Rocla Pty Limited
ABN: 31 000 032 191

Green Valley Sand Quarry

AQUATIC ECOLOGY ASSESSMENT

Prepared by:

Cardno Ecology Lab

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AQUATIC ECOLOGY ASSESSMENT

of the

Green Valley Sand Quarry

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EXECUTIVE SUMMARY

Cardno Ecology Lab Pty Ltd was contracted by R.W. Corkery & Co. Pty Ltd, on behalf of Rocla Pty Ltd, to undertake the aquatic ecology component of the *Environmental Assessment* for the proposed construction of the southern and access roads, as part of the Green Valley Sand Quarry Project. The southern access road will include the construction of an underpass adjacent to Paddys River at the Hume Highway crossing. The underpass will be graded to create a minimum 4.8 m vertical clearance to the bridges and will incorporate a sump for water drainage and a type F traffic barrier for flood protection.

The aims of the study were to:

- Review existing information, including threatened species legislation relevant to aquatic flora and fauna;
- Provide a detailed description of aquatic habitats and biota in Paddys River in the area of proposed works for the southern intersection;
- Assess the health of this reach of Paddys River using the AusRivAS analysis of macroinvertebrate assemblages; and
- Identify potential environmental constraints to the proposed works and recommend potential mitigation measures.

The proposed study area is located within and adjacent to Paddys River at the Hume Highway bridges crossing. Paddys River is located in the Wollondilly River sub-catchment of the Hawkesbury - Nepean River catchment, which drains into Lake Burragorang. Paddys River flows westwards from its source in Sutton Forest and then northwards into the Wollondilly River. The former NSW DPI (now I&I NSW (Fisheries)) identified several road crossings on Paddys River and Wollondilly River downstream of the study area that may disrupt the longitudinal connectivity of the waterways. Land use in the region is primarily for pasture although there are some forested areas.

Previous surveys in the Wollondilly sub-catchment found that the macroinvertebrate assemblages were generally impaired and the rivers in poor health. The fish assemblage in the Wollondilly River contained a mixture of native and introduced species, including the threatened Macquarie perch. The majority of species are able to complete their life cycle entirely within freshwater, the only diadromous species present can climb large barriers (longfinned and shortfinned eels) or are stocked. Platypuses have been recorded in the Wollondilly sub-catchment and are believed to be present in the lower reaches of Paddys River. A literature search indicated that seven listed threatened and protected aquatic species and communities (including platypus) potentially occur within this region of the Hawkesbury – Nepean catchment. The proposed works potentially contribute to three listed key threatening processes; (i) degradation of riparian vegetation (ii) removal of large woody debris, and (iii) alteration of natural flow regimes.

Aquatic biota were sampled at two replicate sites for each of three locations in Paddys River; at the Hume Highway Bridge crossing immediately adjacent to the proposed works, and at locations approximately 500 m upstream and downstream of this point. Water quality and aquatic habitats were also assessed. The structure and composition of macrophyte beds were determined, macroinvertebrates assemblages from pool edge habitats were sampled using AusRivAS protocols and fish were sampled using bait traps and electrofishing. Macroinvertebrate samples were processed in the laboratory and the resulting data analysed using the AusRivAS predictive model. Water quality data were compared with ANZECC guidelines for the protection of aquatic ecosystems.

The habitat and biota were moderately healthy at the locations surveyed. The river was composed primarily of alternating runs and pools with one large pool section building up behind a channel constriction and gravel road crossing just upstream of the Hume Highway bridges. On either side of the channel, the land sloped upwards into open woodland or partially cleared pasture. The riparian vegetation and banks in the vicinity of the Hume Highway bridges were degraded, presumably from previous works associated with the highway and/or bridges.

Water quality was consistent among all three sites, with turbidity and pH within the ANZECC guidelines, but electrical conductivity and dissolved oxygen levels were above and below the guideline trigger values, respectively.

Macrophytes were relatively abundant at all sites surveyed with tall spikerush, water ribbons, common reed and water milfoil dominating. AusRivAS analyses of aquatic macroinvertebrates suggest that this reach of Paddys River is in relatively good condition with the communities at the majority of the sites equivalent to reference condition. There was, however, a greater representation of pollution-tolerant taxa in the Paddys River sites suggesting some water pollution and/or localised habitat degradation. Five species of fish were recorded, three native and two introduced. No threatened or protected species or communities were observed during the field survey.

Potential environmental constraints associated with the project relate predominantly to the mobilisation of sediments into the river from the proposed works and pollutants associated with heavy vehicles and roadways. Elevated sediment loads in particular can lead to a reduction in primary productivity, cause direct mortality of macroinvertebrates and fish, degrade habitat (such as riffles, spawning grounds and deep holes) and decrease longitudinal connectivity between populations and/or habitats. However, mitigation strategies, such as standard construction site sediment controls, appropriate water quality monitoring and development of management plans that can respond to environmental contingencies, can be implemented to ensure that sedimentation and pollution of Paddys River do not occur as a result of the proposed works.

The proposed works are not anticipated to contribute to the three nominated listed threatening processes. The riparian vegetation was already extremely degraded along the section of the Paddys River adjacent to the proposed underpass. The proposed works should not disturb snags in the low flow channel of Paddys River, which is contained within the centre 20 m span of the Hume Highway bridges as the underpass will be positioned under the eastern span, on the other side of the eastern bridge piers. Hydrological modelling indicates that the works would cause minimal changes to the existing flow regime, and as such, significant effects on aquatic ecology are not expected.

The project will have no impact on the majority of regional threatened species and communities as neither the taxa nor their habitat occur within the area potentially affected by the proposed works. Assessments of Significance carried out for the Macquarie perch and giant dragonfly indicate that potential impacts on these species would be negligible provided standard sediment and pollution control strategies are implemented.

1. INTRODUCTION

Cardno Ecology Lab Pty Ltd was contracted by R.W. Corkery & Co. Pty Ltd, on behalf of Rocla Materials Pty Ltd, to undertake the aquatic ecology component of the *Environmental Assessment* for the proposed construction of the southern intersections and approaching access roads, as part of the Green Valley Sand Quarry Project.

This construction needs to meet RTA's requirements for safe entry and egress of trucks travelling to and from the proposed quarry without compromising the safety of traffic on the adjacent Hume Highway. The proposed northern intersection would be constructed at the existing entrance to the ""Green Valley"" property and the northern access road would largely follow a section of the Old Hume Highway. The dispatch of trucks to the north and the arrival of trucks from the south are planned via a new southern intersection. The southern access road is expected to generally follow the route of an existing track to Paddys River which traverses the ""Green Valley"" property and an area of Crown Land and then loops around the bridges that cross over Paddys River to join the north-bound lanes of the Hume Highway. The southern access road underpass will be graded by up to 2 m to create the minimum 4.8 m vertical clearance to the bridges stipulated by RTA and include the construction of a central sump for water drainage. To minimize water entering the underpass, it is proposed that a Type F traffic barrier be constructed along the underpass and additional drainage, in the form of a new culvert, be provided north of the bridges.

1.1 AIMS

The scope of works for the aquatic ecology component included:

- Review of existing information on aquatic ecology;
- Review of threatened species legislation regarding aquatic invertebrates, aquatic plants ("macrophytes"), fish and platypus;
- Provision of a detailed description of aquatic habitats, flora and fauna present upstream, downstream and in the immediate area of the Hume Highway crossing;
- Assessment of the health of this reach of Paddys River based on collection of aquatic macroinvertebrates and AusRivAS; and
- Identification of potential environmental constraints to the proposed road works and recommendations for mitigation measures.
- Assessment of impact of the proposed road works on aquatic fauna and flora.

1.2 STUDY AREA

The Study Area was located at the Hume Highway crossing of Paddys River, approximately 36 km north east of the town of Goulburn. The Study Area comprised 1.5 km reach of Paddys River, covering all aquatic habitat from 800 m upstream of the Hume Highway crossing to 650m downstream of the crossing. Three study 'locations' were established in the Study Area to represent aquatic ecology (i) upstream of the proposed works (Location 1), (ii) at the proposed works site (Location 2), and (iii) downstream of the proposed works (Location 3) (**Figure 1**). Two replicate sampling sites were established at each location: Sites 1 and 2 at Location 1, Sites 3 and 4 at Location 2 and Sites 5 and 6 at Location 3.

2. REVIEW OF EXISTING INFORMATION

Existing information on aquatic habitats and their associated biota within Paddys River and the Wollondilly River was obtained by searching Cardno Ecology Lab's extensive library and undertaking searches for relevant literature using the internet.

This assessment has included reference to threatened species and threatening processes listed under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), *Fisheries Management Act 1999* (FM Act) and *Threatened Species Conservation Act 1995* (TSC Act). Threatened species, populations and ecological communities that occur or could potentially occur within the Study Area were identified by reviewing the current listings on databases maintained by Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA), Industry and Investment NSW (I&I NSW) and NSW Department of Environment, Climate Change and Water (DECCW). Database searches were made over 8-9 September 2010.

The DEWHA Environmental Reporting Tool was used to determine whether any species listed as threatened or protected under the schedules of the EPBC Act occurred in the Study Area. The Paddys River catchment was used as the search area for the Environmental Reporting Tool.

The DECCW Geographic Region Search was used to determine whether any threatened aquatic plant species or endangered ecological communities listed under the TSC Act were present in the Study Area. The search was performed on the Bungonia and Burragorang (Part A) sub-regions of the Hawkesbury-Nepean Catchment Management Authority (H-NCMA) area.

The I&I NSW Threatened and Protected Species Record Viewer was used to search the Paddys River and Wollondilly River regions for records of threatened and protected species listed by Schedules 4, 4A and 5 of the FM Act.

2.1 PHYSICAL SETTING

Paddys River is located in the Wollondilly River sub-catchment of the Hawkesbury - Nepean River catchment, which drains into Lake Burragorang. Paddys River flows westwards from its source in Sutton Forest, north of Bundanoon and then northwards into the Wollondilly River. The land surrounding the Paddys River section of the Wollondilly sub-catchment is used primarily for pasture/grazing.

The Lake Burragorang storage and dam wall located approximately 110 km downstream of Paddys River represents a significant barrier to aquatic ecological processes and longitudinal connectivity with the Hawkesbury-Nepean river system and estuarine/marine habitat further downstream. The former NSW Department of Primary Industries (DPI) (now Industry of Investment NSW – Fisheries) also identified several road crossings on Paddys River and Wollondilly River downstream of the study area that may create barriers to aquatic ecological processes (DPI NSW 2006a).

The "Green Valley" property contains a network of drainage lines which flow into Paddys River. The drainage lines are ephemeral 1st-order streams and carry surface flows only during large storm events due to the small upslope catchment and limited runoff in the area (R W Corkery & Company 2010). The drainage lines consist of simple depressions in the landscape and therefore lack stream beds and banks. The rainfall runoff and infiltration from the property feeds a number of hanging swamps on surrounding lands.

2.2 WATER QUALITY

Water quality data are available for four sites along Paddys River: above Granite Falls, at Hume Highway, below the Bundanoon STP and at Tooma Road (NSW Government 2008). These data, however, are not comparable, because different parameters were recorded at each site and this was done on different occasions and for different lengths of time. The data from the site above Granite Falls, for example, were collected between 1970 and 1984 and are measures of electrical conductivity, instantaneous flow, stream water level, temperature, turbidity and pH. The data from the site at the Hume Highway, however, were recorded between April 1998 and March 1999 and consist of blue green algae, enterococci and faecal coliform counts and measures of temperature, water transparency, turbidity and pH.

2.3 AQUATIC PLANTS

The only records found of aquatic plants were recorded from three sites in the lower Wollondilly River approximately 30 km upstream of Lake Burragorang (The Ecology Lab 2006). A total of nine species were recorded, all of which are common in the Hawkesbury-Nepean catchment. Watermilfoil (*Myriophyllum spicatum*), Curly Pondweed (*Potamogeton perfoliatus*) and fine filamentous algae were found at Archies Island. Cumbungi (*Typha orientalis*), Common Rush (*Juncus usitatus*) and River Clubrush (*Schoenoplectus validas*) were recorded at Goodmans Ford Bridge. Giant Ribbonweed (*Vallisneria gigantea*), Curly Pondweed, Knotweed (*Persicaria decipiens*) and Umbrella sedge (*Cyperus erograstus*) were found upstream of 500 Acre Flat.

2.4 AQUATIC MACROINVERTEBRATES

Chessman (1992) is known to have sampled aquatic macroinvertebrates in Paddys River and the Wingecarribee River in August and November 1991, however, this information could not be sourced.

Three sites on the Upper Wollondilly (upstream of Paddys River junction at Goonagulla, Gundowringa and Baw Baw bridge) and three sites in the Wollondilly sub-catchment (i.e. the Tarlo River at Tarlo, Wollondilly River at Jooriland and Bannaby Creek at Adavale Road) are included in Sydney Catchment Authority's Macroinvertebrate Monitoring Program. In spring 2004, the health of the macroinvertebrate assemblages associated with edge and/or riffle habitats at these sites was assessed using the AusRivAS protocol and the majority were found to be impaired (Ecowise 2005). In the Upper Wollondilly, the fauna associated with the edge habitat was more diverse than the AusRivAS reference condition (i.e. contained more taxa than expected by the AusRivAS model) at one site, but significantly impaired (fewer macroinvertebrate families than expected) at the other two sites. In the Wollondilly sub-catchment, the fauna associated with the edge habitat was assessed as significantly impaired at one and as severely impaired at the other. The fauna at the only riffle habitat sampled was also classed as severely impaired (i.e. had many fewer taxa than expected). This site is located in a predominantly agricultural area and was characterised by a degraded riparian zone and a high percentage of silt in both the edge and riffle habitats. In 2004, the overall condition of the fauna in the Wollondilly sub-catchment was considered moderately poor. Ecowise (2005) also noted that the fauna in the upper section of the Wollondilly sub-catchment had been in poor health since 2001.

In autumn 2006, the condition of the aquatic macroinvertebrate fauna associated with edge and riffle habitats was assessed at Archies Island and upstream of 500 Acre Flat on the Lower Wollondilly River (The Ecology Lab 2006). Both sites are located downstream of the confluence with Paddys River. The fauna associated with the edge habitat was assessed as being equivalent to the AusRivAS reference condition, whereas that associated with the riffle habitat was severely impaired at one site and significantly impaired at the other.

Brainwood *et al.* (2008) recorded three species of freshwater mussels*, Hyridella depressa, H. drapeta* and *Velesunio ambiguus* at a small causeway on Paddys River near the Hume Highway and noted that freshwater mussels were also present at Kippilaw Weir on the Upper Wollondilly River.

2.5 FISH

The Bionet database indicates that 11 native and six alien fish species have been recorded in the Wollondilly sub-catchment (**Table 1**). The records for Paddys River are restricted to one native species, mountain galaxias (*Galaxias olidus*), and two alien species, rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*). It should be noted that Bionet has only one record of fish, the introduced mosquitofish (*Gambusia holbrooki*) in the reach of the Lower Wollondilly River (Reach 1) which is upstream of the confluence with Paddys River, but records of 6 species (3 native and 3 alien) further upstream in the Upper Wollondilly River (Reach 4). There are no records of fish in the reach of the Lower Wollondilly River (Reach 2) immediately downstream of the confluence with Paddys River, but records of four native and three alien species in the reach of the Lower Wollondilly (Reach 3) which stretches from the confluence with Tarlo River to Lake Burragorang. Only two species, both alien, have been recorded in the Tarlo River. The database indicates that three native and two alien fish species are present in Gunieacor Creek which feeds into Lower Wollondilly Reach 3. The Wingecarribee River appears to support the most diverse fish fauna, with five native and five alien species having been recorded. Only two species have been recorded in Black Bobs Creek, a tributary of the Wingecarribee River. It is important to bear in mind that the records for some rivers or reaches are likely to be more complete than for others, because of sampling bias. The movement of fish species between these river systems will also be limited by barriers to fish passage, such as the weirs on the Upper Wollondilly River.

