturbance is likely to be localised and transient in nature. The extraction of water would reduce the water level in Gardiners Pool by an average of 1-4 mm during moderate to high flows and 6-9 mm during low to moderate flows. As the water that is removed would be replenished by flows from upstream, the effect of this reduction on the availability of habitat between the extraction site and the backed up waters of Burrendong Dam would be relatively small and transient. The decline in availability of aquatic habitat would also diminish with distance downstream. The impact on aquatic habitat would be most significant when 12 ML/day is extracted from a river flow of 38 ML/day. This would result in a decrease in water level of 23 mm, but would be a rare event, occurring on 0.11% of extraction days (Geolyse 2012). There would be no effect on the availability of aquatic habitat during low and very low flows, because extraction would not occur

	under these conditions. If this species is present in the streams along the pipeline route, the availability and quality of its habitat would be affected by the construction work. The potential impacts include loss or modification of physical habitat and changes in water quality due to increased sediment load and accidental releases of drilling fluids, fuels or lubricants. These impacts would be localised and generally short-term in nature, except for loss of habitat. The potential for such impacts would be minimised by limiting the construction footprint, using construction methods that limit disturbance of the stream bed and bank, using appropriate sediment and erosion control measures and translocating animals, if necessary. There is a potential for cumulative impacts to occur in Summer Hill Creek, due to multiple pipeline crossings.
<i>Does the proposal affect a threatened species at the limit of its known distribution?</i>	Historical records show that Silver Perch were present throughout most of the Murray-Darling Basin. This species has undergone a dramatic decline in abundance and distribution over the last few decades and is now absent from most of its natural range. The largest natural population is found in the central Murray River system downstream of Yarrawonga Weir. There are also reports of self-sustaining populations in the Macquarie River. In the past ten years, this species has been released into several reservoirs and dams in the Upper Macquarie catchment, including Lake Burrendong. As there are no barriers to the upstream movement of fish above this lake, it is possible that some individuals may either be present in or periodically migrate into the upper Macquarie River in the vicinity of the proposed Pipeline Intake. The Project Area is a considerable distance from the downstream and upstream limits of the upper Macquarie River, so there are unlikely to be any effects on distribution limits.
<i>How is the proposal likely to affect current disturbance regimes?</i>	The major processes that affect aquatic habitats and their biota in the Project area are surface water flows, runoff during rainfall events and fire. The average amount of water that would be extracted from the Macquarie River per year (1616 ML) is equivalent to 0.11% of the annual flow in the river past the offtake site (Geolyse 2012). The average and maximum amounts extracted per day would be 1.6% and 31.5% of the flows in the river, respectively. Hydrological modelling indicates that extraction would result in a 5-8 ML/d decrease in low to moderate flows and 0-6 ML/d reduction in moderate to high flows, but would have no effects on the amplitude or frequency of low flow events (i.e. those below 22 ML/d). The hydrological modelling indicates that extraction of 31.5% of the flows within the river is likely to occur on only 0.2% of extraction days. The impact of the Project on the current flow regime would consequently be minor.
<i>How is the proposal likely to affect habitat connectivity?</i>	The limited spatial extent of the pipeline crossings and availability of potential habitat for this species elsewhere in the creeks indicate the Project is unlikely to result in fragmentation or isolation of potential Silver Perch habitat. As the Project Design Criteria indicate that extraction would cease when flows drop below 38 ML/d, it is unlikely that loss of habitat connectivity within the upper Macquarie River would occur. The Offtake Structure is unlikely to prevent the movement of Silver Perch within the Macquarie River, because of its small size relative to available instream habitat. It may, however, pose an obstacle to their movement, particularly if exposed during periods of low flow. The use of coffer dams in the construction of the pipeline crossings would result in a temporary loss of connectivity. The impact of this would be minimised by limiting the period for which

	the coffer dam is installed and translocating any fish contained within the dam to adjacent areas of the streams.
<i>How is the proposal likely to affect critical habitat?</i>	No critical habitats for Silver Perch are listed under the <i>FM Act</i> . The recommended and declared critical habitats listed on the NSW Critical Habitat Register (OEH, 2012) and DSEWPAC Register of Critical Habitat (2009) does not occur within the Project area or its surrounds.

