

Technical Paper **2**  
AQUATIC ECOLOGY



*Report to:*  
**Parsons Brinckerhoff Australia Pty Ltd**

# **Aquatic Ecology Assessment for the Keepit Dam Upgrade**

**REVISED FINAL**

November 2007

**The Ecology Lab** Pty Ltd

Marine and Freshwater Studies



# Aquatic Ecology Assessment for the Keepit Dam Upgrade

November 2007

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Report Number – 36/0203

Report Status – Final, 9/11/2007

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## EXECUTIVE SUMMARY

Three options for the upgrade of Keepit Dam are currently being considered by State Water in consultation with relevant authorities and stakeholders. State Water consultant's, Parsons Brinckerhoff, have commissioned The Ecology Lab to assess the potential impacts resulting from construction works of the three dam safety upgrade options on the aquatic habitats and biota potentially impacted by these works.

The overall aim of the study is to provide baseline information on aquatic habitats, and populations of fish and macroinvertebrates that would allow assessment of each of the options with respect to impacts on aquatic ecology. A broad-scale approach to the identification of aquatic habitats, biota and water quality was required due to the paucity of data on these topics at the present time. Surveys of fish, macroinvertebrates and water quality were selected as valid indicators of overall ecosystem health and a basis on which to assess the impacts of the three options. Assessments of significance of listed threatened species, populations and communities; river snail (*Notopala sublineata*), olive perchlet (*Ambassis agassizii*), purple spotted gudgeon (*Mogurnda adspersa*), silver perch (*Bidyanus bidyanus*), Murray cod (*Maccullochella peelii peelii*), Namoi River turtle (*Elseya bellii*), and the lowland Darling River aquatic ecological community, have been undertaken in accordance with State and Federal threatened species legislation.

Aquatic habitats in the Peel and Namoi Rivers below the dam were generally degraded by land clearing and grazing impacts which have resulted in reduced riparian vegetation, increased erosion and introduction of exotic vegetation. There are however numerous important habitat features including; riffle/pool sequences, deep pool refuges, sections of continuous native riparian vegetation, beds of aquatic macrophytes, large snags and a variety of stream substrata. Water levels in this reach of the Namoi River are predominantly regulated by releases from Keepit Dam. Within the Peel River, water levels are regulated by releases from Chaffey Dam, agricultural off-take and rainfall.

Lake Keepit is a large artificial water body created by the flooding of the Namoi River following the construction of Keepit Dam. The water level in the lake at the time of sampling was 17% of full supply level due to the persistent drought, and the present aquatic habitat was not necessarily representative of that found when the lake is closer to full supply. The lake contained extensive aquatic habitat, particularly along the old channel of the Namoi River and the inflowing tributaries, where large standing dead trees from the original riparian zone provide large woody debris (snags) which support a variety of aquatic fauna. Other habitat types included rocky outcrops, deep holes and extensive shallow areas with fine silt substrata in the upper reaches of the flooded Namoi River channel.

The Namoi River upstream of the current water level to the town of Manilla consisted of a variety of habitats including long deep pools and rapid flow over cobble bed riffles. Riparian vegetation was highly variable with some reaches having extensive native trees (mainly eucalypts) along the banks, while others were dominated by introduced species such as willow or have been extensively cleared. Instream and emergent aquatic macrophytes were present throughout this section of the river. Stock access to the river was extensive and contributed to bank erosion along with instability due to clearing of riparian vegetation. Flow within this section of the Namoi River was regulated by water releases from Split Rock Dam upstream on the Manilla River.

Water quality variables recorded in the Peel and Namoi Rivers downstream of the Keepit dam upgrade works were generally outside of ANZECC (2000) guidelines for salinity, pH and Dissolved Oxygen indicating generally poor water quality in the catchment. Within

Lake Keepit salinity and pH were consistently outside of ANZECC guidelines. Dissolved oxygen and turbidity levels were generally within the guidelines.

Macroinvertebrate sampling using the AUSRIVAS protocol assessed the ecological condition of most sites as poorer than expected in comparison with the AUSRIVAS model reference sites. Analysis of the macroinvertebrate community composition indicated that water quality was moderately to severely impaired and the macroinvertebrate communities were mainly composed of tolerant animals. No specimens belonging to the threatened invertebrate species River Snail (*Notopala sublineata*) were recorded.