The Freshwater Fish Database maintained by the former DPI (NSW) has records for four sites on Paddys River and five sites each on the Upper and Lower Wollondilly River (**Table 2**). These records indicate that five native species, longfinned eel (*Anguilla reinhardtii*), mountain galaxias, Australian smelt (*Retropinna semonii*), flathead gudgeon (*Philypnodon grandiceps*) and an unidentified gudgeon (*Hypseleotris* sp.), and three introduced species, goldfish (*Carassius auratus*), redfin perch (*Perca fluviatilis*) and mosquitofish, occur in Paddys River. Three native species, Australian smelt, flathead gudgeon and an unidentified gudgeon, and four introduced species, goldfish, common carp, redfin perch and mosquitofish, have been recorded in the Upper Wollondilly. The Lower Wollondilly, as expected, supports a more diverse fish fauna with a total of ten native species and six introduced species having been recorded by the former DPI. Long-finned eels, climbing galaxias (*Galaxias brevipinnis*), freshwater catfish (*Tandanus tandanus*), Macquarie perch (*Macquaria australasica*), dwarf flathead gudgeon (*Philypnodon sp.*) empire gudgeon (*Hypseleotris compressa*) and firetailed gudgeon (*Hypseleotris galii*) are the additional native species, while rainbow trout (*Oncorhynchus mykissii*) and oriental weather loach (*Misgurnus anguillicaudatus*) are the additional introduced species recorded in the Lower Wollondilly.

Macquarie perch, a species that is listed as threatened under both State and Federal legislation (see Section 2.7), is also known to occur in the Tarlo and Wingecarribee Rivers of the Wollondilly sub-catchment (DPI NSW 2005a). Silver perch (*Bidyanus bidyanus*) and exotic brown trout and rainbow trout are known to have been historically stocked in the Wollondilly sub-catchment (NSW Fisheries 2003). The practice of introducing trout into the Wollondilly River below Marsden Weir (Goulburn) was ended due to the potential impact they may have on the persistence of local populations of Macquarie perch. Two other introduced species, common carp and redfin perch, recorded in the Wollondilly sub-catchment have also been associated with the decline of Macquarie perch populations (Graham *et al*. 2005, DPI NSW 2009).

2.6 PLATYPUS

The Bionet database indicates that Platypus (*Ornithorhynchus anatinus*) have been recorded in the all three reaches of the Lower Wollondilly River, the Upper Wollondilly River, Wingecarribee River, Black Bobs Creek, Murruin Creek, Jocks Creek and Guneacor Creek. There are no records on this database of Platypus in Paddys River or Tarlo River. The Wollondilly River Sub-catchment Summary produced by the Hawkesbury-Nepean CMA (2008), however, indicates that Platypus occur in the section of Paddys River that stretches from just below Bundanoon Village to just before the confluence with Wollondilly River, in three reaches of the Lower Wollondilly River and in two reaches of the Upper Wollondilly River. This means that platypus could potentially occur within the Study Area. They have also been recorded in Long Swamp, which is located adjacent to Long Swamp Creek, a tributary of Paddys River (DEWHA 2008).

The platypus is a long-lived species and is totally dependent on aquatic ecosystems for its survival. The occurrence of platypus is dependent on adequate supplies of benthic invertebrates which they use as food and the availability of earth banks in which they build their resting and nesting burrows (Grant and Temple-Smith 1998). Rivers or streams with relatively steep earth banks consolidated by the roots of native vegetation, abundant invertebrate prey, cobbled or gravel substrates, overhanging shady vegetation and a sequence of pools and riffles are considered ideal platypus habitat. This species can also be found in lakes, farm dams and moderately-degraded streams. Platypus populations are vulnerable to degradation of suitable water bodies caused by agriculture, damming, drainage and pollution.

2.7 THREATENED AND PROTECTED SPECIES, POPULATIONS, COMMUNITIES AND PROCESSES

2.7.1 Listings under the *Environment Protection and Biodiversity Conservation Act 1999*

2.7.1.1 Threatened Species

The Environmental Reporting Tool linked to the *EPBC Act* indicated (when searched on 9 September 2010) that one endangered fish species, Macquarie perch (*Macquaria australasica*), one vulnerable fish species, the Australian grayling (*Prototroctes maraena*) and one Vulnerable plant species Dense Cord-Rush (*Baloskion longipes*) may either occur or suitable habitat for them may occur in the area.

There are two distinct populations of Macquarie perch in NSW, a western form found in the Murray-Darling Basin, and an eastern form found in south-eastern coastal NSW, including the Hawkesbury-Nepean and Shoalhaven catchments (DPI NSW 2005b). Macquarie perch have also been translocated into a number of river systems. They are found in lake and river habitats, particularly in the upper reaches of rivers and their tributaries. This species spawns in spring or summer in shallow upland streams or flowing parts of rivers. The eggs settle among stones and gravel of the stream or river bed. This species is threatened by:

- Changes in water quality associated with agriculture and forestry;
- Modification of natural river flows and temperatures as a result of the construction of dams and weirs;
- Spawning failures resulting from cold water releases from dams;
- Competition from introduced fish species;
- Diseases, such as epizootic haematopoietic necrosis, which is carried by redfin perch; and
- Over-fishing in the past.

The historical distribution range of Australian grayling included coastal streams from the Grose River, west of Sydney, southwards through NSW, Victoria and Tasmania (DPI NSW 2006b). On mainland Australia, this species has been recorded from rivers flowing east and south of the main dividing ranges. It is absent from the inland Murray-Darling system (McDowall 1996) and there are no records of it occurring in either Paddys River or the Wollondilly River. Australian grayling form fast-moving shoals in clear stream and rivers with moderate flow. Eggs of grayling develop in gravel beds, and once hatched the larvae are swept downstream to marine habitat where they develop before returning upstream to freshwater at six months of age (DPI NSW 2006b). Threats to Australian grayling include:

- Construction of weirs and dams, which prevent downstream and upstream migration;
- Land clearing that degrades water quality and causes siltation;
- Smothering of gravel beds by fine sediment; and
- Competition from the introduced brown trout.

Dense cord-rush is a rush-like herb found in swamps or depressions in sandy alluvium. Although the species can be found in wet or dry sclerophyll forests and grassy woodlands it is also known from montane bogs and its distribution overlaps with the threatened ecological community of Temperate Highland Peat Swamps on Sandstone. Dense cord-rush has been recorded in Hanging Rock Swamp (Penrose State Forest), located to the south east of the Study Area. Threats to dense cord-rush include:

- Road works and weed spraying;
- Foraging behaviour of feral pigs; and
- Changes to hydrology.

2.7.1.2 Threatened Ecological Communities

The four freshwater wetlands that occur along the tributaries of Paddys River before its junction with the Wollondilly River: Stingray Swamp and Hanging Rock Swamp in Penrose State Forest, Long Swamp near Canyonleigh and Mundego Swamp near Wingello are included within the endangered ecological community, Temperature Highland Peat Swamps and listed as Nationally Important Wetlands **Figure 2** provides a map showing the locations of these threatened ecological communities. Long Swamp is situated approximately 7km west of Tennyson Park and is thus downstream of the "Green Valley" Project Site, but upstream of the Long Swamp Creek confluence with Paddys River. The other swamps are located upstream of the Project Site.

Long Swamp extends approximately 5 km along the length of Long Swamp Creek and has a catchment of approximately 30 km^2 (DEWHA 2008). Long Swamp is 2 m deep in parts and contains large amounts of peat compost material. The margins of the swamp support reeds. Most of the native fauna associated with the swamp are terrestrial. The only aquatic animals recorded are platypus and eels, however, it should be noted that the owner of Long Swamp is considering introducing fish species (DEWHA 2008). Stingray and Hanging Rock Swamps typically have a herb layer dominated by sedges and a shrub layer. Caddis fly larvae (*Trichoptera* spp.) have been found in the creeks flowing into Stingray Swamp (Wetland Care Australia 2008). The ecological significance of these wetlands stems from the role of the swamp sediment and vegetation in the maintenance and regulation of water flow and quality in the catchment, and thus maintenance of catchment stability and water quality. Their listing under the *EPBC Act* means that activities such as urban development, hydrological changes, grazing and peat mining which are likely to have a significant impact upon the Temperate Highland Peat Swamps should be referred to the Commonwealth Minister for the Environment for assessment and approval.

2.7.2 Listings under the *Threatened Species Conservation Act 1995*

2.7.2.1 Threatened Species

The Geographic Region Search indicated that giant dragonfly (*Petalura gigantea*), Klaphake's sedge (*Carex klaphakei*) and Dense Cord-Rush (*Baloskion longipes*) were present within the Burragorang (Part A) sub-region.

The giant dragonfly (*Petalura gigantea*) is listed as Endangered under Schedule 1 of the *TSC Act*. This dragonfly lives in permanent swamps and bogs with some free water and open vegetation (DECC 2009). The adults emerge in October and live for one summer. They spend most of their time settled on low vegetation on or adjacent to the swamp, except when hunting for flying insects over and along the margins of the swamp. The larvae live in burrows under the swamp, but leave these at night to feed on insects and other invertebrates on the surface. The larvae grow slowly and may remain in this state for up to 10 to 30 years. This species is known to occur in the Burragorang Part A, Bungonia and Moss Vale sub-regions of the Hawkesbury-Nepean catchment and has been recorded in Hanging Rock Swamp (Wetland Care 2008) and Stingray Swamp (NPWS 2008). Degradation of habitat is the major threat to this species.

Klaphake's sedge is listed as Endangered under Schedule 1 of the *TSC Act*. It is restricted to habitat of swamps on sandstone at altitudes greater than 600 m AHD. The species is only known from three locations, including a very localised population in montane bog near Penrose, to the south east of the Study Area. Threats to this species include:

- runoff into sites from urban areas and highways;
- grazing and trampling by stock causing root damage, prevention of seedling establishment and erosion;
- sand extraction;
- clear-felling of nearby pine forest.

Dense cord-rush is listed as Vulnerable under Schedule 2 of the *TSC* Act.

2.7.2.2 Threatened Ecological Communities

The Paddy River wetlands are also listed under the *TSC Act* as part of the Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions, ecological community.

2.7.2.3 Key Threatening Processes

"Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands" is listed as a Key Threatening Process on Schedule 3 of the *TSC Act* (DECC 2005b). Human activities that reduce or increase flows, change the seasonality of flows, change the frequency, duration, magnitude, timing, predictability and variability of flow events, alter surface and subsurface water levels and change the rate of rise or fall of water levels can all alter the natural flow regimes of water courses. The proposed construction of the underpass and the Type F traffic barrier are expected to reduce the waterway area and therefore potentially change the existing flow regime.

The flow regime is a key driver of river ecology, and changes to flow can alter the geomorphological process of sediment erosion, transport and deposition that structure a variety of important channel habitat forms, change macrophyte communities, influence water properties important to biological assemblages and alter in-stream connectivity, isolating habitats and populations.

Examples of impacts on aquatic biota associated with altering natural flow regimes include:

- Restricted access to habitat for foraging, refuge or reproduction;
- Reductions in flow can decrease the amount of organic matter on which invertebrates and vertebrates depend on;
- Changes in flow can increase erosion and lead to sedimentation impacts on aquatic communities and degradation of the riparian zone; and
- Deeper and more permanent standing water can facilitate the establishment and spread of exotic species.

These alterations can pose a threat to species, populations or ecological communities which rely on river flows for their short term and long term survival and thereby contribute to loss of biological diversity and ecological function in aquatic ecosystems.

2.7.3 Listings under the *Fisheries Management Act 1994*

2.7.3.1 Threatened Species

Two of the endangered species, Macquarie perch and Sydney Hawk Dragonfly, and one of the vulnerable species, Silver Perch (*Bidyanus bidyanus*), listed currently under the *FM Act* are known to occur in the Hawkesbury-Nepean drainage system (DPI NSW 2008).

The Sydney Hawk Dragonfly is extremely rare, having been collected in small numbers at only a few locations in a small area to the south of Sydney, between Audley and Picton (NSW DPI 2007). This species was discovered in 1968 from Woronora River and Kangaroo Creek, south of Sydney, and has subsequently been found in the Nepean River at Maldon Bridge near Wilton. The species is also known to occur in the Georges River and Port Hacking drainages. This dragonfly spends most of its life as an aquatic larva, with adults emerging from the water and living for only a few weeks or months. The larvae appear to have specific habitat requirements and have only been found under rocks in deep, cool, shady pools (NSW DPI, 2007). This species is threatened by:

- River regulation and changes in flows that cause the disappearance of natural deep pools;
- Habitat degradation associated with removal of riparian vegetation, drainage works and sedimentation;
- Water pollution and sedimentation due to land clearing, waste disposal and stormwater runoff from urban, industrial and agricultural development in the catchment; and
- Chance events such as natural disasters (drought) that eliminate the remaining local populations.

There are no records for this species within the Wollondilly River sub-catchment of the Hawkesbury-Nepean.

Silver perch are native to the Murray-Darling River system and have also been stocked into rivers and impoundments in the Murray-Darling Basin. This species appears to prefer fast-flowing, open waters, particularly where there are rapids and races. Adults migrate upstream in spring and summer to spawn. Juveniles sometimes move upstream in response to rising water temperatures and levels. Silver perch are threatened by:

- Modification of natural river flow and temperature regimes resulting from construction of dams and weirs;
- Cold-water releases from dams resulting in spawning failures;
- Degradation of instream habitats through the loss of riparian vegetation, sedimentation, barriers to passage and water quality decline;
- Competition from introduced fish species such as carp, redfin perch and gambusia;
- Stocking of inappropriate genetic strains, poor quality silver perch or silver perch hybrids; and
- Diseases such as epizootic haematopoietic necrosis.

2.7.3.2 Protected Species

The Australian grayling is a listed Protected species under the *FM Act*.

2.7.3.3 Key Threatening Processes

Three of the key threatening processes listed under the *FM Act*, "Degradation of Riparian Vegetation", "The Removal of Large Woody Debris From NSW Rivers and Streams" and "Instream Structures and Mechanisms that Alter Natural Flow" are relevant to the proposed works (DPI NSW 2005b, 2005c). The term "riparian vegetation" refers to the plants that occur on the land that adjoins, directly influences or is influenced by bodies of water, such as creeks, rivers, lakes and wetlands on river floodplains. Riparian vegetation is important ecologically because it:

- provides a source of organic matter;
- provides shade and shelter and creates a habitat for fish;
- provides a supply of large woody debris, which is used as habitat and spawning sites by many native fish species;
- stabilises river beds and banks, binds soil and protects against erosion; and
- acts as a filter for sediments, phosphorous and organic nitrogen, improving the quality of water entering watercourses.

The proposed construction works are likely to result in damage and/or removal of riparian vegetation, albeit on a localized scale. The change in the flow regime could also have an adverse effect on riparian vegetation. Degradation of riparian vegetation has been listed as a key threatening process, because of the adverse effects it can have on threatened species, populations and communities and the threat it poses to other species, populations and communities, which are not currently threatened. These effects include:

- Altered timing and quality of organic debris;
- Erosion due to altered channel structure;
- Increased nutrient and sediment runoff;
- Loss of food and habitat for aquatic and terrestrial fauna; and
- Introduction of vegetation which reduces the diversity of native invertebrate communities.

Instream woody debris provides complex habitat for macroinvertebrates and particularly fish, including refuge from predation, habitat for prey and as damming structures that create pools.

Instream structures, such as dams, weirs, canals, navigation locks, floodgates, culverts, flow regulators, levee banks, erosion control structures and causeways, can modify natural flow. Bridges and similar structures that have minimal impact on flow and off-stream structures such as artificial canals, farms dams and reservoirs are not included (DPI NSW 2005b).

2.7.4 Listings under the *National Parks and Wildlife Act 1974*

In NSW, native animals, including the platypus, are protected under the National Parks and Wildlife Act 1974.

3. FIELD INVESTIGATIONS

The objectives of the field investigations were to:

- Describe the aquatic habitats, flora and fauna present upstream, downstream and in the immediate area of the Hume Highway Crossing; and
- Assess the health of this reach of Paddys River based on collection of aquatic macroinvertebrates and use of the Australian River Assessment System (AusRivAS).

3.1 SITE SELECTION

Three study ‘locations’ were established within the Study Area to represent aquatic ecology (i) upstream of the proposed works (Location 1), (ii) at the proposed works site (Location 2), and (iii) downstream of the proposed works (Location 3) (**Figure 1**). Two replicate sampling sites were established at each location ; Sites 1 and 2 at Location 1, Sites 3 and 4 at Location 2 and Sites 5 and 6 at Location 3 (**Figure 1**). GPS coordinates marking the upstream and downstream boundary of each site are listed in **Appendix 1**.

At each of the six sites aquatic habitat was described, water quality measured and aquatic biota were sampled.