Table 16: NSW Threatened Population Assessment

Murray River Basin Population of the Freshwater Catfish (*Tandanus tandanus*)
(Source: Lintermans 2009; Fisheries Scientific Committee 2008d)

Assessment Criteria	Response
How is the proposal likely to affect the life cycle of the threatened species and/or population?	The Freshwater Catfish is a benthic species that lives, feeds and breeds near the bottom. It does not migrate. This species spawns in spring and summer when water temperatures are 20-24° C. The eggs are deposited in a nest constructed of pebbles and gravel within a circular to oval depression. The eggs are large and non-adhesive and settle into the interstices of the substratum. The nest is guarded and fanned by male fish. The construction of the Offtake Structure is likely to disturb any Freshwater Catfish that occur in the vicinity of Gardiners Hole. The noise and vibration of the pump during extraction operations could potentially disturb any Freshwater Catfish present nearby. Their most likely response to disturbance from noise, loss of habitat and increased sediment load would be to move to suitable habitat elsewhere in the river. As the footprint of the development is relatively small and there is suitable habitat for this species nearby, the construction work is likely to have only a limited impact on the spawning habitat of this species. The offtake of water could potentially result in the impingement and entrainment of eggs and larvae. Juveniles, sub-adults and adults would be less susceptible to entrainment, due to their greater swimming abilities. Losses of eggs and larvae would be minimised by screening the offtake, slowly ramping up the pump velocity, restricting offtake to a maximum of 12 ML/d over 19 hours and purging the screen after each extraction period. Impacts could be minimised further by installing devices that deflect fish away from the pump.
How is the proposal likely to affect the habitat of this threatened population?	Freshwater catfish occur in a variety of habitats, including rivers, creeks, lakes, billabongs and lagoons, in clear to turbid waters and over a variety of substrata, including mud, gravel and rock. They may be found in flowing streams, but appear to prefer sluggish or still waters. This species could consequently be present in the upper Macquarie River and the larger creeks along the pipeline route. The construction of the Offtake Structure is likely to disturb any Freshwater Catfish that occur in the vicinity of Gardiners Hole. Their most likely response to disturbance from noise, loss of habitat and increased sediment load would be to move to suitable habitat elsewhere in the river. As the footprint of the development is relatively small and there is suitable habitat for this species nearby, the impact of the construction work is likely to be localised and of minor significance. The construction of the Offtake Structure would lead to permanent loss of approximately 12 m² of underlying benthic substratum, which is equivalent to approximately 0.02% of the pool habitat. Adjoining areas of habitat are also likely to be disturbed by the works. The disturbance to these areas would be localised and transient in nature. The limited spatial extent of the construction and availability of potential habitat for this species nearby and elsewhere in the upper Macquarie River, suggests that fragmentation and isolation of habitat are unlikely to occur. The extraction of water would reduce the water level in Gardiners Pool by an average of 1-4 mm during moderate to high flows and 6-9 mm during low to moderate flows. As the water that is