A combination of fish sampling methods including dip netting, bait trapping and electrofishing were used to sample fish in the Namoi and Peel Rivers downstream of Keepit Dam. Six species were recorded within this part of the study area which comprised three exotic and three native species. No listed threatened species were sampled in this part of the study area. The freshwater catfish (*Tandanus tandanus*) is considered as a species of conservation concern because of its apparent reduction in abundance and distribution within its natural range and was found within this reach of the Namoi River.

Within Lake Keepit fish sampling was undertaken using gillnets. The six species recorded within the lake comprised two exotic species and four native species. Native species collected included the federally listed endangered; Murray Cod (*Maccullochella peelii*), the NSW listed vulnerable; Silver Perch (*Bidyanus bidyanus*), and species of concern; freshwater catfish. The two listed species (Murray Cod and Silver Perch) as well as Golden Perch (*Macquaria ambigua*) are regularly stocked within the lake by the local recreational fishing club in conjunction with DPI (NSW Fisheries). The introduced species; Common Carp (*Cyprinus carpio*) and Goldfish (*Carassius auratus*), were found both upstream and downstream of Keepit Dam, indicating that their current distribution is throughout the study area despite the presence of the barrier to fish passage created by the dam.

All three options involve raising the existing main and subsidiary dam walls, modification of the peninsula near the dam wall, and construction of new saddle dams and spillways. The main potential impacts on the aquatic habitat and biota that could result from construction activities are associated with mobilisation of sediment from earthworks into the main water body of Lake Keepit or into the Peel and Namoi Rivers downstream of the dam. Impacts on the aquatic ecology that may result from increased sediment runoff into aquatic habitats include:

- Reduction of water quality including increased turbidity and increased nutrient levels,
- Increased turbidity within the lake could result in the reduction of light penetration and subsequent reduction of aquatic macrophytes, altering existing aquatic habitat,
- Increased nutrient levels may encourage algal growth with potential toxic algal blooms – resulting in negative impacts on aquatic fauna,
- Increased sedimentation within water courses which can result in the reduction of available deep water refuge areas for aquatic biota and smothering of important habitat features such as beds of aquatic macrophytes and rocky substratum.

The above impacts can be effectively minimised or eliminated by the incorporation of mitigation measures during the construction phase of the project. These measures should be incorporated into a site specific environmental management plan when upgrade designs have been finalised. Such mitigation measures should include:

- Where possible, sediment should be prevented from entering the main body of Lake Keepit and the Namoi and Peel Rivers. This can be achieved by the use of sediment fences or bunding between earthworks and waterbodies.
- Where sediment fences are not appropriate because construction activities occur on the waterline, sediment dispersal within the lake should be contained within a limited area in the vicinity of works by the use of a floating silt curtain. The silt curtain should be deployed to enclose all works along the waterline, and should enclose as small an area of the water body as possible.
- Revegetation of disturbed areas such as access roads and stockpile sites following completion of construction to prevent ongoing erosion and resultant runoff into the Peel and Namoi Rivers and Lake Keepit.
- Removal of large woody debris, and riparian vegetation to be avoided, minimised or mitigated.

The three different long term options are considered as having equivalent potential impacts on the aquatic ecology of the Namoi-Peel River system downstream of Keepit Dam and in the main water body of Lake Keepit itself. It is important however to recognise that option B1 has a greater potential impact on the lower Peel River (if considered independently of the lower Namoi River) because of the construction of the subsidiary dam wall spillway. Options D2 and D3 have a greater potential impact on the Namoi River below the dam because of the construction of the boat ramp and sailing club spillways.

Provided that recommended mitigation measures are incorporated into the construction stage of the Keepit Dam upgrade, potential impacts on the aquatic ecology will be minimised or eliminated altogether and are unlikely to have any significant impact on threatened species, populations and communities that may be present within the study area.

Impacts on the aquatic ecology of the Namoi and Peel Rivers and within Lake Keepit associated with the operation of the upgraded dam are currently being investigated by State Water and do not fall within the scope of this report.

## **1.0 INTRODUCTION**

### **1.1 Background and Aims**

Three options for the upgrade of Keepit Dam are currently being considered by State Water in consultation with relevant authorities and stakeholders. State Water consultant's, Parsons Brinckerhoff, have commissioned The Ecology Lab to assess the potential impacts resulting from construction of three dam safety upgrade options on the aquatic habitats and biota potentially impacted by the options.