3.2 SAMPLING METHODS

3.2.1 Habitat Characteristics

At each site, a standardised description of the adjacent land and the condition of riverbanks, channel and bed was recorded using a modified version of the Riparian, Channel and Environmental Inventory (RCE) (Chessman *et al*. 1997) (See **Appendix 2**). Habitat descriptors included:

- geomorphological characteristics of the waterways;
- flow regime of the waterways (e.g. intermittent or permanently flowing);
- types of land use along the waterway (e.g. industries associated with the river, recreational uses);
- riparian vegetation and instream vegetation (e.g. presence/absence, native or exotic, condition);
- substratum type (e.g. rock, sand, gravel, alluvial substratums);
- presence of refuge areas;
- presence of spawning areas (e.g. gravel beds, riparian vegetation, snags); and
- presence of natural or artificial barriers to fish passage both upstream and downstream (e.g. weirs, dams, waterfalls, causeways).

The waterway at each site was classified for fish habitat according to the NSW Guidelines and Policies for Fish Friendly Roads (Fairfull and Witheridge 2003; Appendix 3).

3.2.2 Water Quality

Water quality was measured at each site using a Yeo-Kal 611 probe. Physical-chemical properties measured included: electrical conductivity (mS/cm and µS/cm); salinity (ppt); temperature (^{0}C); turbidity (ntu); dissolved oxygen (mg/L and % saturation); pH; and ORP (oxidation reduction potential: mV). Alkalinity was measured *in situ* using hand-held titration cells from CHEMetrics. During each survey, two replicate measures of each variable were taken from just below the water surface at each site, except for alkalinity, where only one replicate measure was taken.

3.2.3 Macrophytes

The percentage cover of macrophyte taxa within the wetted width of the channel was estimated at each site.

3.2.4 Macroinvertebrates

Macroinvertebrates in the edge habitats at the six study sites were sampled within the spring period (15th October to 15th December) in accordance with the Rapid Assessment Method (RAM) based on AusRivAS (Turak *et al.* 2004). At each macroinvertebrate study site, the chemical and physical variables required for running the AusRivAS predictive model were also recorded. The macroinvertebrate study sites for RAM sampling were at least 100 m in length, as required by the protocol.

Dip nets with a mesh size of 250µm were used to collect invertebrates from edge habitat at each site. Edge habitat is defined as areas along creek banks with little or no flow, including alcoves and backwaters, with abundant leaf litter, fine sediment deposits, macrophyte beds, overhanging banks and areas with trailing bank vegetation (Turak *et al.* 2004). The dip net was first used to disturb animals by agitating bottom sediments and suspending invertebrates into the water column. The net was then swept through this cloud of material to collect suspended invertebrates and surface dwelling animals. Samples were collected over a total length of 10 m, usually in 1-2 m sections, ensuring that all significant edge sub-habitats within each site were sampled (Turak *et al.* 2004).

Each RAM sample was rinsed in the net with local water to minimise fine particles and placed into a white sorting tray. Animals were removed from the tray using forceps and pipettes. Trained staff removed animals for a minimum period of thirty minutes. Thereafter, removals were performed in ten minute periods to a total of one hour, at which time removals would cease if no new taxa were found in a ten minute period. The animals collected were placed inside a labelled jar containing 70% ethanol and taken to the laboratory. Finally, debris remaining in the tray after processing was returned to the creek in the locality where the sample was originally collected.

The presence of larger mobile macroinvertebrates (such as freshwater crayfish) was investigated by means of electrofishing.

3.2.5 Fish

Two non-destructive sampling methods, electrofishing and bait traps, were used to sample fish and large macroinvertebrates occurring within appropriate habitats at each site. All the fish caught, except specimens of introduced pest species such as the mosquitofish, (*Gambusia holbrooki*), were returned unharmed to the water.

At each site, five bait traps were deployed. The traps used were rectangular in shape and approximately 350 mm long and 200 mm wide with an entrance tapering to 45 mm, with 3 mm mesh size throughout. Traps were deployed in shallow water habitats such as bare substratum, macrophytes and submerged snags. Traps were baited with approximately 70 mg of a mixture of chicken pellets and sardines and were left overnight for approximately 18 hours.

Electrofishing is a commonly used technique for sampling fish in freshwater habitats such as creeks, drainage ditches and streams. The technique involves discharging an electric pulse into the water which stuns fish, allowing them to be easily netted, counted, identified and released. Electrofishing was done in riffles, shallow pools and beneath overhanging banks and vegetation. One staff member used the electrofisher, whilst a second handled a dip net and was primarily responsible for capture of stunned fish. Captured fish were placed into a fish box, filled with stream water, which was handled by a third person on the bank. The third person acted as a safety officer for the other two. Three replicate “shots” of approximately 90 seconds of continuous fishing time were done at each site. Fishing power (amps) was standardised across sites by adjusting voltage output according to the electrical conductivity of the water.

3.3 LABORATORY METHODS

Animals in the AusRivAS macroinvertebrate samples were removed, identified using a binocular microscope, and counted to a maximum of ten animals, as per the AusRivAS protocol. Taxa were identified to family level except for Araneae, Cladocera, Copepoda, Hydracarina, Nematoda, Nemertea, Oligochaeta and Ostracoda. Chironomidae were identified to sub-family level as required by the model. Some families of Anisoptera (dragonfly larvae) were identified to lower taxonomic resolution (species), because they could potentially include threatened aquatic species. Identification of animals was validated by a second experienced scientist performing QA checks on each sample.

3.4 DATA ANALYSIS

3.4.1 Water Quality

Water quality data were compared with the ANZECC (2000) default trigger values for slightly disturbed upland rivers in south-eastern Australia.

3.4.2 Macroinvertebrate AusRivAS Models

The AusRivAS protocol uses an internet-based software package to determine the environmental condition of a waterway based on predictive models of the distribution of aquatic macroinvertebrates at undisturbed, reference sites. The data from this study were analyses using the NSW model for pool edge habitats sampled in spring. The AusRivAS predictive model generates the following indices.

- OE50Taxa - This is the number of macroinvertebrate families with a greater than 50% predicted probability of occurrence that were actually observed (i.e. collected) at a site expressed as a ratio of the number of macroinvertebrate families with a greater than 50 % probability of occurrence expected to occur at pristine sites with similar physical and chemical characteristics. OE50 taxa values range from 0 to slightly greater than 1 and provide a measure of the impairment of macroinvertebrate assemblages at each site. Values close to 0 indicate an impoverished assemblage while values close to 1 indicate that the condition of the assemblage is similar to that of the reference streams.
- Overall Bands derived from OE50Taxa scores which indicate the level of impairment of the assemblage. AusRivAS bands are graded as follows:
  - **Band X** = Richer invertebrate assemblage than reference condition;
  - **Band A** = Equivalent to reference condition (OE50 upper limit = 1.16);
  - **Band B** = Sites below reference condition (i.e. significantly impaired) (OE50 upper limit = 0.83);
  - **Band C** = Sites well below reference condition (i.e. severely impaired) (OE50 upper limit = 0.51); and.
  - **Band D** = Impoverished (OE50 upper limit = 0.19).

The revised SIGNAL2 biotic index (Stream Invertebrate Grade Number Average Level) developed by Chessman (2003) was also 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 between 1 and 10 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 then 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, doubtful, mildly, moderately or severely degraded, respectively.

Two SIGNAL scores produced by the AusRivAS predictive model were also examined:

- O0Signal index - observed SIGNAL score for taxa that have a probability of occurrence greater than 0%. This is calculated by averaging the SIGNAL grades for all the taxa observed and is equivalent to the SIGNAL score developed by Chessman (1995).
- OE0Signal index - the ratio of the observed to expected SIGNAL score per site for taxa that have a probability of occurrence of more than 0%.

3.5 RESULTS

Field sampling was done over the 4th and 5th November 2008. Weather conditions were clear on the 4th but became overcast on the 5th.

3.5.1 Habitat Characteristics

The land surrounding the Study Area comprises a mixture of natural open *Eucalypt* woodland, pasture for grazing and cleared areas associated with the Hume Highway. Spoil and gravel associated with road repair and construction were piled in a cleared area to the north east of the Hume Highway bridges spanning Paddys River. The river channel was at approximately 583 m AHD.

The RCE (Riparian, Channel and Environmental inventory) scores indicated that the overall quality of the aquatic habitat was poorer directly under the Hume Highway Bridges (i.e. at Location 2) than at the locations situated upstream and downstream of the crossing (i.e. at Locations 1 and 3, respectively) (**Table 2**). The quality of the aquatic habitat was similar at the latter locations. The quality of the habitat was the same at the sites within each location (i.e. they had identical RCE scores). The reach of Paddys River at the three locations provided major to moderate fish habitat (Class 1 – 2 waterway) (**Table 2**).

3.5.1.1 Location 1 (Sites 1 and 2)

Location 1 was situated approximately 600 m upstream of the Hume Highway crossing (**Figure 1**). At this location, the eastern bank slopes moderately down to the river and was covered by open Eucalypt woodland. The riparian vegetation was dominated by tea tree (*Leptospermum* sp.) and mat rush (*Lomandra longifolia*). The land on the western bank appeared to have been used for grazing as the woodland understorey had been replaced by pasture grasses and the riparian vegetation had been significantly disturbed and was infested with blackberry (*Rubus fruticosus*).

The river channel was narrow in the uppermost section of Site 1 (**Plate 1a**), but widened further downstream (**Plates 1b** & **1c**). Towards the downstream end of Site 1, the channel was deeper and macrophytes, such as tall spikerush (*Eleocharis sphacelata*), were increasingly restricted to shallower waters on the sides of the channel. At the downstream end of Site 2, the channel widened and was dominated by the common reed (*Phragmites australis*) (**Plate 1d**). The channel substratum was composed primarily of silt although there were patches of bedrock and boulders. Flow was relatively week, and ceased almost entirely in the deeper pools and reed beds, where there was a moderate amount of detrital material and large woody debris (snags).

3.5.1.2 Location 2 (Sites 3 and 4)

Location 2 was directly underneath the Hume Highway crossing and extended a small distance upstream and downstream of the bridges (**Figure 1**). The banks were cleared and dominated by exotic grasses (**Plates 2a** & **2b**). The riparian vegetation was significantly degraded, composed primarily of exotic grasses, with a small number of Casuarinas (*Allocasuarina* sp.), introduced poplars, tea trees and blackberry.

There were two gravel road crossings at Location 2, one either side of the Hume Highway bridges (**Plates 2c** & **2d**). The crossing at Site 3 appeared to impede flow and cause the water to pool upstream. This pool contained dense beds of macrophytes, such as tall spike rush, water ribbon (*Triglochin microtuberosum*), blunt pondweed (*Potamogeton ochreatus*) and water milfoil (*Myriophyllum* sp.) (**Plate 3a**). The channel narrowed downstream of the road crossing at Site 3 (**Plate 3b**) before opening up into a wider pool immediately under the dual bridge structure of the Hume Highway crossing (**Plate 3c** & **3d**). Downstream, the channel became narrow and shallow, and supported increasingly dense beds of macrophytes, such as water ribbons and water milfoil. In the riparian zone, tea trees and blackberry became more dense (**Plate 4a**).

The channel substratum at both crossings and in the faster-flowing narrow river sections was composed of coarse material, such as gravel, pebble and cobble, whereas the pool substratum was dominated by silt, with some boulders. Given the considerable previous works and alteration to landforms at this location, it is difficult to ascertain whether the coarser benthic material was natural or waste from the construction of the bridges and gravel crossings. Large woody debris was present in some sections, particularly in the downstream half of Site 4 away from the bridges.

3.5.1.3 Location 3 (Sites 5 and 6)

Location 3 was situated approximately 500 m downstream of the Hume Highway crossing (**Figure 1**). Both sides of the river were covered by open Eucalypt woodland. *Leptospermum* sp. and *Lomandra longifolia* were the dominant species on the immediate river banks.

The channel was approximately 6 m wide throughout Sites 5 and Site 6 and contained no wider pooling sections. Macrophytes, such as tall spikerush, water ribbons and water milfoil, were dominant in the deeper sections of the channel, whereas knotweed (*Persicaria* sp.) was more common in the shallows of sandbars and the channel sides (**Plate 4b**). The channel substratum was composed primarily of silty sand and had a moderate cover of detritus and large woody debris. At the bottom of Site 6, the channel was shallower and dominated by the common reed, *Phragmites australis*. Below the end of Site 6, the channel opened up into a wide pooling section that extended hundreds of metres downstream to a culvert.

3.5.2 Water Quality

The *in situ* water quality measurements presented in **Appendix 4** represent a “snapshot” view of water quality on the day sampled. **Table 3** compares the mean pH, electrical conductivity, turbidity and dissolved oxygen readings for each site with the relevant ANZECC (2000) guidelines. At all six sites, the mean pH and turbidity values recorded were within the ANZECC guidelines (2000). The electrical conductivity of the water within this section of the Paddys River was moderately high, with all sites having mean values considerably in excess of the upper limit of 350 $\mu S\ cm^{-1}$ specified in the ANZECC guidelines (**Appendix 4**). The dissolved oxygen levels, in contrast, were well below the lower limit (90 % saturation) of the ANZECC guidelines at Sites 1-4, but only just below the limit at Sites 5 and 6 (**Appendix 4**).

3.5.3 Macrophytes

Macrophytes were relatively abundant at all six sites surveyed (**Table 4**). The reach of Paddys River within the Study Area was characterised by long deep pools and narrow, shallower sections with higher velocity flow. Tall spikerush, water ribbons (**Plate 5a**), ribbonweed and water milfoil (**Plate 5b**) were found in deeper waters than the other macrophytes. They were common on the side of deep pools and throughout the channel of the shallower sections. Shallower sections of pools were occasionally dominated by the common reed *Phragmites australis*. Flat, shallow expanses, commonly found on the edge of wider pools and partially submerged sandbars in narrower sections, were often dominated by knotweed (**Plate 5c**). Tall spikerush and water ribbons were the most abundant macrophytes across the six sites, followed by water milfoil and, to a lesser extent, knotweed.

3.5.4 Aquatic Macroinvertebrates

3.5.4.1 General Findings

A total of 50 macroinvertebrate taxa were identified from the samples collected in pool edge habitat across the three locations (**Table 5**, **Appendix 5**). The composition of the macroinvertebrate assemblages was relatively similar across the six study sites (**Appendix 5**), although Site 1 had fewer insect taxa than the other sites and Sites 2, 3 and 4 were the most diverse (**Table 5**).

Empty shells of freshwater mussels were frequently observed along the river bank at Location 2 and the freshwater crayfish (*Euastacus* sp.) was most abundant at this location (**Figure 2**).

3.5.4.2 AusRivAS Analyses

Macroinvertebrate assemblages from the pool edge habitats were classified as equivalent to reference condition (Band A) at Sites 3-6, indicating that most of the taxa predicted to occur in the system were present (**Table 6**). The OE50 values for Sites 4-6, however, were towards the lower limit of the Band A scale. The macroinvertebrate assemblage at Site 2 was classed as Band X, which implies that it was more biologically diverse than reference sites (i.e. contained more taxa than expected. The fauna at Site 1 was classed as significantly impaired (Band B), due to the absence of several key expected taxa (**Table 6**).

The O0Signal scores ranged from 3.62 to 4.43 and indicate that all sites contained more pollution-tolerant than pollution-sensitive taxa (**Table 6**). The O0Signal scores also suggest that this section of Paddys River is moderate to severely polluted, with the fauna at the sites directly underneath the Hume Highway crossing (i.e. at Location 2) being the most degraded. The OE0 Signal scores were lower than one at all sites, indicating that pollution-sensitive taxa are a relatively more important component of macroinvertebrate assemblages at reference sites. The SIGNAL2 scores were slightly greater than the O0Signal scores varying from 3.91 to 4.67. The fauna at Sites 4 and 6 had the lowest SIGNAL2 scores. This indicates that the variation in SIGNAL2 scores across study sites was not consistent with that in O0Signal scores.

3.5.5 Fish

A total of five fish species were sampled over the six sites (**Figure 3**, **Appendix 6**). Flathead gudgeon (*Philypnodon grandiceps*)(**Plate 6a**), firetailed gudgeon (*Hypseleotris galii*)(**Plate 6b**) and Australian smelt (*Retropinna semoni*)(**Plate 6c**) are native species, while mosquitofish (Plate 6d) and goldfish (*Carassius auratus*) are introduced species.

Flathead gudgeons and firetailed gudgeons were the only fish and freshwater crayfish (*Euastacus* sp.) was the only large invertebrate caught in the bait traps (**Appendix 6**). The two species of fish were caught at Sites 2 and Site 3, but not at any of the other sites. The freshwater crayfish was found only at Site 4.