	removed would be replenished by flows from upstream, the effect of this reduction on the availability of habitat between the extraction site and the backed up waters of Burrendong Dam would be relatively small and transient. The decline in availability of aquatic habitat would also diminish with distance downstream. The impact on aquatic habitat would be most significant when 12 ML/day is extracted from a river flow of 38 ML/day. This would result in a decrease in water level of 23 mm, but would be a rare event, occurring on 0.11% of extraction days (Geolyse 2012). There would be no effect on the availability of aquatic habitat during low and very low flows, because extraction would not occur under these conditions. If Freshwater Catfish were present in the larger streams along the pipeline route, the availability and quality of its habitat would be affected by the construction work. The potential impacts include loss or modification of physical habitat and changes in water quality due to increased sediment load and accidental releases of drilling fluids, fuels or lubricants. These impacts would be localised and generally short-term in nature, except for loss of habitat. The potential for such impacts would be minimised by limiting the construction footprint, using construction methods that limit disturbance of the stream bed and bank, using appropriate sediment and erosion control measures and translocating animals, if necessary. There is a potential for cumulative impacts to occur in Summer Hill Creek, due to multiple pipeline crossings. The limited spatial extent of the pipeline crossings and availability of potential habitat for this species elsewhere in the creeks indicate the Project is unlikely to result in fragmentation or isolation of potential Freshwater Catfish habitat.
Does the proposal affect a threatened populations at the limit of its known distribution	The Murray River Basin Freshwater Catfish population originally occurred throughout the Murray-Darling River System, except in the cooler parts of the southern tributaries. There has been a significant and rapid decline in the distribution and abundance of this species. Freshwater catfish are now rare or absent from many of the major tributaries in NSW, including the Murray, Darling, Murrumbidgee and Lachlan rivers. A moderate remnant population is still present in the Macquarie catchment upstream of Warren. This species has been recorded in the vicinity of the proposed site of the Offtake Structure (GHD 2011; Cardno this study) and further upstream (at Bruinbun) (NSW DPI 2006). The Project Area is a considerable distance from the downstream and upstream limits of the upper Macquarie River, so there are unlikely to be any effects on distribution limits.
How is the proposal likely to affect current disturbance regimes?	The major processes that affect aquatic habitats and their biota in the Project area are surface water flows, runoff during rainfall events and fire. The average amount of water that would be extracted from the Macquarie River per year (1616 ML) is equivalent to 0.11% of the annual flow in the river past the offtake site (Geolyse 2012). The average and maximum amounts extracted per day would be 1.6% and 31.5% of the flows in the river, respectively. Hydrological modelling indicates that extraction would result in a 5-8 ML/d decrease in low to moderate flows and 0-6 ML/d reduction in moderate to high flows, but would have no effects on the amplitude or frequency of low flow events (i.e. those below 22 ML/d). The hydrological modelling indicates that extraction of 31.5% of the flows within the river is likely to occur on only 0.2% of extraction days. The impact of the Project on the current flow regime would consequently be minor.

How is the proposal likely to affect habitat connectivity?	As the Project Design Criteria indicate that extraction would cease when flows drop below 38 ML/d, it is unlikely that loss of habitat connectivity within the upper Macquarie River would occur. The small size of the Offtake Structure relative to available instream habitat suggests that it is unlikely to prevent the movement of Freshwater Catfish within the upper Macquarie River. The structure may, however, pose an obstacle to their movement, particularly if exposed during periods of low flow.
How is the proposal likely to affect critical habitat?	No critical habitats for Murray River Basin population of Freshwater Catfish are listed under the FM Act. The recommended and declared critical habitats listed on the NSW Critical Habitat Register (OEH, 2012) and DSEWPAC Register of Critical Habitat (2009) do not occur within the Project area or its surrounds.

6.2.3 Assessment of Impacts on Key Threatening Processes

6.2.3.1 Offtake Structure

The proposed clearing of vegetation and earthworks on the river banks would result in loss of and degradation of some of the native riparian vegetation along the river. As indicated in Section 4.1.2.1, the disturbance of the riparian zone would be localised, temporary and addressed by rehabilitation works undertaken after the construction work is completed. The effects of the loss and degradation of riparian vegetation on native fish and aquatic macroinvertebrates that utilise the wood debris, leaf fall or detritus produced by this vegetation would be minimal, as inputs of these would continue from upstream of the construction works.

The installation of the Offtake Structure and rock armouring may require large woody debris, such as tree trunks, branches or root masses, to be removed from a small area of the river bed. Snags are present at the offtake site, but cover only 5% of the area surveyed (Section 3.5.1.1). Impacts on this potential aquatic habitat, if present within the construction footprint, could be avoided by relocation elsewhere within Gardiners Hole.

The installation of a coffer dam around the construction site would result in a temporary modification to the natural flows within a small section of Gardiners Hole.

As explained in Section 4.1.3.2, the operation of the offtake would alter the natural flows within the upper Macquarie River and Summer Hill Creek. It would lead to a slight reduction in low to moderate and moderate to high flows (i.e. those across the 10th to 80th percentile flow range) in the river, but would have no effect on low flows, nor would it create the latter (Geolyse 2012). The proposed transfer of water from the Macquarie River would increase the average annual volume of spills from Suma Park Dam, which in turn would increase the average annual flows in Summer Hill Creek. As the flow regime in NSW rivers and streams is naturally highly variable and the aquatic biota within these systems are adapted to such variability it is highly unlikely that the small modification in flows resulting from extraction would have any measurable adverse effects on the aquatic biota within the two watercourses.