All three options involve raising the existing main and subsidiary dam walls, modification of the peninsula near the dam wall, and construction of new saddle dams and spillways. The main potential impacts on the aquatic habitat and biota that could result from construction activities are associated with mobilisation of sediment from earthworks into the main water body of Lake Keepit or into the Peel and Namoi Rivers downstream of the dam.

The overall aim of the study is to provide baseline information on aquatic habitats, and populations of fish and macroinvertebrates that would allow assessment of each of the options with respect to impacts on aquatic ecology. A broad-scale approach to the identification of aquatic habitats, biota and water quality was required due to the paucity of data on these topics at the present time. Surveys of fish, macroinvertebrates and water quality were selected as valid indicators of overall ecosystem health and a basis on which to assess the impacts of the three options.

Specifically, the aims of the study are to:

1. Assess the current distribution and abundance of native and introduced fish including stocked species within Keepit Dam (Lake Keepit),
2. Assess the current distribution and abundance of native and introduced fish downstream of Keepit Dam in the Namoi and Peel Rivers,
3. Assess the nature and extent of fish habitat within Lake Keepit and the potentially influenced reaches of the Namoi and Peel Rivers, including assessments of current blockages to fish passage
4. Assess ecological stream health using the AUSRIVAS protocol for aquatic macroinvertebrate sampling within potentially influenced reaches of the Namoi and Peel Rivers
5. Assess water quality using physio-chemical parameters such as dissolved oxygen, turbidity, pH and conductivity
6. Determine if threatened species of worms, crustaceans, fish or aquatic insects are present and, if so, likely to be impacted by each of the proposed upgrade options.

### **1.2 Study Area**

The study area includes water courses upstream and downstream of Keepit Dam potentially impacted by the proposed upgrade construction works.

The study area is considered in terms of two distinct regions:

1. Water courses downstream of Keepit Dam, including the Namoi River below the main dam wall and the Peel River downstream of the Keepit Dam sub-wall. This region also includes the Namoi River below the Peel River confluence downstream to Gunnembene crossing.
2. The main water body of Keepit Dam (Lake Keepit) and its tributaries (primarily the Namoi River upstream to Manilla).

### 1.3 Existing Information

#### 1.3.1 Aquatic Environment

The overall health of the Namoi River Valley, which incorporates all of the study area was considered in a study by Thoms *et al.* (1999). This study found:

- Riparian zone were degraded
- Gravel extraction and fluctuating water levels have had adverse impacts on channel morphology including; bank instability and sedimentation
- Dams and river regulation have impacted the physical and biological environments
- Poor land management practices were evident
- Water quality was poor due to high levels of nutrients, turbidity and salinity
- Native fisheries were poor, with low species diversity and abundance.

#### 1.3.2 Aquatic Fauna - Fish

In an extensive study of fish fauna in New South Wales Harris and Gehrke (1997) identified significant differences in fish communities between regulated and unregulated rivers. The proportion of native species was much higher in unregulated rivers in all regions surveyed, including the Darling River catchment containing the Namoi River. The study suggested that flow regulation has reduced the resilience of the state's rivers and native fish to invasion by introduced fish species. Harris and Gehrke (1997) cited reduced abundance of fish larvae, suppressed growth rates, altered community structure and reduced species diversity as effects on the native fish fauna caused by flow regulation. Their study also showed that the only species of fish that showed a positive response to flow regulation were the alien species redbfin perch, goldfish and carp and one native species, Australian smelt.

Hypolimnetic (cold water) releases from the bottom of thermally stratified reservoirs can have significant impacts on the aquatic biota in downstream environments for distances of hundreds of kilometres (Harris, 2001). These include; temperature decreases of 8-12 degrees Celsius below summer peaks, reduction in annual temperature ranges, and delay in summer peak temperatures. This can have effects on aquatic biota such as; reduced fish growth rates, mortality of juvenile fish, unfavourable spawning conditions, reduction of macroinvertebrate species and abundance and can create favourable conditions for alien species such as carp, goldfish, trout and redbfin perch.