Australian smelt was the most abundant species of fish sampled by electrofisher. The highest abundances of smelt and freshwater crayfish were recorded at Location 2 (**Figure 3**). Smelt were most frequently caught over pebble and cobble substrata in the faster moving waters of narrow channel sections in Site 3. Moderate-sized schools of smelt were also observed at Site 1 during AusRivAS macroinvertebrate sampling undertaken on the 4th November.

3.5.6 Platypus

No platypus were observed when the sampling for fish, macroinvertebrates and macrophytes was carried out. It should, however, be noted that these were sampled during the middle of the day when platypus are usually less active (although some can be diurnal) and hidden from view in their burrows.

The suitability of the habitat within the Study Area for platypus was considered to be variable. Relatively steep earth banks consolidated by tea trees and Eucalypts were present at some sites (e.g. Site 1) and aquatic macroinvertebrates were abundant, however, the two sites at Location 2 appeared to have unsuitable bank structure for platypus burrows. Cobble and gravel substrata favoured by platypus were relatively uncommon and the channel bed was dominated by sandy silts. Riffles were rare as this reach of Paddys River was primarily composed of long pools and runs.

3.6 DISCUSSION

The riparian vegetation found in the Study Area reflected the varying land use in the region with *Eucalypt* woodland, pasture and cleared areas all present. The riparian community in the project footprint (Location 2) was particularly disturbed, having presumably been cleared during previous works associated with the Hume Highway and bridge crossings. There were few shrubs or trees and the riparian vegetation was dominated by exotic pasture grasses.

The aquatic habitat within the Study Area was characterized by large pooling sections lined by common reed and tall spike rush and runs supporting macrophytes such as water ribbon, water milfoil and tall spike rush. The pools upstream of Location 2 and downstream of Location 3 were situated behind two separate road crossings that impeded river flow. Riffle habitat was rare. The channel substratum was dominated by silt but there were some differences among locations, with bedrock present at the upstream Location 1, and sand more important in the runs at Location 3. The channel bottom in the Study Area had been modified by presence of two submerged gravel crossings and sections of large boulders in pool sections that may have been left over from previous road works.

Water quality was consistent among locations, but showed some evidence of degradation. Turbidity and pH, for example, were within the ANZECC guidelines, but electrical conductivity was higher than the guidelines at all sites sampled while dissolved oxygen was generally below the lower limit of the guidelines.

The AusRivAS analyses of aquatic macroinvertebrates suggest that the reach of Paddys River within the Study Area is in relatively good condition with the assemblages at the majority of sites equivalent to reference condition. There was, however, a greater representation of pollution-tolerant taxa in the Paddys River sites relative to AusRivAS reference conditions suggesting that the Study Area was subject to some pollution or localised habitat degradation. The macroinvertebrate assemblages found in this reach of Paddys River appear to be in a better condition than at the sites in the Wollondilly sub-catchment, which were assessed as being in poor health with moderately poor faunal assemblages in 2004 (Ecowise 2005).

Previous fish surveys undertaken in Paddys River and reaches of equivalent altitude in the upper and lower Wollondilly River indicate that both native and introduced species are present. The native and introduced species sampled during the current study did not feature among the records from Paddys River on the Bionet database, but have been caught during surveys of this river system undertaken by I&I NSW. All of the species of fish found in the Study Area are able to complete their life cycles within freshwater. No diadromous fish (i.e. species that migrate to estuarine or marine waters at some stage of their life cycle) were caught during this survey of Paddys River. This was expected given the barriers to fish passage that exist downstream of the location. It should, however, be noted that long-finned eels, a diadromous species which is capable of climbing instream barriers such as weirs, has been recorded in Paddys River and the Lower Wollondilly River by the former DPI (NSW). Australian bass, another diadromous species, has been found in the nearby Wingecarribee River, but its presence therein is more likely to be due to stocking than migration. Although Macquarie perch are known to be present within the Wollondilly River, there are no records of it occurring in Paddys River.

The native species identified in this survey, Australian smelt, flathead gudgeon and firetail gudgeon, are found in both lentic and lotic environments and would therefore be expected to occur in both the pool and runs habitat available in Paddys River. The introduced mosquitofish and goldfish are commonly found in disturbed environments. They tend to prefer slow moving waters and would be expected to occur in higher densities in the reed beds in the pool sections.

4. ASSESSMENT OF IMPACTS

4.1 DESCRIPTION OF PROPOSED WORKS

The construction of southern and northern intersections on the Hume Highway and upgrade of the existing southern and northern access roads are the proposed works associated with the Green Valley Sand Quarry Project. **Figure 4** provides a plan of the proposed works adjacent to Paddys River with details of these works given in (GHD, 2010).

The proposed northern intersection would have a left in/left out configuration and full acceleration and deceleration tapers. It would be constructed at the existing entrance to the "Green Valley" property. The northern access road from the intersection to the sand processing area would largely follow an area of the Old Hume Highway, but would require minor widening of the south-bound road.

The dispatch of trucks to the north and the arrival of trucks from the south would occur via a new southern intersection. The southern access road is proposed to generally follow the route of an existing track to Paddys River which traverses the "Green Valley" property and an area of Crown Land and then loops around the bridges that cross over Paddys River to join the north-bound lanes of the Hume Highway. The north-bound left hand lane of the Hume Highway between the northern abutment of the bridge and the intersection would be widened for the incorporation of a deceleration lane.

The southern access road underpass will be graded by up to 2 m to create the minimum 4.8 m vertical clearance beneath the bridge stipulated by RTA. The underpass will not be free draining below the level of the existing embankment, so a pump will be required to dewater this section. The underpass design incorporates a one-way crossfall to facilitate drainage of water to a sump located at the centre of the underpass. A rigid, Type F traffic barrier would be constructed to protect the existing bridge piers adjacent to the underpass from errant vehicles. This barrier would also prevent inundation of the underpass to a level approximately 0.4 m above average bed level in the northern span of the existing bridges. To minimize the amount of water entering the underpass it is proposed that additional drainage, in the form of a new culvert, be constructed to the north of the bridges in the Hume Highway.

A computer model-based study of flood flows in Paddys River beneath the bridges indicates that the proposed underpass will reduce the channel area for flood events below eight months average recurrence interval (ARI) (GHD, 2010). This will have a negligible effect on flooding levels in the vicinity of the bridge and a negligible impact on flow velocities through the bridges. The difference in water level under the Hume Highway bridges would be between 0.01 and 0.03 m. GHD (2010) estimates that the proposed work would result in a change in existing flow velocities from 2.56 – 2.8 m/s to 2.31 – 2.89 m/s under a 100 year ARI and from 0.84 – 0.91 m/s to 0.77– 0.88 m/s under a 1 year ARI.

4.2 POTENTIAL ENVIRONMENTAL CONSTRAINTS ASSOCIATED WITH THE PROPOSED WORKS

4.2.1 Miscellaneous Environmental Constraints

4.2.1.1 Water Contamination

Pollutants associated with heavy vehicles and roadways may enter Paddys River from the sump drainage and flood flows that inundate the underpass. Pollutants such as hydrocarbons, aromatic hydrocarbons (lubricating oils and fuels) and heavy metals (e.g. lead in fuels, copper in brake linings, and zinc and cadmium in tyres) may have a detrimental effect on aquatic biota or habitat. There are published trigger values for these toxicants designed to protect aquatic ecosystems in Australia (ANZECC 2000).

4.2.1.2 Sediment Mobilisation

The proposed construction and upgrade of the intersections and access roads associated with the Green Valley Sand Quarry Project would be major works. Earthworks and run-off over unprotected spoil or cleared land may result in the mobilisation of sediments into Paddys River. Mobilised sediments could then be transported to downstream reaches. An increase in sediment load can degrade water quality and important habitat features resulting in a loss of biodiversity and a shift towards a more pollution-tolerant biotic assemblage.

Increased levels of suspended sediments could clog the gills and/or feeding apparatus of macroinvertebrates found in Paddys River, such as the mayfly (Leptophlebidae) and the less abundant stonefly (Gripopterygidae), both of which have external gills and are sensitive to reduced water quality (Signal grades = 8) (Waters 1995). Australian smelt, one of the native fish species recorded in the river, is known to be relatively intolerant to elevated sediment loads and fish kills have occurred at suspended sediment concentrations of 190 – 200 mg L^{-1} (Pusey *et al*. 2004). Other species of fish, such as firetailed gudgeon, are more tolerant of high turbidity (Pusey *et al*. 2004).

An increase in turbidity and suspended sediments would reduce primary productivity of aquatic plants and, as a result, negatively affect grazers that feed on periphyton and macrophytes (Ryan 1991). This includes mayflies (Baetidae, Signal grade 5), caddisflies (Leptoceridae, Signal grade 6), and beetles (Elmidae , Signal grade 7). Macrophyte beds are also important habitat for native fish, providing refuge from predators and supporting macroinvertebrate prey assemblages.

High sediment loads can reduce available habitat by infilling interstitial spaces in the stream bed. This, in turn, can cause a decline in the population of bottom-dwelling invertebrates (Ryan 1991). Sediment can also smother and infill important fish habitat such as submerged woody debris and deep holes in pools.

The likelihood and magnitude of impacts on macroinvertebrates would be greater closer to the construction site where turbidity and sedimentation impacts are likely to be greatest. Fish are relatively mobile and have the capacity to seek out more favourable conditions and to recolonise following the disturbance.

Potential impacts from mobilised sediment can be minimised with standard sediment control measures. Mobilised sediment is unlikely to pose a significant threat to the aquatic ecology of Paddys River, provided these control measures are implemented.

4.2.2 Listed Key Threatening Processes

4.2.2.1 Degradation of Riparian Vegetation

The benefits of riparian vegetation to freshwater biota were outlined in Section 2.7.3.3.

The riparian vegetation was already extremely degraded along the section of the Paddys River adjacent to the proposed underpass (Location 2), where the impact of construction is likely to be greatest. It is unlikely that the proposed works would further degrade riparian vegetation such that there would be a significant impact on Paddys River aquatic ecology.

4.2.2.2 Removal of Large Woody Debris

The benefits of instream large woody debris to freshwater biota were outlined in Section 2.7.3.3.

There was little large woody debris within the section of Paddys River adjacent to the proposed underpass, with more present immediately downstream towards the end of Site 4. Moreover, the construction of the proposed underpass should not disturb existing large wood debris in the low flow channel of Paddys River, which is contained within the centre 20 m span of the Hume Highway bridges. As such, the proposal is not expected to result in the removal of large woody debris habitat from Paddys River.

4.2.2.3 Instream Structures and Mechanisms that Alter Natural Flow

The potential impacts of instream structures and mechanisms that alter natural flow freshwater biota were outlined in Sections 2.7.2.3. and 2.7.3.3.

The construction of the proposed underpass is anticipated to reduce the channel area for a range of flows. A concern was that this may alter the river hydrology, causing changes to flow depth and velocity.

Increased flooding/water depth upstream of the underpass could result in an increase in lentic (still water) habitat and associated biota (including exotic species that favour this type of aquatic environment) at the expense of existing lotic habitat. An increase in depth could also reduce availability of bank habitat utilised by species such as platypus (should they be present in the area).

A reduction in channel width can also result in an increase in flow velocity for a given discharge volume. Increased water velocity can influence sediment transport processes, changing downstream bed forms (and associated biota). Flows are important in structuring macrophyte communities and high flow velocities can increase the chance of stem rupture and the ability of instream macrophytes to persist. Similarly, an increase in sheer stress associated with higher velocities may select against benthic organisms less tolerant of higher velocity flows. High velocity flows can also create a barrier to upstream habitat for fish which are unable to negotiate the increased speed. This could restrict the ability of fish to access upstream habitat for foraging, reproduction or dispersal, fragmenting populations and lead to the extirpation of some species upstream.

The hydrological modelling undertaken by GHD (2010) indicates that the proposed works would cause minimal changes to flooding depth and flow velocity (Section 5.2). It is therefore highly unlikely that these hydrological changes will have a significant effect on the aquatic ecology of Paddys River.

Flooding depth (1 year ARI flow) is only anticipated to change by 0.01 to 0.03 cm. A change of this magnitude would not cause a significant change in existing lentic and lotic habitat (and associated biotic communities) nor availability of bank habitat. Similarly, depth changes for flows of more frequent recurrence are anticipated to be even smaller and would have no significant effect on ecological processes associated with water depth such as fish passage.

Predicted changes in velocity for the 1 year ARI and 100 year ARI flows (GHD 2010) are negligible and would not be expected to affect existing ecological processes relating to flow velocity such as fish passage or induce macrophyte stem rupture. Similarly, velocity changes for flows of more frequent recurrence are anticipated to be smaller and have no ecological consequence.

The proposal will have no effect on seasonal patterns in flow.

Existing road crossings on Paddys River, such as the one downstream at Inverary Road or the gravel road crossing on the southern side of the Hume Highway bridges, continue to have a far greater effect on the natural flow regime of Paddys River than is predicted to occur as a result of the proposed underpass construction.

4.2.3 Threatened and Protected Species, Communities and Populations

No threatened or protected species, populations or communities were observed in the Location 2 or in the sections of Paddys River upstream and downstream of the project footprint (Location 1 and 3).

4.2.3.1 Macquarie perch, *Macquaria australasica*

The Macquarie perch is listed as Endangered under the *FM Act* and the *EPBC Act*.

No Macquarie perch were observed during the Cardno Ecology Lab survey but the species is known to be present in the adjoining Wollondilly River (NSW DPI 2005a). Whilst DPI have identified several road crossings on the Wollondilly and Paddys rivers that are potential barriers to passage (DPI NSW 2006a), it is possible that Macquarie perch are still able to spend some part of their life cycle within Paddys River. Therefore an Assessment of Significance was prepared as required by the *EPBC Act* and a Seven Part Test due to its listing under the *FM Act*.

Conclusion: Given the lack of significant changes to hydrology and the manageable nature of potential impacts from sedimentation and pollution, it was concluded that the proposed works would be unlikely to affect Macquarie perch. See Appendix 7.1.1 and 7.2.1 for details of the Assessment of Significance and Seven Part Test. Referral of the proposal in relation to this species to the Department of Environment, Water, Heritage and the Arts as prescribed by the *EPBC Act* is therefore not required.

4.2.3.2 Giant Dragonfly, *Petalura gigantea*

The giant dragonfly is listed as Endangered under Schedule 1 of the *TSC Act*.

The giant dragonfly has been recorded in Stingray Swamp and Hanging Rock Swamp, two of the areas within the protected Paddys River wetland complex. Stingray Swamp is located approximately 10 km to the east of the study area and appears to mark the southern extent of the species recorded distribution. The largest population of giant dragonfly is believed to be within sphagnum swamp areas within the Wingecarribee Swamp, near Moss Vale to the north east.

Key habitat features of giant dragonfly include swamps, bogs or wetlands, which are used for breeding, shelter and roosting. The larvae are distinguished from other species of dragonfly by an apparent inability to swim and terrestrial habits (DECC 2008, DECC 2009). The larvae inhabit long chambered burrows built under swamps and emerge from the burrow entrances at night and in wet weather, in search of insects and other arthropods to eat. Larvae are not known to swim and avoid open water (DECC 2008). Vegetation within 500 m of breeding habitat is utilised for foraging by adults.

There did not appear to be appropriate swamp or bog habitat present within the area potentially affected by the proposed works. Riverine pool habitat was present, with emergent macrophytes and silty bottom, but this was contained within the main channel and was bordered by pasture or sloping *Eucalypt* woodland. It is unknown whether giant dragonfly utilise river pool habitat. A Seven Part Test was prepared due to the proximity of recorded dragonfly in Stingray Swamp to the study area.

Conclusion: The Seven Part Test concluded that the proposed works would be unlikely to affect giant dragonfly (See **Appendix 7.2.2** for full details of Seven Part Test).

4.2.3.3 Sydney Hawk Dragonfly, *Austrocordulia leonardi*

The Sydney hawk dragonfly is listed as Endangered under the *FM Act*.

The known distribution of the Sydney hawk dragonfly includes three locations in a small area to the south of Sydney between Audley and Picton. Extensive sampling has failed to discover further specimens in others areas suggesting that it has a highly restricted distribution within the catchment of the Nepean River (DPI NSW 2007). The Sydney hawk dragonfly has not been sampled in the Wollondilly sub-catchment, and given its restricted distribution it is not expected to occur within the region of the Study Area.