The operation of the Offtake Structure would not result in the removal of large woody debris or lead to degradation of native riparian vegetation in either watercourse.

6.2.3.2 Water Pipeline

The proposed clearing of vegetation and earthworks on the creek banks would result in loss of and degradation of some of the native riparian vegetation. As indicated above, these impacts would be localised, temporary and addressed by rehabilitation works undertaken after the construction work is completed. The effects of the loss and degradation of riparian vegetation on native fish and aquatic macroinvertebrates that utilise the wood debris, leaf fall

or detritus produced by this vegetation would be minimal, as inputs of these would continue from upstream of the construction works.

The construction of the pipeline crossings may require large woody debris, such as tree trunks, branches or root masses, to be removed from small areas of the creek bed. Snags are present in at the four existing crossings over Summer Hill Creek, but occupy a much smaller proportion of the area surveyed at the Second, Third and Fourth Crossings ($\leq 10\%$) than at the First Crossing (70%) (Section 3.5.2). Impacts on this potential aquatic habitat at the crossings could be avoided by relocating the woody debris outside the construction footprint.

The installation of coffer dams around the crossing sites would result in a temporary modification to the natural flows within small sections of the creek.

The operation of the pipeline would have no effects on the three Key Threatening Processes identified in Section 6.2.1.5 or on Groundwater Dependent Ecosystems.

6.2.3.3 Discharge Structure

Neither the construction nor operation of the Discharge structure would have any effects on the three Key Threatening Processes identified in Section 6.2.1.5.

6.3 Conclusions

The various measures that would be taken to avoid, minimise, mitigate and offset impacts associated with the Offtake Structure, Water Pipeline and Discharge Structure indicate the Project is likely to have only minor effects on the long-term viability of local populations of threatened fish species in the Macquarie River and it is therefore unlikely to accelerate their extinction or place them at risk of extinction. The Project is also likely to have no measurable effects on the ecological character of the Macquarie Marshes.

7 Overall Conclusion

On the basis of the assessment of the existing aquatic environment and the description of the proposed transfer of water, this aquatic ecology assessment concludes that there are no major constraints that would jeopardise the Project. It is, however, important that Construction and Operational Environmental Management Plans, stipulating the various control measures that are to be used to minimise the potential for onsite and offsite impacts on aquatic habitats and associated aquatic biota, are developed and implemented.

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8 References

- Allen, G.R., Midgley, S.H. and Allen, M. (2002). *Field Guide to the Freshwater Fishes of Australia*. Western Australian Museum pp394.
- Anderson, P. G., Fraikin, C. G. J. and Chandler, T. J. (1998). Natural gas pipeline crossing of a coldwater stream: Impacts and recovery. In: *Proceedings of the International Pipeline Conference, vol. 2* (pp. 1013–1020). Calgary, AB, Canada: American Society of Mechanical Engineers.
- ANZECC/ARMCANZ (2000). *Australian and New Zealand Guidelines for Fresh and Marine Waters*. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.
- Armitage, P. D., and Gunn, R. J. M. (1996). Differential response of benthos to natural and anthropogenic disturbances in three lowland streams. *Internationale Revue der Gesamten Hydrobiologie*, 81: pp. 161–181.
- Australian Heritage Commission (2002). Australian Natural Heritage Charter for conservation of places of natural heritage significance. Second Edition. Australian Heritage Commission. Canberra.
- Baker, T. and Raisin, G. (2000). *An Assessment of Riverine Health in the Macquarie, Castlereagh and Bogan River Catchments*. A Murray Darling 2001 Initiative Project: Central West Catchment River Corridor Health Survey (CW1040.97).
- Baumgartner, L., Reynoldson, N., Cameron, L. and Stanger, J. (2007). The effects of irrigation practices on fish of the Murray Darling Basin. NSW Department of Primary Industries – Fisheries Final Report Series No. 92.
- Baumgartner, L. J., Reynoldson, N. K., Cameron, L. and Stanger, J. G. (2009). Effects of irrigation pumps on riverine fish. *Fisheries Management and Ecology* **16**, 429–437.
- Biosis Research (2012). The Macquarie River to Orange Pipeline Project - Terrestrial Flora and Fauna Assessment. Unpublished report to GHD and Orange City Council.
- Blackley, T. (2003). Screening Irrigation Offtakes in the Murray-Darling Basin to Reduce Loss of Native Fish. In: *Downstream Movement of Fish in the Murray-Darling Basin. Statement, recommendations and supporting papers*. Workshop held in Canberra, June 2003. Eds. M. Lintermans and W. Phillips. Murray-Darling Commission, Canberra.
- Brock, P. (ed.) (1997). *Macquarie Marshes Land and Water Management Plan*. Macquarie Marshes Catchment Committee.
- Bunn, S.E. and Arthington, A.H. (2002). Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. *Environmental Management*, 30, pp. 492–507.
- Cardno (2012). *Macquarie Orange Pipeline Project. Water Quality, Geomorphology and Specific Hydrology & Water Use*. Report prepared for GHD.
- Chessman, B.C. (2003). New sensitivity grades for Australian river macroinvertebrates. *Marine and Freshwater Research* 54, pp. 95–103.
- Chessman, B. C., Growns, J. E. and Kotlash, A. R. (1997). Objective derivation of macroinvertebrate family sensitivity grade numbers for the SIGNAL biotic index: Application to the Hunter River system, New South Wales. *Marine and Freshwater Research*, 48, pp. 159–172.
- Chessman, B. C., Royal, M.J. and Muschal, M. (2008a). Does water extraction from unregulated streams affect aquatic macrophyte assemblages? An evaluation based on comparisons with reference sites. *Ecohydrology* **1**, pp. 67–75.