A study of Keepit Dam on the Namoi River (Preece and Jones, 2002) showed disruption of thermal spawning cues for selected native fish species as a result of cold water releases. Preece (2004) undertook a study of cold water pollution below dams in NSW and found

Keepit Dam to be one of nine dams identified as causing severe thermal disturbance in the Namoi River downstream.

Fish fauna present in the Namoi River catchment include native and introduced species (Web Reference 3). Table 1 lists all fish species potentially present in the Namoi River catchment and their conservation status. However, not all species listed here will necessarily be present within the Keepit Dam Upgrade study area.

### 1.3.3 Aquatic Fauna - Aquatic Macroinvertebrates

A study of aquatic macroinvertebrates within the Namoi River Catchment using the AUSRIVAS methodology (Thoms, 1998) showed that the macroinvertebrate community present at Gunnembene Crossing (downstream limit of the study area) represented good biological condition with a suite of 16 taxa collected. This study also selected sites upstream of Lake Keepit in the Namoi River (well upstream of the study area) that also represented excellent habitat and biological community, with 17 taxa recorded in the site closest to the study area. Sites in the Peel River (well upstream of the study area) showed macroinvertebrate communities to be in good condition, although not of the same excellent level as those in the Namoi, with 15 taxa recorded in the site closest to the study area.

### 1.3.4 Threatened Species

The Commonwealth *Environment Protection and Biodiversity Conservation Act* (1999) and the NSW *Fisheries Management Act* (1994) list threatened species, populations, communities and key threatening processes. The Commonwealth Department of the Environment and Heritage (DEH) threatened species web pages (Web reference 1), The NSW Department of Primary Industries (DPI) – Fisheries threatened species web pages (Web reference 2) and the NSW BioNet database website (Web reference 3) were consulted to determine those listed species, populations and communities relevant to the Keepit Dam Upgrade.

Threatened species listed under the Commonwealth *EPBC Act* whose range may include the Keepit Dam Upgrade study area are:

#### Vulnerable Species

- Murray cod (*Maccullochella peelii peelii*). Records for this species exist within the Namoi River up and downstream of Keepit Dam and within the main waterbody of the dam itself. Records also exist within the Peel River (web reference 3). As such, all of the watercourses of the study area can be considered habitat for this species (Figure 1). This species has also been stocked within the dam from a local hatchery (Diploc and van der Walt, 2005).
- The Namoi River turtle (*Elseya bellii*), is known to inhabit watercourses of the upper Namoi River catchment (Web Reference 4). This species is currently listed as Vulnerable on Schedule 2 of the NSW *Threatened Species Conservation (TSC) Act* (1995). This species is also currently listed as Vulnerable on Schedule 2 of the NSW *Threatened Species Conservation (TSC) Act* (1995).

Assessments of significance were conducted for the potential impact of the proposed Keepit Dam upgrade options on two threatened species; the Namoi River turtle (*Elseya bellii*) and the Murray cod (*Maccullochella peelii peelii*). Where relevant, assessments were made in accordance with the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act* (1999) guidelines and the heads of consideration as specified in the Department of Environment and Conservation/Department of Primary Industries (2005) Draft

Guidelines for Threatened Species Assessment which require consideration under Part 3A of the *Environmental Planning and Assessment (EP&A) Act* of NSW (1979). These assessments are included as Appendix 8.

Threatened species and populations listed under the NSW *FM Act* whose range may include the Keepit Dam Upgrade study area are:

#### Endangered Species

- River snail (*Notopala sublineata*). The river snail once occurred throughout the flowing rivers of the Murray-Darling system; however it is now virtually extinct throughout its natural population. The study area lies within the expected natural range of this species, however the closest records for this species are well downstream in the Namoi River near Narrabri, and these all predate 1980 (Web reference 2).

#### Endangered Populations

- Olive perchlet (*Ambassis agassizii*). The study area lies within the original distribution of the western population of the olive perchlet (McDowell, 1996), however the nearest record within the Namoi River is at Walgett at the Darling River confluence and dates to 1910 (Web reference 3). The study area is not considered within the current range of this species.
- Purple spotted gudgeon (*Mogurnda adspersa*). The study area lies within the original distribution of the western population of the purple spotted gudgeon, however the species has only been recorded once in its inland range since 1983 (Web reference 2). The study area is not considered within the current range of this species.