In view of the unlikely occurrence of the Sydney hawk dragonfly in the area potentially affected by the proposed works, a Seven Part Test was not considered necessary.

Conclusion: The proposed works would be most unlikely to affect Sydney hawk dragonfly, nor would it be necessary to modify the project with respect to the conservation of this species.

4.2.3.4 Australian Grayling, *Prototroctes maraena*

The Australian grayling is listed as Protected under the *FM Act* and Vulnerable under the *EBPC Act*.

Australian grayling occur in streams and rivers on the eastern and southern flanks of the Great Dividing Range from Sydney southwards to the Otway Ranges in Victoria, and Tasmania (McDowall 1996, NSW DPI 2006c). Grayling prefer watercourses with low turbidity and gravel substrata, and occupy lowland reaches all the way into high elevation reaches at 1000 m AHD (McDowall 1996). However, this species has not been recorded within the study area or the Wollondilly sub-catchment.

The species has an amphidromous life cycle and must therefore migrate to marine/estuarine waters during its life cycle. Newly hatched larvae are phototactic (move towards light) and swim to the surface where they are swept downstream to estuarine/marine waters migrating back to adult freshwater habitats at the age of 6 months. Populations are therefore very susceptible to barriers to passage. Adults suffer heavy post-spawning mortality so it is possible after a few years without juvenile recruitment that local extinction may occur (Morris *et al*. 2001). For example, following the construction of the Tallowa Dam on the Shoalhaven River in 1976 no Australian grayling were subsequently recorded in reaches above or below the dam.

Australian grayling have not been recorded from the Hawkesbury – Nepean River system since the 1950s (Morris *et al*. 2001). Warragamba Dam represents an impassable barrier to juvenile grayling attempting upstream migrating into the Wollondilly sub catchment. The construction of Warragamba Dam was completed in 1960 so it is very unlikely there are any grayling populations persisting in freshwater reaches upstream of Lake Burragorang. As such, an Assessment of Significance under the *EBPC Act* for Australian grayling was not considered necessary.

<u>*Conclusion*</u>: The proposed works would not affect Australian grayling. Referral of the proposal in relation to this species to the Department of Environment, Water, Heritage and the Arts as prescribed by the EPBC Act is therefore not required, nor should the project be modified with respect to the conservation of this species.

4.2.3.5 Silver Perch, *Bidyanus bidyanus*

The silver perch is listed as Vulnerable under the *FM Act*.

Silver perch are native to the Murray-Darling river system. Silver perch have been stocked in the Wollondilly River and may therefore now occur in Paddys River. As the Wollondilly sub-catchment is not part of their natural distribution (DPI NSW 2003), a Seven Part Test was not considered necessary.

<u>*Conclusion*</u>: The proposal will not affect silver perch within their natural distribution range, nor should the project be modified with respect to the conservation of this species.

4.2.3.6 Platypus, *Ornithorhynchus anatinus*

In NSW, native animals, including the platypus, are protected under the National Parks and Wildlife Act. The platypus is not a listed threatened species and can be common in many parts of its range.

No platypuses were observed during the Cardno Ecology Lab field study and the area of the proposed underpass (Location 2) had degraded banks and riparian vegetation which are potentially unsuitable for platypus burrows.

Platypus densities are variable and related to variables such as habitat quality. One study in the upper Shoalhaven River estimated a population of 14 – 18 individuals inhabited a 1.5 km reach that contained two large pools (Grant and Carrick 1978), whilst another study in Victoria reported much lower densities, estimating the population contained 1.3 – 2.1 adults per kilometre (Serena 1994). Platypuses are also known to forage over distances of up to four kilometres during a 24 hour period and appear to be relatively strong swimmers, capable of making headway into at least a flow of 1.2 m/s (Grant and Temple-Smith 1998). Major threats to platypus include degradation of suitable water bodies caused by agriculture, urban development, damming, drainage and pollution.

Provided mitigation measures are employed to ensure that the proposed works have minimal impact on habitat and water quality (i.e. from mobilised sediments and/or toxicants) it is unlikely there would be an impact on local platypus populations (should they be present). Predicted hydrological changes associated with the underpass are negligible and will have no effect on longitudinal connectivity or existing proportions of lentic and lotic habitat. Given the low density and large home range of platypus relative to the footprint of the proposed works, the loss of a small section of degraded (and unsuitable) bank habitat to the underpass should have limited effects on platypus populations, if present.

Conclusion: It is unlikely that the proposal will have a significant impact on local platypus populations should any be present in the Study Area.

4.2.3.7 Temperate Highland Peat Swamps

Paddys River Wetland complex (including Stingray Swamp, Hanging Rock Swamp, Long Swamp and Mundego Swamp) are listed under the *TSC Ac*t as part of the threatened ecological community “Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions”. The Paddys River wetlands are also listed under the *EPBC Act* as part of the endangered ecological community “Temperature Highland Peat Swamps and listed as Nationally Important Wetlands”.

Identified threats to the values of Paddys River Wetlands include increased erosion in the catchment, modified hydrology (drainage and water extraction), increased soil acidity, fire, increased frequency and duration of drought and impacts associated with climate change.

Stingray Swamp, Hanging Rock Swamp and Mundego Swamp are all located upstream of the Study Area. Long Swamp is located 4 km to the north of the Study Area and drains into Long Swamp Creek which enters Paddys River downstream of the Study Area, close to the confluence with Wollondilly River.

As none of these swamps are located immediately downstream of the Study Area, they would be unaffected by potential impacts that could extend downstream, such as increased sediment loads. The proposed works are predicted to have negligible effect on the hydrology of Paddys River and therefore no effect on longitudinal connectivity between downstream habitats and populations and the swamps. As such an Assessment of Significance or Seven Part Test was not considered necessary.

Conclusion: The proposed works is unlikely to have any effect on the threatened swamps included in the Paddys River Wetlands. Referral of the proposal in relation to this community to the Department of Environment, Water, Heritage and the Arts as prescribed by the *EPBC Act* is therefore not required.

4.2.3.8 Klaphake's Sedge, *Carex klaphakei*

Klaphake's sedge is listed as Endangered under the *TSC Act*.

The species is found among other native sedges and rushes in high-altitude montane swamps on sandstone. It can be locally common but over a very small area in highly restricted habitat. It has been recorded from Penrose in association with the threatened Temperate Highland Peat Swamps.

Threats to Klaphake's sedge include runoff from roads and urban areas, grazing and trampling by stock, sandmining and logging of adjacent forests.

It is considered unlikely that the species is present within the Study Area. Klaphake's sedge has not been previously recorded in the Study Area, nor was it observed during this survey. No habitat in the form of montane sandstone swamps was present within the Study Area.

Furthermore, potential habitat and the known population of the species are located within the catchment upstream of the Study Area and would be unaffected by relevant downstream impacts potentially associated with the project (see Section 4.2.3.7). As such a Seven Part Test was not considered necessary.

Conclusion: The proposed works would be most unlikely to affect Klaphake's sedge, nor would it be necessary to modify the project with respect to the conservation of this species.

4.2.3.9 Dense Cord-Rush, *Baloskion longipes*

Dense cord-rush is listed as Vulnerable under the *TSC Act* and the *EPBC Act*.

Dense cord-rush is nominally an aquatic species. Although it occurs in tall open forests and grassy woodland it also inhabits high-altitude sandstone peat swamps. The distribution of the species overlaps with Temperate Highland Peat Swamps and it has previously been recorded in Hanging Rock Swamp in Penrose State Forest.

Known threats to dense cord-rush include road works and weed spraying and the foraging of feral pigs. Changes to hydrology are a suspected threat.

It is considered unlikely that the species is present within the Study Area. Dense cord-rush has not been previously recorded in the Study Area, nor was it observed during this survey. No habitat in the form of montane sandstone swamps was present within the Study Area.

Furthermore, potential habitat and the known population of the species are located within the catchment upstream of the Study Area and would be unaffected by relevant downstream impacts potentially associated with the project (see Section 4.2.3.7). As such an Assessment of Significance or Seven Part Test was not considered necessary.

Conclusion: The proposed works would be most unlikely to affect dense cord-rush, nor would it be necessary to modify the project with respect to the conservation of this species. Referral of the proposal in relation to this community to the Department of Environment, Water, Heritage and the Arts as prescribed by the *EPBC Act* is therefore not required.

5. RECOMMENDATIONS

5.1 POLLUTION

Rocla proposes to adopt a contingency plan which would result in all water accumulating in the sump of the Hume Highway underpass being pumped automatically to one of the dams constructed within the Project Site thereby avoiding any pollution of Paddys River and its riparian zone.

5.2 SEDIMENT MOBILIZATION

The mobilisation of sediment into Paddys River can be minimised through the use of standard sediment and erosion control procedures during construction of the intersections and associated access roads.

Erosion and sediment controls, such as bunding, silt fences, silt curtains, drains and settlement ponds, should be installed prior to any construction or earthworks. Where possible, works and the associated areas of disturbance should be minimised within 50 m of the watercourse. Disturbed areas or spoil should be removed on the day of construction and revegetated following the completion of construction. During the construction of the underpass care, should be taken to avoid damaging the channel banks and instream silt curtains should be used, if necessary. Existing large woody debris and riparian vegetation should be left in place, where possible.

Water quality should be monitored for variables related to construction and earthwork activity such as turbidity, suspended solids and nutrients. Replicate samples should be taken upstream and downstream of the proposed works site, and values compared with the ANZECC guidelines. The stormwater management plan will have contingencies in place to respond to results that exceed ANZECC trigger values.

Care should be taken with selection and construction of the new drainage channel to ensure no erosion or siltation is caused by the discharge.

6. ACKNOWLEDGEMENTS

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8. TABLES

Table 1. BIONET records of fish species occurring in rivers within the Wollondilly River sub-catchment. Note there are no records for Lower Wollondilly Reach 2, Jocks and Murruin Creeks.

Common Name	Scientific Name	Rivers						Creek
		Paddy's	Wollondilly			Tarlo	Wingecarribee	Guineacor
			Lower Wollondilly		Upper Wollondilly			
			Reach 1	Reach 3	Reach 4			
Native Fish								
Shortfinned Eel	*Anguilla australis*							✓
Longfinned Eel	*Anguilla reinhardtii*			✓				
Climbing Galaxias	*Galaxias brevipinnis*							✓
Mountain Galaxias	*Galaxias olidus*	✓					✓	✓
Australian Smelt	*Retropinna semoni*				✓		✓	
Olive Perchlet	*Ambassis agassizi*				✓			
Coxs Gudgeon	*Gobiomorphus coxii*				✓		✓	
Flathead Gudgeon	*Philypnodon grandiceps*			✓			✓	
Unidentified Gudgeon	*Philypnodon* sp.			✓				
Australian Bass	*Macquaria novemaculeata*						✓	
Freshwater Catfish	*Tandanus tandanus*			✓				
Alien Fish								
Oriental Weatherloach	*Misgurnus anguillicaudatus*			✓			✓	
Goldfish	*Carassius auratus*						✓	
Mosquitofish	*Gambusia holbrooki*		✓	✓			✓	
Redfin Perch	*Perca fluviatilis*				✓			
Rainbow Trout	*Oncorhynchus mykiss*	✓		✓	✓	✓	✓	✓
Brown Trout	*Salmo trutta*	✓			✓	✓	✓	✓

Wollondilly River Reach Descriptions
Upper Wollondilly, Reach 4 - Upstream of Mulwaree River confluence
Lower Wollondilly, Reach 1 - Mulwaree River confluence to Paddy's River confluence
Lower Wollondilly, Reach 2 - Paddy's River confluence to Tarlo River confluence
Lower Wollondilly, Reach 3 - Tarlo River confluence to Lake Burragorang

Table 2. Fish species that have been recorded in (a) Paddys River; (b) Upper and (c) Lower Wollondilly River by NSW DPI (Fisheries). Note that records of species in Paddy's River are of fish caught, except for long-finned eels which were observed. Source: Freshwater Fish Database

(a) Paddy's River

Common name	Scientific name	Site			
		Canyonleigh	Corio	Quarry nr Paddy's River	Paddy's River
Native species					
Longfinned Eel	*Anguilla reinhardtii*	✓	✓		✓
Mountain Galaxias	*Galaxias olidus*			✓	✓
Australian Smelt	*Retropinna semoni*	✓	✓		✓
Flathead Gudgeon	*Philypnodon grandiceps*		✓		✓
Gudgeon	*Hypseleotris* sp.		✓		
Total number of native species		2	4	1	4
Introduced species					
Goldfish	*Carassius auratus*	✓	✓		✓
Redfin perch	*Perca fluviatilis*		✓		
Mosquitofish	*Gambusia holbrooki*	✓	✓		
Total number of introduced species		2	3	0	1

Continued

Table 2 continued

(b) Upper Wollondilly River

Common name	Scientific name	Site Copford's Park	Longreach	Marsden Weir	Mummel	Pejar Dam
Native species						
Longfinned Eel	*Anguilla reinhardtii*					
Climbing Galaxias	*Galaxias brevipinnis*					
Australian Smelt	*Retropinna semoni*			✓	✓	
Freshwater Catfish	*Tandanus tandanus*					
Macquarie Perch	*Macquaria australasica*					
Flathead Gudgeon	*Philypnodon grandiceps*	✓	✓	✓	✓	✓
Dwarf Flathead Gudgeon	*Philypnodon sp.*					
Empire Gudgeon	*Hypseleotris compressa*					
Firetailed Gudgeon	*Hypseleotris galii*					
Gudgeon	*Hypseleotris* sp.	✓				
Total number of native species		2	1	2	2	1
Alien species						
Rainbow Trout	*Oncorhynchus mykiss*					
Goldfish	*Carassius auratus*	✓		✓	✓	
Common carp	*Cyprinus carpio*	✓				
Redfin perch	*Perca fluviatilis*	✓	✓			
Oriental Weather Loach	*Misgurnus anguillicaudatus*					
Mosquitofish	*Gambusia holbrooki*	✓			✓	
Total number of introduced species		4	1	1	2	0

Continued

Table 2 continued

(b) Lower Wollondilly River

Common name	Scientific name	Site: Goodmans Ford	Guineacore Ck Junct	Jooriland Crossing	The Junction	Wollondilly Arm
Native species						
Longfinned Eel	*Anguilla reinhardtii*			✓		
Climbing Galaxias	*Galaxias brevipinnis*		✓			
Australian Smelt	*Retropinna semoni*	✓		✓		✓
Freshwater Catfish	*Tandanus tandanus*	✓				
Macquarie Perch	*Macquaria australasica*	✓				
Flathead Gudgeon	*Philypnodon grandiceps*	✓		✓		✓
Dwarf Flathead Gudgeon	*Philypnodon sp.*	✓		✓		
Empire Gudgeon	*Hypseleotris compressa*			✓		
Firetailed Gudgeon	*Hypseleotris galii*	✓				✓
Gudgeon	*Hypseleotris* sp.					✓
Total number of native species		6	1	5	0	4
Alien species						
Rainbow Trout	*Oncorhynchus mykiss*	✓		✓		
Goldfish	*Carassius auratus*	✓			✓	
Common carp	*Cyprinus carpio*	✓				✓
Redfin perch	*Perca fluviatilis*				✓	
Oriental Weather Loach	*Misgurnus anguillicaudatus*	✓		✓		✓
Mosquitofish	*Gambusia holbrooki*	✓		✓		✓
Total number of introduced species		**5**	**0**	**3**	**2**	**3**

Table 3. RCE and fish habitat scores for sites in the study area. See Appendix 2 for derivation of RCE scores and Appendix 3 for derivation of fish habitat classification.

Location	Site	RCE	Fish Habitat Classification
1	1	34	1/2
	2	34	1/2
2	3	28	1/2
	4	28	1/2
3	5	33	1/2
	6	33	1/2

Table 4. Mean water quality at Paddy's River study locations in comparison with ANZECC (2000) guidelines for the protection of aquatic ecosystems for upland rivers in south–east Australia. See Appendix 4 for mean values ± S.E.. DO = Dissolved Oxygen. $ = below guidelines, # = above guidelines, ü = within guidelines.

Location	Site	pH	Conductivity (µS cm^{-1})	Turbidity (ntu)	DO (% Sat.)
		6.5 - 8	30 - 350	2 - 25	90 - 110
	1	✓	↑	✓	↓
1	2	✓	↑	✓	↓
2	3	✓	↑	✓	↓
	4	✓	↑	✓	↓
3	5	✓	↑	✓	↓
	6	✓	↑	✓	↓

Table 5. Percent cover of macrophyte species within the wetted width of the Paddy's River channel.