- Chessman, B. C., Muschal, M, and Royal, M.J. (2008b). Comparing apples with apples: use of limiting environmental differences to match reference and stressor exposure sites for bioassessment of streams. *River Research and Applications* 24, pp. 103–117.
- Chessman, B. C., Royal, M.J. and Muschal, M. (2011). The challenge of monitoring impacts of water extraction on macroinvertebrate assemblages in unregulated rivers. *River Research and Applications* 27, pp. 76–86.
- Commonwealth of Australia (2009). Matters of National Environmental Significance. Significant impact guidelines 1.1.Environment Protection and Biodiversity Conservation Act 1999 significant impact guidelines.
- Coysh, J, Nichols, S. Ransom, G., Simpson, J., Norris, R., Barmuta, L. and Chessman, B. (2000). *AUSRIVAS Macroinvertebrate Bioassessment Predictive Modelling Manual*.
- Cotterell, E. (1998). *Fish passage in streams: fisheries guidelines for design of stream crossings*. Fish Habitat Guideline FHG001, Queensland Department of Primary Industries, Brisbane, Qld. 40pp.
- CSIRO (2008). *Water Availability in the Macquarie-Castlereagh*. A report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project.144 pp.
- Davies, P.E., Harris, J.H., Hillman, T.J. and Walker, K.F. (2008). *SRA Report 1: A Report on the Ecological Health of Rivers in the Murray-Darling Basin, 2004-2007*. Prepared by the Independent Sustainable Rivers Audit Group for the Murray-Darling Basin Ministerial Council. MDBC publication No. 16/08.
- Department of Environment and Conservation and Department of Primary Industries (2005). *Guidelines for Threatened Species Assessment*. Sydney, Australia.
- Department of Land and Water Conservation (DLWC) (2002). *The NSW State Groundwater Dependent Ecosystems Policy*.
- Department of the Environment, Water, Heritage and the Arts (DEWHA) (2000). *Information Sheet on Ramsar Wetlands: The Macquarie Marshes*.
- DEWHA (2008). National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands. Module 2 of the National Guidelines for Ramsar Wetlands. Implementing the Ramsar Convention in Australia. Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra.
- DIPNR (2004). *A guide to the Water Sharing Plan for the Macquarie and Cudgegong Regulated Rivers Water Source*.
- DSEWPAC (2010).Biodiversity Species Profile and Threats Database. *Macquaria australasica* — Macquarie Perch http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=66632
- DSEWPAC (2011). Survey guidelines for Australia's threatened fish Guidelines for detecting fish listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999.
- Environment Agency UK (2005). *Screening for Intake and Outfalls: a best practice guide*. UK Environment Agency Science Report SC030231.
- Fairfull, S., Witheridge, G. (2003). *Why Do Fish Need to Cross the Road?– Fish Passage Requirements for Waterway Crossings*. NSW Fisheries, Cronulla.
- Faulks, L.K., Gilligan, D.M. and Beheregaray, L.B. (2010). Evolution and maintenance of divergent lineages in an endangered freshwater fish, *Macquaria australasica*. *Conservation Genetics* 11, pp. 921-934.
- Fisheries Scientific Committee (2008a). Final Determination *Galaxias rostratus* – flathead galaxias. Ref. No.FD39 File No. FSC 06/04.

- Fisheries Scientific Committee (2008b). Final Determination *Macquaria australasica* – Macquarie perch. Ref. No. FD37. FSC 99/20.
- Fisheries Scientific Committee (2008c). Final Determination *Mogurnda adspersa* - Purple spotted gudgeon. Ref. No.FD35 File No. FSC 00/15.
- Fisheries Scientific Committee (2008d). Final Determination The *Tandanus tandanus* – Eel tailed catfish in the Murray/Darling Basin as an endangered population. Ref. No.FD41 File No. FSC 08/02.
- Fisheries Scientific Committee (2009). Recommendation *Ambassis agassizii* – (Olive Perchlet).Ref. No.FR17 File No. FSC 01/09.
- Geolyse (2012). The Macquarie River to Orange Pipeline Project. Hydrology and Water Security Assessment.
- GHD (2011a). *Report for Orange Drought Emergency Connection Project (DECP) Seasonal Aquatic Ecology Survey*. Report prepared for Orange City Council.
- GHD (2011b). *Orange Drought Relief Connection Pipeline EA Part B*. Report prepared for Orange City Council.
- GHD (2011c). *Orange DECP. Advice on operating rules*. Letter to David Waddell, Orange City Council dated 24 June 2011.
- Green, D., Petrovic, J., Moss, P. and Burrell M. (2011). *Water resources and management overview: Macquarie-Bogan catchment*. NSW Office of Water, Sydney
- Harris, J. H. and Mallen-Cooper, M. (1994). Fish passage development in the rehabilitation of fisheries in mainland south-eastern Australia. In Cowx, I. G. (Ed.) *Proceedings of the International Symposium and Workshop on Rehabilitation of Freshwater Fisheries*. Hull, April 1992.
- IconneXX (2011). *Macquarie River Source and the Ploughmans Valley North Orange Development. Water Quality Risk Assessment*. Workshop Summary Paper for Orange City Council.
- Kingsford R. T. and Thomas R. F. (1995) The Macquarie Marshes in arid Australia and their waterbirds: a 50 year history of decline. *Environmental Management* 19, pp. 867–78.
- Kingsford, R.T. and Auld, K. (2005) Waterbird breeding and environmental flow management in the Macquarie Marshes, arid Australia., *River Research and Application*, 21, pp. 187–200.
- Kingsford R.T., Nebel S. and Brandis, K. (2007). Ecological character description for the Macquarie Marshes Nature Reserve Ramsar Site. University of New South Wales: Sydney.
- Koehn, J.D. and Harrington, D.J. (2006). Environmental conditions and timing for the spawning of Murray cod (*Maccullochella peelii peelii*) and the endangered trout cod (*M. macquariensis*) in southeastern Australian rivers. *River Research and Applications* 22, pp. 327–342.
- Lévesque, L.M. and Dubé, M.G.(2007). Review of the effects of in-stream pipeline crossing construction on aquatic ecosystems and examination of Canadian methodologies for impact assessment. *Environmental Monitoring and Assessment* 132, pp. 395-409.
- Lintermans, M. (2009). *Fishes of the Murray-Darling Basin. An Introductory Guide*. Murray-Darling Basin Authority.
- Morris, S.A., Pollard, D.A., Gehrke, P.C. and Pogonoski, J.J. (2001). Threatened and Potentially Threatened Freshwater Fishes of Coastal New South Wales and the Murray-Darling Basin. NSW Fisheries, Sydney Final Report Series No. 33.