Family	Scientific Name	Common Name	Location 1		Location 2		Location 3	
			Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Cyperaceae	*Eleocharis sphacelata*	tall spikerush	10	7	15	10	20	7
Cyperaceae	*Scirpus* sp.	clubrush			4	1		
Potamogetonaceae	*Potamogeton ochreatus*	blunt pondweed			1			
Alismataceae	*Alisma plantago -aquatica*	water plantain			0.5			
Haloragaceae	*Myriophyllum* sp.	water milfoil	7		7	5		15
Elatinaceae	*Elatine gratioloides*	waterwort					1	1
Juncaceae	*Juncus usitatus*	spiny rush						1
Juncaginaceae	*Triglochin microtuberosum*	water ribbon	5	5	10	10	15	
Hydrocharitaceae	*Vallisneria gigantea*	ribbonweed			5	5		
Nymphaeaceae	*Nymphoides* sp.	waterlily	1	1	1			0.5
Poaceae	*Phragmites australis*	common reed		20				15
Polygonaceae	*Persicaria* sp.	knotweed	2	0.5	5	2	5	12
Typhaceae	*Typha* sp.	cumbungi			2			

Table 6. Numbers of macroinvertebrate taxa sampled from edge habitat in Paddy's River.

	Location 1		Location 2		Location 3		Total
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	
Number of worm taxa	3	2	3	3	3	3	3
Number of crustacean taxa	4	4	4	4	4	3	5
Number of mollusc taxa	2	2	3	4	1	2	4
Number of insect taxa	15	25	20	21	22	19	35
Number of mayfly taxa	1	3	3	1	2	2	4
Number of damselfly/dragonfly taxa	5	6	3	3	4	3	7
Number of bug taxa	1	3	2	4	3	3	4
Number of beetle taxa	1	4	3	3	1	3	5
Number of true fly taxa	4	4	4	5	5	4	6
Number of caddis-fly taxa	3	3	4	4	5	4	6
Number of other insect taxa	0	1	1	1	2	0	2
Number of other taxa	2	1	3	2	0	2	3
Total Number of taxa	26	34	33	34	30	29	50

Table 7. Summary of AusRivAS results for Paddy's River Spring Edge 2008. Bands based on OE50. See Section 3.4.2 for description of variables.

Location	Site	Band	OE50	NTE50	NTC50	O0Signal	OE0Signal	Signal 2
1	1	B	0.72	12.48	9	4.02	0.83	4.22
1	2	X	1.25	11.99	15	4.22	0.87	4.67
2	3	A	0.92	12.00	11	3.88	0.80	4.27
2	4	A	0.88	12.50	11	3.62	0.75	3.91
3	5	A	0.88	12.53	11	4.43	0.92	4.64
3	6	A	0.83	12.01	10	3.98	0.83	4.10

9. FIGURES

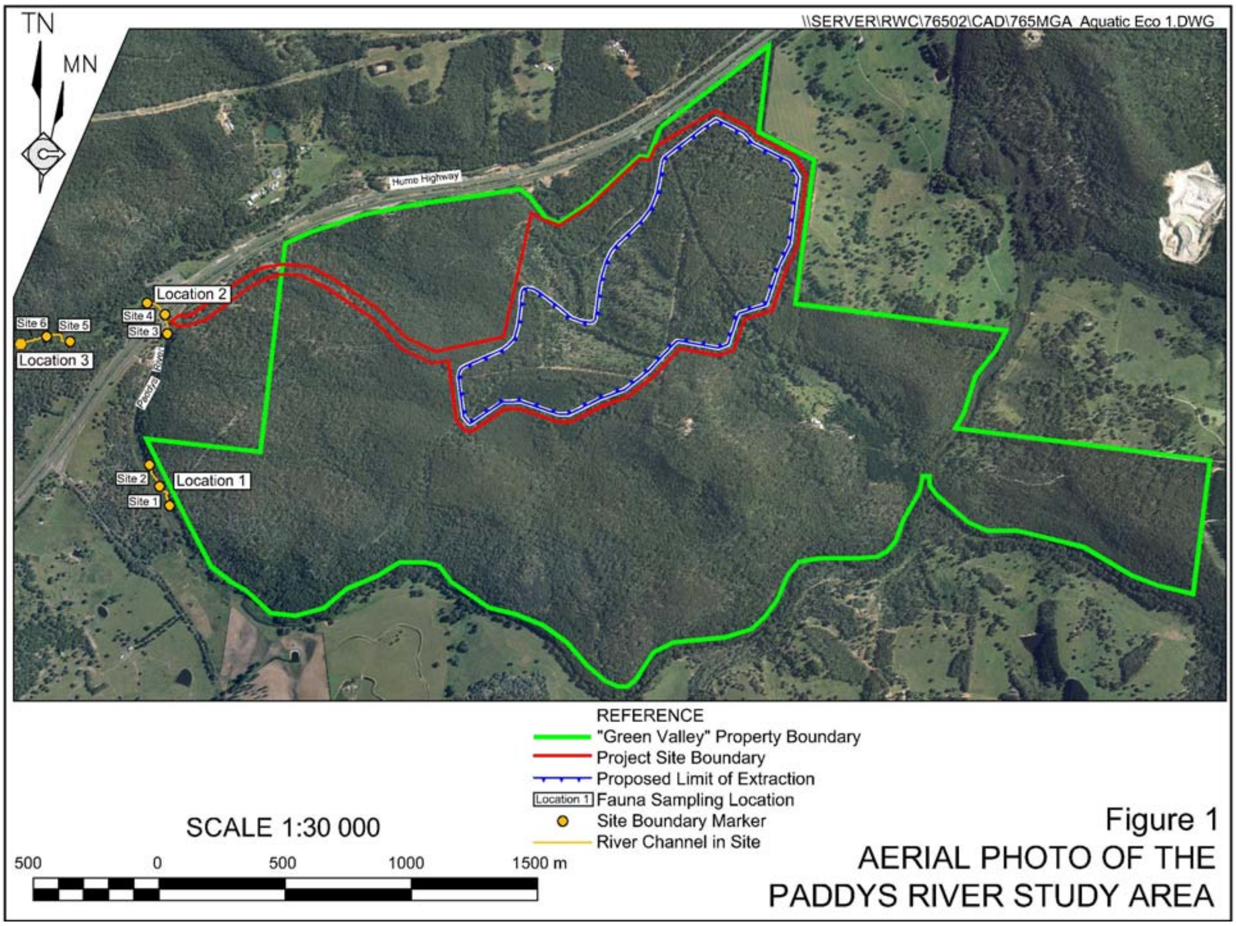


Figure 1. Aerial photo of the Paddys River Study Area.

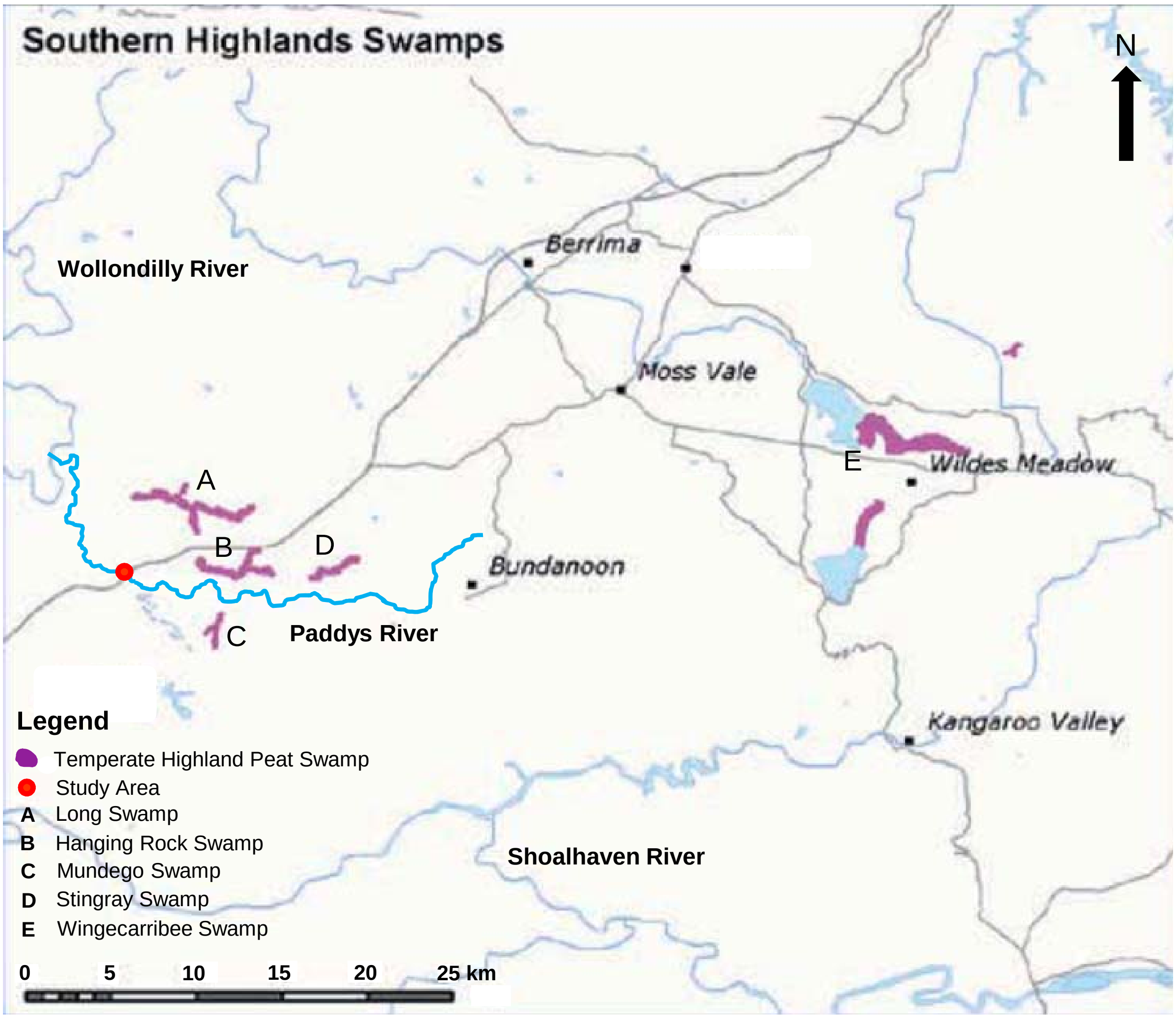


Figure 2. Temperate Highland Peat Swamps on Sandstone in the Southern Tablelands . Image adapted from DEH (2005)

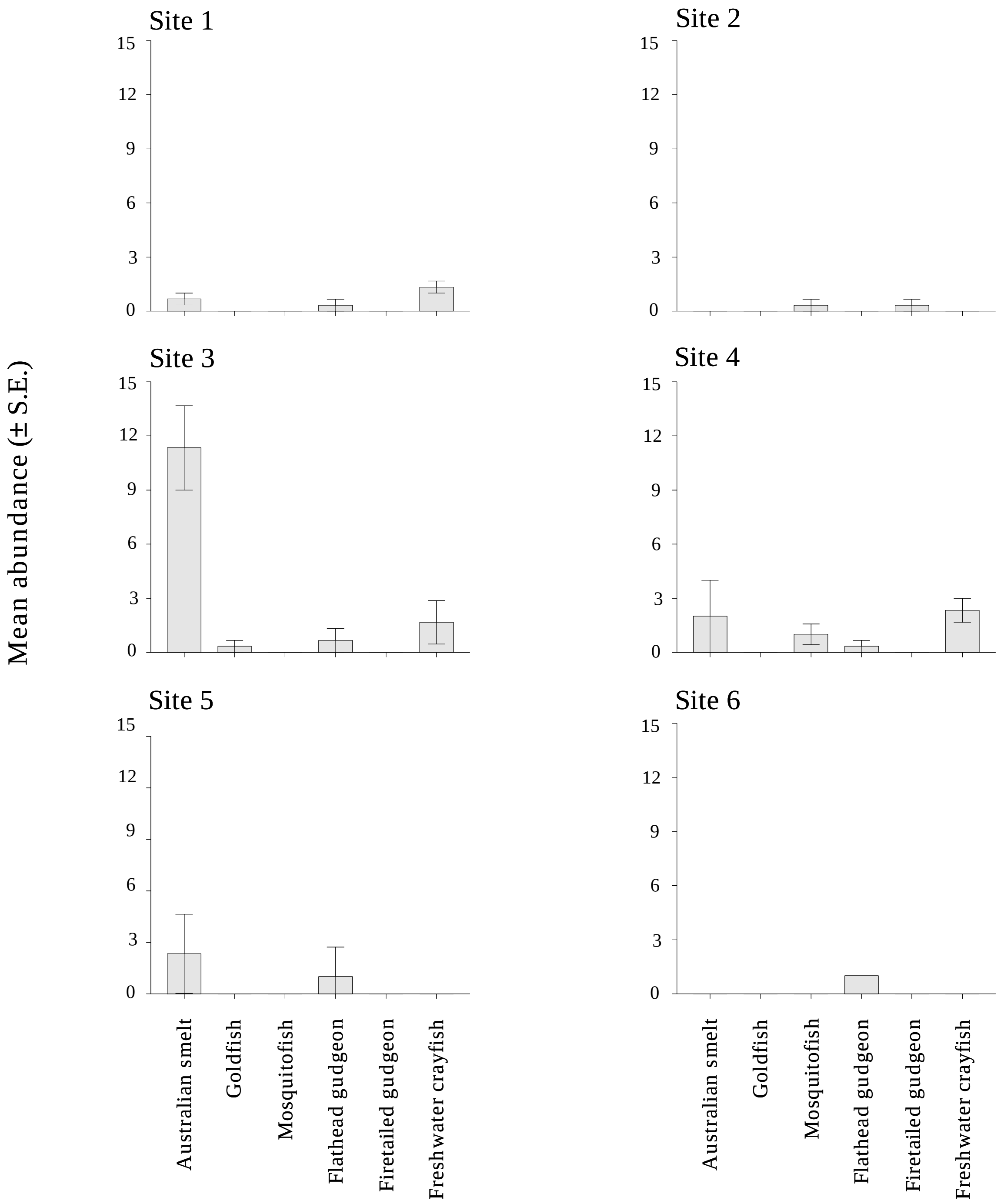
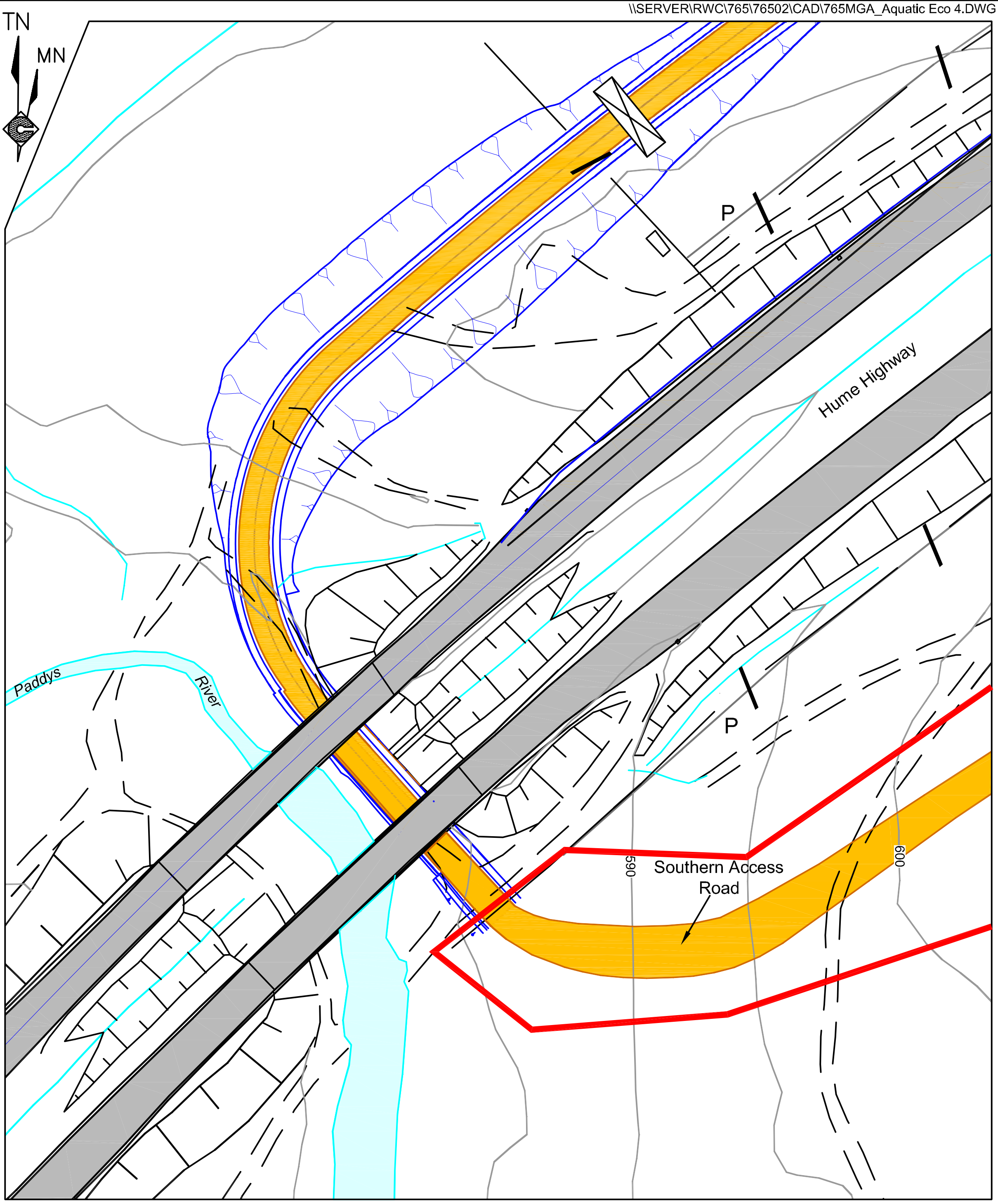


Figure 3. Mean abundance of fish and large macroinvertebrates sampled by electrofisher at each site.

\\SERVER\RWC\765\76502\CAD\765MGA_Aquatic Eco 4.DWG



REFERENCE

- Project Site Boundary
- 670 Existing Contour (m AHD)(Interval = 5m)
- Existing Sealed Road
- Existing Track
- Cadastral Boundary
- Fence
- Proposed Road Works
- River / Drainage Line or Watercourse

SCALE 1:1 500

25 0 25 50 75 m

Source: GHD (2010)

Figure 4
PROPOSED ROAD WORKS
ADJACENT TO PADDYS RIVER

10. PLATES

All plates are in colour on the Project CD.

(a)

(b)

(c)

(d)

Plate 1a – d: (a) Top of Site 1 looking downstream; (b) bottom of Site 1 looking upstream; (c) top of Site 2 looking downstream; (d) bottom of Site 2 dominated by *Phragmites australis*.

(a

(b

(c

(d

Plate 2a – d: (a) Hume Highway bridge at Paddy's River - Looking downstream at eastern bank from Site 3 (n.b. The gravel track forms part of the proposed route of the Southern Access Road under the Hume Highway that would require excavation); (b) Looking upstream at the eastern bank from Site 4; (c) gravel road crossing at Site 3 looking west; (d) gravel road crossing at Site 4 looking west.

(a

(b

(c

(d

Plate 3a – d: (a) Macrophyte bed at top of Site 3 looking downstream to gravel road crossing and Hume Highway; (b) Site 3 channel looking downstream from gravel road crossing; (c) bottom of Site 3 looking upstream; (d) top of Site 4 looking downstream at second Hume Highway bridge crossing.

(a

(b

(c

(d

Plate 4a – d: (a) looking upstream from the gravel road crossing located near the bottom of Site 4; (b) bottom of Site 5 looking upstream at shallow sandbar covered by knotweed (*Persicaria* sp.); (c) top of Site 6 looking downstream; (d) bottom of Site 6 looking upstream - tall spikerush and tips of watermilfoil are visible above the water surface.

(a

(b

(c

(d

Plate 5a – d: (a) tall spikerush (*Eleocharis sphacelata*) and water ribbons (*Triglochin microtuberosum*); (b) water milfoil (*Myriophyllum* sp.); (c) knotweed (*Persicaria* sp.); (d) freshwater crayfish (*Euastacus* sp.).

(a

(b

(c

(d

Plate 6a – d: (a) flathead gudgeon (*Philypnodon grandiceps*); (b) firetailed gudgeon (*Hypseleotris galii;*) (c) Australian smelt (*Retropinna semoni*); (d) mosquitofish (*Gambusia holbrooki*).

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11. APPENDICES

Appendix 1 GPS coordinates of the study sites (Datum UTM WGS84).

Appendix 2 River descriptors, associated categories and values used in the modified riparian, channel and environmental inventory (RCE) From Chessman et al. (1997).

Appendix 3 Fish habitat classification criteria for watercourses and recommended crossings types (Source: Fairfull and Witheridge, 2003).

Appendix 4 Mean (± S.E., n = 2) physical water quality indicators recorded in situ at each site.

Appendix 5 Presence of macroinvertbrate taxa sampled in Paddys River edge habitat.

Appendix 6 Total abundances of fish and large macroinvertbrates caught in bait traps deployed at the six study sites

Appendix 7 Assessment of significance for the potential effects of the “Green Valley” Sands Project roadworks on Macquarie perch (*Macquaria australasica*) and giant dragonfly (*Petalura gigantea*).

APPENDIX 1. GPS COORDINATES OF THE STUDY SITES (DATUM UTM WGS84)

Appendix 1. GPS coordinates of the study sites (Datum UTM WGS84).

Location	Position	Site	Upstream Site Boundary		Downstream Site Boundary	
			Easting	Northing	Easting	Northing
1	Upstream	1	236478	6162178	236444	6162268
		2	236444	6162268	236396	6162357
2	Hume Highway Crossing	3	236468	6162885	236460	6162974
		4	236460	6162974	236382	6163001
3	Downstream	5	236079	6162849	235987	6162863
		6	235987	6162863	235891	6162833

APPENDIX 2 RIVER DESCRIPTORS, ASSOCIATED CATEGORIES AND VALUES USED IN THE MODIFIED RIPARIAN, CHANNEL AND ENVIRONMENTAL INVENTORY (RCE) FROM CHESSMAN ET AL. (1997)

Appendix 2. River descriptors, associated categories and values used in the modified riparian, channel and environmental inventory (RCE) From Chessman *et al*. (1997).

Descriptor and category	Score	Descriptor and category	Score
1. Land use pattern beyond the immediate riparian zone		8. Riffle / pool sequence	
Undisturbed native vegetation	4	Frequent alternation of riffles and pools	4
Mixed native vegetation and pasture/exotics	3	Long pools with infrequent short riffles	3
Mainly pasture, crops or pine plantation	2	Natural channel without riffle / pool sequence	2
Urban	1	Artificial channel; no riffle / pool sequence	1
2. Width of riparian strip of woody vegetation		9. Retention devices in stream	
More than 30 m	4	Many large boulders and/or debris dams	4
Between 5 and 30 m	3	Rocks / logs present; limited damming effect	3
Less than 5 m	2	Rocks / logs present, but unstable, no damming	2
No woody vegetation	1	Stream with few or no rocks / logs	1
3. Completeness of riparian strip of woody vegetation		10. Channel sediment accumulations	
Riparian strip without breaks in vegetation	4	Little or no accumulation of loose sediments	4
Breaks at intervals of more than 50 m	3	Some gravel bars but little sand or silt	3
Breaks at intervals of 10 - 50 m	2	Bars of sand and silt common	2
Breaks at intervals of less than 10 m	1	Braiding by loose sediment	1
4. Vegetation of riparian zone within 10 m of channel		11. Stream bottom	
Native tree and shrub species	4	Mainly clean stones with obvious interstices	4
Mixed native and exotic trees and shrubs	3	Mainly stones with some cover of algae / silt	3
Exotic trees and shrubs	2	Bottom heavily silted but stable	2
Exotic grasses / weeds only	1	Bottom mainly loose and mobile sediment	1

Table 2 Continued

Descriptor and category	**Score**	**Descriptor and category**	**Score**
5. Stream bank structure		12. Stream detritus	
Banks fully stabilised by trees, shrubs etc	4	Mainly unsilted wood, bark, leaves	4
Banks firm but held mainly by grass and herbs	3	Some wood, leaves etc. with much fine detritus	3
Banks loose, partly held by sparse grass etc	2	Mainly fine detritus mixed with sediment	2
Banks unstable, mainly loose sand or soil	1	Little or no organic detritus	1
6. Bank undercutting		13. Aquatic vegetation	
None, or restricted by tree roots	4	Little or no macrophyte or algal growth	4
Only on curves and at constrictions	3	Substantial algal growth; few macrophytes	3
Frequent along all parts of stream	2	Substantial macrophyte growth; little algae	2
Severe, bank collapses common	1	Substantial macrophyte and algal growth	1
7. Channel form			
Deep: width / depth ratio less than 7:1	4		
Medium: width / depth ratio 8:1 to 15:1	3		
Shallow: width / depth ratio greater than 15:1	2		
Artificial: concrete or excavated channel	1		

APPENDIX 3 FISH HABITAT CLASSIFICATION CRITERIA FOR WATERCOURSES AD RECOMMENDED CROSSINGS TYPES (SOURCE: FAIRFULL AND WITHERIDGE, 2003).

Appendix 3. Fish habitat classification criteria for watercourses and recommended crossings types (Source: Fairfull and Witheridge, 2003).

Classification	Characteristics of Waterway Type	Minimum Recommended Crossing Type
Class 1 – Major Fish Habitat	Major permanently or intermittently flowing waterway (e.g. river or major creek), habitat of a threatened fish species.	Bridge, arch structure or tunnel.
Class 2 – Moderate fish habitat	Named permanent or intermittent stream, creek or waterway with clearly defined bed and banks and with semi-permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and / or fish observed inhabiting the area.	Bridge, arch structure, culvert or ford.
Class 3 – Minimal fish habitat	Named or unnamed waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (e.g. fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or recognised aquatic habitats.	Culvert or ford
Class 4 – Unlikely fish habitat	Named or unnamed watercourse with intermittent flow during rain events only, little or no defined drainage channel, little or no free standing water or pools after rain event (e.g. dry gullies or shallow floodplain depression with no permanent wetland aquatic flora present).	Culvert, causeway or ford

APPENDIX 4. Mean (± S.E., n = 2) physical water quality indicators recorded in situ at each site.

Appendix 4. Mean (± S.E., n = 2) physical water quality indicators recorded *in situ* at each site.

Location	Site	pH		Salinity (ppt)		Conductivity (µS cm^{-1})		Conductivity (mS cm^{-1})		Temperature (^{0}C)		Turbidity (ntu)		Dissolved Oxygen (mg L^{-1})		Dissolved Oxygen (% Saturation)		ORP (mV)	
		Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
1	1	7.07	0.02	0.36	0.03	789.00	69.00	0.68	0.07	16.53	0.04	3.52	0.16	6.80	0.10	69.55	1.15	394.00	12.00
	2	7.08	0.02	0.42	0.00	939.00	0.00	0.82	0.02	16.34	0.00	2.80	0.10	6.55	0.05	66.90	0.30	419.50	3.50
2	3	7.18	0.00	0.41	0.01	917.00	15.00	0.80	0.01	16.47	0.02	3.03	0.03	6.45	0.05	66.05	0.15	441.50	1.50
	4	7.09	0.01	0.44	0.02	960.00	18.00	0.82	0.02	16.39	0.02	3.12	0.04	6.70	0.00	68.25	0.15	425.00	5.00
3	5	7.14	0.01	0.47	0.01	1044.00	5.00	0.93	0.02	17.53	0.08	3.53	0.24	8.05	0.05	85.10	0.80	429.00	1.00
	6	7.14	0.00	0.48	0.01	1045.50	3.50	0.93	0.01	17.50	0.00	3.33	0.15	8.05	0.05	85.40	0.60	431.00	1.00

Appendix 5. Presence of macroinvertbrate taxa sampled in Paddy's River edge habitat.

Macroinvertebrate Taxa	Location 1		Location 2		Location 3	
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Spongillidae			✓			
Hydridae	✓		✓	✓		✓
Dugesiidae	✓	✓	✓	✓	✓	✓
Nematoda	✓		✓	✓	✓	✓
Corbiculidae/ Sphaeriidae	✓		✓	✓		
Ancylidae				✓		
Planorbidae	✓	✓	✓	✓		✓
Physidae		✓	✓	✓	✓	✓
Oligochaeta	✓	✓	✓	✓	✓	✓
Cladocera			✓	✓	✓	
Copepoda	✓	✓	✓	✓	✓	✓
Ostracoda	✓	✓	✓	✓	✓	✓
Ceinidae	✓	✓		✓		
Atyidae	✓	✓	✓		✓	✓
Hydracarina	✓	✓	✓	✓		✓
Caenidae		✓	✓			✓
Baetidae			✓			
Oniscigastridae	✓	✓	✓	✓	✓	✓
Leptophlebiidae		✓			✓	
Coenagrionidae	✓	✓	✓	✓	✓	✓
Isostictidae		✓				
Megapodagrionidae	✓	✓				
Synlestidae	✓	✓			✓	
Gomphidae	✓	✓	✓		✓	✓
Aeshnidae				✓		
Hemicorduliidae (=Corduliidae)	✓	✓	✓	✓	✓	✓
Gripopterygiidae		✓			✓	
Veliidae		✓		✓	✓	✓
Corixidae	✓	✓	✓	✓	✓	✓
Naucoridae				✓		
Notonectidae		✓	✓	✓	✓	✓
Sialidae		✓				
Dytiscidae	✓	✓	✓	✓	✓	✓
Gyrinidae			✓			✓
Hydrophilidae		✓		✓		
Scirtidae (= Helodidae, Cyphonidae)		✓				
Elmidae		✓	✓	✓		✓
Chironomidae/Chironominae	✓	✓	✓	✓	✓	✓
Chironomidae/Orthocladiinae	✓	✓	✓	✓	✓	✓
Chironomidae/Tanypodinae	✓	✓	✓	✓	✓	✓
Ceratopogonidae	✓	✓	✓	✓	✓	
Simuliidae					✓	✓
Sciomyzidae				✓		
Hydrobiosidae					✓	✓
Hydroptilidae	✓	✓	✓	✓	✓	✓
Ecnomidae			✓	✓		
Atriplectididae					✓	
Calamoceratidae	✓	✓	✓	✓	✓	✓
Leptoceridae	✓	✓	✓	✓	✓	✓
Pyralidae			✓	✓	✓	

Appendix 6. Total abundances of fish and large macroinvertbrates caught in bait traps deployed at the six study sites (n = 5 bait traps per site).

Appendix 6. Total abundances of fish and large macroinvertbrates caught in bait traps deployed at the six study sites (n = 5 bait traps per site).

Scientific Name	Common Name	Location 1		Location 2		Location 3	
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Retropinna semoni	Australian smelt	0	0	0	0	0	0
Carassius auratus	Goldfish	0	0	0	0	0	0
Gambusia holbrooki	Mosquitofish	0	0	0	0	0	0
Philypnodon grandiceps	Flathead gudgeon	0	2	1	0	0	0
Hypseleotris galii	Firetailed gudgeon	0	2	3	0	0	0
Euastacus sp.	Freshwater crayfish	0	0	0	1	0	0
Number of empty traps		5	2	3	4	5	5

APPENDIX 7. ASSESSMENTS OF SIGNIFICANCE

Assessments of significance were conducted for the potential impact of the proposed construction of northern and southern intersections and access roads for the “Green Valley” Sands Project on two threatened species: the giant dragonfly (*Petalura gigantea*) and the Macquarie perch (*Macquaria australasica*). Assessments were made in accordance with the *Commonwealth Environmental Protection and Biodiversity Conservation (EPBC) Act* guidelines and the Seven Part Tests outlined in Section 5A of the *Environmental Planning and Assessment (EP&A) Act of NSW*.

7.1 Assessment of Significance for Threatened Species Listed Under the *EPBC Act*

7.1.1 Macquarie perch

The Macquarie perch (*Macquaria australasica*) is currently listed as Endangered under the *EPBC Act*. Macquarie perch was not recorded during field survey nor were any records found of it from within the Study Area. This species is, however, known to be present in the adjoining Wollondilly River. Whilst DPI have identified several road crossings on the Wollondilly and Paddys rivers that are potential barriers to passage (DPI NSW 2006a), it is possible that Macquarie perch are still able to spend some part of their life cycle within Paddys River. Therefore an Assessment of Significance was performed as required by the *EPBC Act*.