- Murray Darling Basin Authority (MDBA) (2012). Assessment of environmental water requirements for the proposed Basin Plan: Macquarie Marshes. MDBA Publication No: 28/12
- National Murray Cod Recovery Team (2010a). National Recovery Plan for the Murray Cod *Maccullochella peelii peelii*. Department of Sustainability and Environment, Melbourne.
- National Murray Cod Recovery Team (2010b). Background and Implementation Information for the National Recovery Plan for the Murray Cod *Maccullochella peelii peelii*. (Department of Sustainability and Environment, Melbourne.
- Nicol, S.J., Barker, R.J., Koehn, J.D., and Burgman, M.A. (2007). Structural habitat selection by the critically endangered trout cod *Maccullochella macquariensis*. *Biological Conservation* 138, pp.30-37.
- NIWA (2007). *Fish Screening: Good Practice for Canterbury*. NIWA Client Report CHC2007-092. Project INZ06501. pp 8-35.
- NSW DECCW (2010). *Macquarie Marshes Adaptive Environmental Management Plan - Synthesis of information projects and actions*.
- NSW DPI (undated). Policy and Guidelines for Fish Friendly Waterway Crossings.
- NSW DPI (2005). Profiles for species, populations & ecological communities. Silver perch. http://pas.dpi.nsw.gov.au/Species/Species_Profile.aspx?SpeciesListingID=11
- NSW DPI (2006a). Trout cod (*Maccullochella macquariensis*) Recovery Plan.
- NSW DPI (2006b). Silver Perch *Bidyanus bidyanus* NSW Recovery Plan.
- NSW DPI (2008). News releases 2008. Rare fish thrive at Dubbo Zoo. <http://www.dpi.nsw.gov.au/archive/news-releases/fishing-and-aquaculture/2008/rare-fish-thrive-dubbo-zoo>
- NSW DPI (2011). 9000 trout cod fingerlings to be released into the Macquarie River. <http://www.dpi.nsw.gov.au/aboutus/news/recent-news/fishing-and-aquaculture/9000-fingerlings-to-be-released>.
- NSW Fisheries (1999). Policy and Guidelines Aquatic Habitat Management and Fish Conservation
- NSW Fisheries (2003). Environmental Impact Statement on Freshwater Fish Stocking in NSW. Volume 3 Appendices. Appendix B1 Freshwater stocking records of the NSW Fisheries database.
- NSW Office of Water (2010a). Controlled activities. Guidelines for laying pipes and cables in watercourses.
- NSW Office of Water (2010b). Controlled activities. Guidelines for in-stream works.
- NSW Office of Water (2010c). Controlled activities. Guidelines for outlet structures.
- NSW Office of Water (2011a). Controlled activities. Guidelines for riparian corridors.
- Orange City Council (2011). Media Release From General Manager 7 November 2011. River Licence Option.
- Piscopo, G. (2001). NSW Department of Water and Land Conservation. Groundwater vulnerability map and explanatory notes – Macquarie Catchment.
- Poff, N., Leroy, Allan J.D., Bain, M.M., Karr, J.R., Prestegard, K.L., Richter, B.D., Sparks, R.E. and Stromberg, J.C. (1997). The natural flow regime, a paradigm for river conservation and Restoration. *BioScience*, 47, pp. 769–84.
- Puckridge, J.T., Sheldon, F., Walker, K.F. and Boulton, A.J. (1998). Flow variability and the ecology of large rivers, *Marine Freshwater Research*, 49, pp. 55–72.