Is the action likely to lead to a long-term decrease in the size of an important population of a species?

Macquarie perch are known to occur in the Wollondilly sub-catchment, including the Wollondilly, Tarlo and Wingecarribee rivers, but their use of Paddys River is unknown (DPI NSW 2005a). The causes of decline of the Macquarie perch include: barriers to spawning migrations, overfishing, habitat degradation and fragmentation, competition with introduced species, impacts on invertebrate food fauna and infection by the epizootic haematopoietic necrosis virus (EHN) (Morris *et al*. 2001, McDowall 1996).

Predicted hydrological changes from the proposal are minimal and will therefore not have any impact on Macquarie perch. Local population decline is possible as a result of impacts such as habitat degradation, increased competition and reduced fish passage, which may be caused by increased siltation and pollution associated with the construction and operation of the proposal.

Increased siltation may lead to habitat degradation such as smothering of spawning habitat (although little was observed over the three study locations), benthic habitat for macroinvertebrate prey and infilling deep holes used by adults. Degraded habitats may facilitate colonisation or expansion of invasive species such as carp and redfin perch which have been implicated in the decline of Macquarie perch populations. Increased siltation could lead to reduced longitudinal connectivity, fragmenting populations and restricting access to habitats.

Cumulatively, this may result in a decline in distribution and/or density of a local Macquarie perch population in Paddys River but may not be critical to long term persistence of the Wollondilly sub-catchment population.

These potential impacts can be minimised or eliminated by implementing the standard sediment control safeguards, and as such it is considered unlikely that the proposal will lead to a long-term decrease in the size of the regional *M .australasica* population.

Will the action fragment an existing important population into two or more populations?

Populations of the western drainage form of the Macquarie perch have become fragmented across much of their previous range due to the creation of barriers such as dams and weirs (Morris *et al*. 2001). In instances where regulated flows have inhibited spawning cues or barriers have prevented access to spawning habitat, these isolated populations have declined (Morris *et al*. 2001).

The predicted changes to hydrology from the construction of the underpass are negligible and would not create a barrier to passage for Macquarie perch and therefore should not fragment any existing population of Macquarie perch.

Siltation from mobilised sediments could exacerbate the existing barrier to passage created by the downstream road crossing at Inverary Road, which acts as a trap for sediment debris. Loss of spawning habitat from sedimentation is unlikely to fragment a population unless a considerable length of a watercourse has been affected such that migrating groups of fish became reproductively isolated.

If standard safeguards to minimize sediment loads are implemented then it is unlikely that the existing longitudinal connectivity within Paddys River will be affected.

Will the action adversely affect habitat critical to the survival of a species?

Macquarie perch are generally found in freshwater reaches with low sediment loads that contain sequences of pools and riffle habitat with occasional deep holes with snags. Increased sediment loads can result in the infilling of deep holes and the smothering of riffle habitat which is important for Macquarie perch spawning and their macroinvertebrate prey.

These potential impacts can be minimized if standard sediment control measures are implemented.

Will the action disrupt the breeding cycle of an important population?

During spring when water temperatures reach 16^{O}C, Macquarie perch migrate upstream to spawn (Morris *et al*. 2001). They form spawning aggregations in pools at the head of riffles and their eggs are carried downstream and lodge among pebbles and gravel in riffles where they will develop (McDowall 1996).

Barriers that impede this breeding migration can lead to a reduction in recruitment and eventual decline in population size. The predicted changes to hydrology from the construction of the underpass are negligible and would not restrict upstream spawning migrations of Macquarie perch. Increased sediment loads from earthworks during construction, however, could accumulate at the Inverary Road crossing (located 800 m downstream of the Study Area) potentially decreasing the passage upstream for migrating perch. This road crossing has been identified by DPI as a potential barrier to passage and a trap for sediment and woody debris (DPI NSW 2006a).

Increased sedimentation can also smother riffle habitat where the perch's adhesive eggs would normally become lodged, again reducing recruitment. However, there was minimal potential perch spawning habitat observed over all three study locations. Research has demonstrated that suspended sediments can negatively impact egg and fry development and disrupt the ability of some freshwater fish to migrate to spawning sites (DFO Canada 2003).

Potential impacts from high sediment loads can be minimised or eliminated by implementing standard sediment control measures, and as such it is considered unlikely that the proposal will disrupt the life cycle of *M. australasica*.

Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?

Trout, carp and redfin perch have been implicated in the decline of Macquarie perch through competition or predation (Morris *et al*. 2001). The epizootic haematopoietic necrosis virus (EHN) disease carried by redfin perch is also considered highly infectious to Macquarie perch. These species are already present within nearby reaches of the lower Wollondilly River (Graham *et al*. 2005, DPI NSW 2009). Redfin perch have been caught and Brown trout and rainbow trout have been observed within Paddys River.

The potential changes in habitat or hydrology associated with the proposed works would not enhance populations of brown trout or rainbow trout. Redfin perch and carp prefer still or gently flowing waters and can tolerate low levels of dissolved oxygen and high turbidity (McDowall 1996). Degradation of habitat from increased siltation may favour carp and/or redfin perch and could facilitate the colonization of these species into the study area or increase their numbers if already present.

The implementation of standard sediment controls would ensure that conditions favourable to harmful invasive species were not created.

Will the action introduce disease that may cause the species to decline?

The Macquarie perch is particularly susceptible to EHN which carried by the redfin perch (Morris *et al*. 2001, McDowall 1996). Redfin perch prefer still or gently flowing waters and can tolerate low levels of dissolved oxygen (McDowall 1996).

Hydrological modelling indicates that the proposal is unlikely to significantly increase the amount of lentic habitat in the Study Area. However, redfin perch are likely to be more resilient to habitat degradation from increased siltation and this may facilitate the colonization of these species into the study area or increase their numbers if already present.

The implementation of standard sediment controls would ensure that conditions favourable to EHN carrying redfin perch were not created.]

Will the action interfere substantially with the recovery of the species?

Recovery objectives for Macquarie perch include the prevention of siltation, the preservation of natural flows and removal of existing barriers to fish passage (Morris *et al*. 2001). The proposed works is not predicted to have any significant impact on natural flows of Paddys River, but sediments mobilised from the construction site may increase siltation and exacerbate barriers to fish passage posed by local road crossings.

The implementation of standard sediment control measures should ensure that the proposal does not substantially interfere with the recovery of the Macquarie perch.

Conclusion: Potential impacts of the proposal on Macquarie perch populations can be effectively minimised or eliminated by the adoption of standard sediment control measures. Referral of this proposed upgrade in relation to this species to the Department of Environment, Water, Heritage and the Arts (DEWHA) as prescribed by the *EPBC Act* is therefore not required.

7.2 Seven Part Tests for Threatened Species Listed Under the *FM Act* and/or *TSC Act*

7.2.1 Macquarie Perch

The *EPBC Act* species assessment for *M. australasica* (Appendix 7.1 above) concluded that the proposal is unlikely to have a significant impact on existing populations of Macquarie perch or habitat if standard sediment control measures are adopted and maintained.

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

During spring when water temperatures reach 16^{O}C Macquarie perch migrate upstream to spawn (Morris *et al*. 2001). They form spawning aggregations in pools at the head of riffles and their eggs are carried downstream and lodge among pebbles and gravel in riffles where they will develop (McDowall 1996).

Barriers that impede this breeding migration can lead to a reduction in recruitment and eventual decline in population size. The predicted changes to hydrology from the construction of the underpass are negligible and would not restrict upstream spawning migrations of Macquarie perch. However, increased sediment loads from earthworks during construction could accumulate at the downstream Inverary Road crossing potentially decreasing the passage upstream for migrating perch. This road crossing has been identified by DPI as a potential barrier to passage and a trap for sediment and woody debris (DPI NSW 2006a).

Increased sedimentation can also smother riffle habitat where the perch's adhesive eggs would normally become lodged, again reducing recruitment. However, there was minimal potential perch spawning habitat observed over all three study locations. Research has demonstrated that suspended sediments can negatively impact egg and fry development and disrupt the ability of some freshwater fish to migrate to spawning sites (DFO Canada 2003).

Potential impacts from high sediment loads can be minimised or eliminated by implementing standard sediment control measures, and as such it is considered unlikely that the proposal will disrupt the life cycle of *M. australasica*.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

No populations of Macquarie perch have been listed as endangered under the *FM Act*.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed

> ***(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or***
>
> ***(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction?***

Not applicable.

d) In relation to the habitat of a threatened species, population or ecological community:

> ***(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and***
>
> ***(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and***
>
> ***(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality?***

Macquarie perch are generally found in freshwater reaches with low sediment loads that contain deep holes with snags and adjacent riffle habitat.

*(*i) As Macquarie perch are generally found in clear waters a temporary reduction in occupancy, if any occur in the Study Area, is possible in downstream areas during construction if there is a large increase in the volume of suspended sediments associated with construction. Furthermore, increased sedimentation can potentially degrade habitat utilized for refuge, foraging and spawning. Refugia such as deep holes can infill and riffle habitat, where fertilized eggs lodge and develop, can become smothered.

Invasive species such as carp and redfin perch are more resilient to degraded habitat than the Macquarie perch, therefore increased siltation may facilitate the colonisation of these species into the Study Area or increase their numbers if already present. Carp and redfin perch have been implicated in the decline of Macquarie perch populations through competition or predation, and the Macquarie perch is particularly susceptible to EHN disease which is carried by the redfin perch (Morris *et al*. 2001, McDowall 1996).

(ii) Populations of the western drainage form of the Macquarie perch have become fragmented across much of their previous range due to the creation of barriers such as dams and weirs (Morris *et al*. 2001). In instances where regulated flows have inhibited spawning cues or barriers have prevented access to spawning habitat, these isolated populations have declined (Morris *et al*. 2001).

The predicted changes to hydrology from the construction of the underpass are negligible and would not create a barrier to passage for Macquarie perch and should not therefore affect longitudinal connectivity. Siltation from mobilised sediments could exacerbate the existing barrier to passage at the downstream road crossing at Inverary Road, which acts as a trap for sediment debris.

(iii) It is not known how far or whether any populations of Macquarie perch extend into Paddys River. The degradation or loss of access to spawning habitat in this reach may contribute to a decline in a local Paddys River population, although it may not affect the persistence of the known population in the Wollondilly River.

If standard sediment control measures are implemented then it is unlikely the proposal would significantly modify, remove or fragment Macquarie perch habitat.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

See *(d)* above

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

Recovery objectives for the Macquarie perch include the prevention of siltation, the preservation of natural flows and removal of existing barriers to fish passage (Morris *et al*. 2001). The proposal is not predicted to have any significant impact on natural flows of Paddys River, but mobilised sediments from the construction site may increase siltation and exacerbate barriers to fish passage posed by local road crossings.

The implementation of standard sediment control measures should ensure that the proposal does not substantially interfere with the recovery objectives for the Macquarie perch.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The threatening processes listed under the *FM Act* relevant to the proposal that require consideration include:

- The removal of large woody debris from NSW rivers and streams;
- The degradation of native vegetation along New South Wales water courses;
- The installation of instream structures (i.e. bridges and culverts) and other mechanisms that alter natural flow regimes of rivers and streams.

The loss of instream woody debris associated with the proposal is expected to be negligible as there was little woody debris within the study area and the construction of the underpass should not impinge on the low flow channel of Paddys River (where the snags are located) which is contained within the centre 20 m span of the Hume Highway bridges.

The riparian vegetation was extremely degraded along the section of the Paddys River adjacent to the proposed underpass (Location 2). It is unlikely that the proposed works would further degrade riparian vegetation such that there would be a significant impact on Paddys River aquatic ecology.

The hydrological modelling by GHD (2010) indicated that the proposed works will cause minimal changes to the natural flow regime of Paddys River and as such will not have a significant effect on the aquatic ecology of Paddys River.

The proposal is not likely to constitute any relevant key threatening processes listed under the *FM Act*.

Conclusion: Potential impacts of the proposal on Macquarie perch can be effectively minimised or eliminated by the adoption of standard sediment control measures.

7.2.2 Giant Dragonfly

Giant dragonfly is listed as Endangered under Schedule 1 of the TSC Act.

Key habitat features of giant dragonfly include swamps, bogs or wetlands which are used for breeding, shelter and roosting. The giant dragonfly has been recorded in Stingray Swamp and Hanging Rock Swamp, two of the protected areas within the Paddys River wetland complex. Stingray Swamp is located approximately 10 km to the east of the study area and appears to mark the southern extent of the species recorded distribution. The largest population is believed to be within sphagnum swamp areas within the Wingecarribee Swamp, near Moss Vale to the north east of the study area. Whilst there did not appear to be suitable habitat for the giant dragonfly within in the area potentially affected by the proposal, a Seven Part Test was done due the proximity of known populations to the study area.

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Adult giant dragonflies are poor fliers and do not readily disperse, usually foraging among vegetation on or adjacent to the swamp (DECC 2099). Females lay eggs into moss or other soft vegetation bordering swamps. The larvae then dig long chambered burrows under the swamp and emerge from the terrestrial entrances at night and in wet weather, in search of insects and other arthropod prey. The larvae are distinguished from other species of dragonfly by an apparent inability to swim and terrestrial habits (DECC 2008). The larval stage is unusually long and can last 10 to 30 years. Adults emerge during spring and fly until late January. (DECC 2008).

The life cycle of the giant dragonfly although very long, is spatially restricted. Undisturbed habitat is necessary for the species to successfully complete its life cycle. Degradation of habitat is therefore the major threat to this species. See Section 7.2.2*(d)* below for detail of the potential impact of the proposal on habitat.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

There are no listed endangered populations of giant dragonfly.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed

> ***(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or***
>
> ***(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction?***

Not applicable.

d) In relation to the habitat of a threatened species, population or ecological community:

> ***(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and***
>
> ***(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and***
>
> ***(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality?***

(i) Key habitat features of giant dragonfly include permanent swamps, bogs or wetlands, with some free water and open vegetation (DECC 2009). Degradation of habitat is the major threat to this species. Identified threats to regional swamp habitat (Paddys River Wetlands) include increased erosion in the catchment, modified hydrology (drainage and water extraction), increased soil acidity, fire, increased frequency and duration of drought, sedimentation, poor water quality and impacts associated with climate change.

The swamp habitat preferred by the giant dragonfly was not observed within the study locations, which contained only alternating river habitat of pools and runs. The pools had silty bottoms with extensive emergent macrophyte stands but were contained within the channel, and bordered by pasture or sloping *Eucalypt* woodland. It is unknown whether giant dragonfly utilise this river pool habitat.

The predicted changes to hydrology caused by the underpass are not expected to have a significant impact on pool habitat within the study area. Potential siltation from the construction site and pollutants from the underpass may degrade pool habitat and water quality, but both can be control with standard mitigation measures.

Known dragonfly habitat, such as Stingray Swamp, Hanging Rock Swamp and possibly the other Paddys River Wetlands, are all located upstream of the study area or on tributaries of Paddys River. As such, preferred habitat of the giant dragonfly would be unaffected by impacts that might extend downstream of the study area.

(ii) Giant dragonfly swamp habitat is relatively fragmented within the region, however the life history of the giant dragonfly is relatively spatially restricted and populations can apparently persist within the swamps. The proposal will not cause fragmentation of existing swamp habitat.

(iii) Not applicable as no known giant dragonfly habitat will be affected or fragmented by the proposal.

The proposal is unlikely to remove, modify or fragment existing giant dragonfly habitat. If standard safeguards are put in place to ensure the proposed works do not mobilise sediment or toxicants into Paddys River then there will be no impact on river pool habitat.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

See Section 7.2.2*(d)* above. The proposal is unlikely to have an effect on critical habitat of the giant dragonfly.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

A recovery plan for the giant dragonfly has not been completed. Key threats to giant dragonfly are habitat loss or degradation. The proposal is unlikely to impact on known giant dragonfly habitat.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

A key threatening process listed on Schedule 3 of the TSC Act relevant to the proposal is "Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands". Predicted changes to flow from the construction of the underpass are negligible and are not considered to be of ecological significance. Mobilised sediments from the construction area have the potential to reduce longitudinal connectivity at downstream barriers, such as the Inverary Road crossing, however these potential changes can be minimised by the implementation of standard sediment control measures.

<u>Conclusion:</u> The proposal is unlikely to impact upon giant dragonfly populations or habitat. Should unknown populations or habitat exist in the study area or downstream then potential impacts can be effectively minimised or eliminated by the adoption of standard sediment and pollution control measures.