- Ramsar Convention (2005), Resolution IX.1 Annex A. A Conceptual Framework for the wise use of wetlands and the maintenance of their ecological character.
http://www.ramsar.org/res/key_res_ix_01_annexa_e.html
- Rayner, T., Jenkins, K. and Kingsford, R. (2009). Small environmental flows, drought and the role of refugia for freshwater fish in the Macquarie Marshes, arid Australia. *Ecohydrology* 2, pp. 440-453.
- Ren, S., Kingsford, R.T. and Thomas, R.F. (2010). Modelling flow to and inundation of the Macquarie Marshes in arid Australia. *Environmetrics* 21, pp. 549-561.
- Sainty, G.R. and Jacobs, S.W.L. (2003). *Waterplants in Australia*. Sainty and Associates Pty Ltd.
- SMEC (2003). *Suma Park Dam Augmentation - Environmental Impact Statement*.
- Smithson, A., (2010). *Upper Macquarie Alluvium – Groundwater Management Area 009; Groundwater Status Report – 2010*. NSW Office of Water, Sydney.
- Swanson, P. (2006). Sweetwater fishing. Lake Burrendong - Wellington / Mumbil, NSW.
- Thiem, J.D., Ebner, B.C. and Broadhurst, B.T. (2008). Diel activity of the endangered Trout Cod (*Maccullochella macquariensis*) in the Murrumbidgee River. *Proceedings of the Linnean Society of New South Wales* 129, pp. 167-173.
- Trout Cod Recovery Team (2008a). *National Recovery Plan for the Trout Cod Maccullochella macquariensis*. Department of Sustainability and Environment, Melbourne.
- Trout Cod Recovery Team (2008b). *Background and Implementation Information for the Trout Cod Maccullochella macquariensis National Recovery Plan*. Department of Sustainability and Environment, Melbourne.
- Trueman, W.T. (2007). Some recollections of native fish in the Murray-Darling system with special reference to the Trout Cod *Maccullochella macquariensis*. Prepared as an interim report for Native Fish Australia (Victoria) Incorporated.
- Turak, E., Waddell, N. and Johnstone, G. (2004). *New South Wales (NSW) Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual*. Environmental Protection Authority. pp. 45.
- Turnpenny, W. H., Struthers, G. and Hanson, K. P. (1998). *A UK Guide to Intake Fish Screening regulations, Policy and Best Practice*. Farley Aquatic Research Laboratories and Hydroplan. Report ETSU H/06/00052/00/00.

Appendix 1: GPS Coordinates of the study sites surveyed within the Project area.

Site	Description	Easting	Northing
1	Suma Park Reservoir	699477	6316802
2	Suma Park Reservoir	699372	6316751
3	Downstream Macquarie River	708585	6346707
4	Upstream Macquarie River	708845	6346403
5	Offtake Macquarie River	708631	6346620
6	Summer Hill Creek – First Crossing	699183	6318447
7	Summer Hill Creek – Second Crossing	699027	6319232
8	Summer Hill Creek – Third Crossing	699253	6323260
9	Summer Hill Creek – Fourth Crossing	704219	6328395

Appendix 2: Numbers of each macroinvertebrate taxon picked from the AUSRIVAS samples collected from the edge habitat at each study site in the Project Area in December 2011.

Taxon	Watercourse/Site								
	Suma Park Reservoir		Macquarie River			Summer Hill Creek			
			Downstream	Upstream	Intake	First Crossing	Second Crossing	Third Crossing	Fourth Crossing
	1	2	3	4	5	6	7	8	9
Aeshnidae		10						1	
Araneae	3			1		1		1	1
Atyidae	8	6	7	10	8	2			2
Baetidae	8	10	1				1	1	4
Caenidae	4	1	1						1
Ceiniidae		1					1		
Ceratopogonidae	1								1
Chironomidae/Chironominae	6	10	2	2	3	10	4	3	2
Chironomidae/Orthocladinae	1								1
Chironomidae/Tanypodinae			1			1			
Cladocera	10	10	2			10	4	3	2
Coenagrionidae	10	10	1						
Copepoda	10	10	1			10	6	3	2
Corixidae	10	10	10	8	10	10	4	10	8
Dugesidae	1	2				2			1
Dytiscidae	1	2				4		1	
Ecnomidae					1			1	
Elmidae					1				
Erpobdellidae						1			
Glossiphoniidae		1							
Gomphidae									1
Hemicorduliidae						1			4
Hirudinidae							1		
Hydracarina	6	10	4		1	10	7	3	1
Hydraenidae		1				6	2	2	
Hydridae	3	1							1
Hydrophilidae	1	2		1		10		2	
Hydroptilidae	2	5							
Hypogastruridae	2					1			3
Leptoceridae	10	10	10	7	4	1		10	10
Leptophlebiidae			1						2
Megapodagrionidae							2		
Mesoveliidae	1								
Naucoridae		1							
Nematoda								1	1
Notonectidae	4		4	6	4	1	4	10	5
Oligochaeta	8	5	1			1	4	3	6
Ostracoda		6				2	7	8	
Parastacidae	2		1					6	1
Physidae	10	10	1	2		10	10	7	10
Planorbidae	1	1					1		
Protoneuridae					1				
Psephenidae									2
Pylidae	1								
Tipulidae			1						1
Veliidae		1							