#### Vulnerable Species

- Silver perch (*Bidyanus bidyanus*). Records for this species exist within the Namoi River up and downstream of Keepit Dam and within the main waterbody of the dam itself. Connectivity of the Namoi River below the dam with the lower Peel River is unimpeded by barriers to fish passage and therefore all watercourses of the study area can be considered habitat for this species. This species has been stocked within the dam from a local hatchery (Diploc and van der Walt, 2005).

#### Endangered Ecological Communities

- Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River. This ecological community has been subjected to numerous and increasing pressures over recent decades. These include; barriers to fish passage, reduced environmental flows, thermal pollution, introduced pests, degradation of the riparian zone due to clearing and grazing, agriculture, salinisation and overfishing (Web Reference 2). The Namoi and the Peel Rivers are tributaries of the Darling River and form part of its lowland catchment. Specifically, the Namoi River from the junction of the Manilla River at Manilla, and the Peel River from Chaffey Dam are part of this endangered ecological community (Web reference 2).

## 2.0 STUDY METHODS

### 2.1 Field Sampling

Field sampling comprised collection of habitat assessments, water quality data, fish sampling in Lake Keepit, the Namoi River downstream of the dam and the Peel River near the confluence with the Namoi River. Macroinvertebrates were sampled in the Namoi and Peel rivers.

#### 2.1.1 Site Selection

##### Downstream of Keepit Dam

Nine sites downstream of Keepit Dam were selected (seven in the Namoi River and two in the Peel River) using site selection criteria for the AUSRIVAS methodology (Turak *et al.*, 2004). Sites were selected to be representative of the diversity of riverine habitats within this region of the study area, as well as being accessible and of appropriate proximity to each other. Sites with both pool and riffle habitat were selected where possible (all except for the downstream site in the Peel River – P02, and the pool at the base of the dam wall on the Namoi River). Sites were 100 metres long and GPS readings were taken to record the position of each site. Access to sites was by 4WD vehicle, small boat and by walking.

##### Lake Keepit and the Upper Namoi River

Ten sites in the main water body of Lake Keepit were selected and two were selected within the upper Namoi River upstream of the current water level of Lake Keepit. Sites within the main water body of the lake were accessed using a boat supplied by State Water. Sites within the upper Namoi River were accessed by 4WD vehicle.

Sites within Lake Keepit were selected to include a variety of habitats found within the dam, including: deep water near the dam wall, rocky outcrops, the main flooded river channel, dead standing trees, silted shallow regions, and the upper most reach of the flood level within the Namoi River channel. The current low water level of the storage restricted site distribution to relatively close proximity to the main flooded river channel, compared with available aquatic habitat when water levels were higher.

The two sites within the upper Namoi were selected on the basis of accessibility and their position at either end of this reach of the river.

GPS readings were taken to record the position of each site.

#### 2.1.2 Habitat Assessment

A qualitative assessment of aquatic habitats was compiled for each site, including the following attributes:

- GPS position (datum: WGS 84)
- general land use of surrounding areas
- instream features such as sequence of pools and riffles (shallow areas with broken water)

- flow, measured at each site using a flowmeter
- stream substratum
- presence, extent and type of instream and riparian vegetation. Plants were identified in the field using the field guide by Sainty and Jacobs (1987).
- potential refuge areas during periods of low flow (e.g. large deep pools)
- presence of fish habitat including snags, bank undercuts and aquatic plants
- presence of barriers to fish passage into and beyond the study area
- waterway type using a classification scheme outlined in Fish Passage Requirements for Waterway Crossings (Fairfull and Witheridge, 2003) (Appendix 2),
- bank structure, using Riparian, Channel and Environmental (RCE) scores. This methodology was developed by Petersen (1992) and modified for Australian conditions by Chessman *et al.* (1997) by combining some of the descriptors, modifying some of the associated categories and simplifying the classifications from 1 to 4 (Appendix 3). The scores are summed to provide the RCE score which provides an index of the environmental state of particular locations for use in management decisions. The version used in this study was based on modifications initiated by New South Wales Environmental Protection Authority. The highest possible score (52) would be assigned to a stream with little or no obvious human disturbance and containing very good habitat characteristics (e.g. diversity of habitats, good shelter, etc.). The lowest possible score (13) would be assigned to a stream with strong evidence of human disturbance and poor aquatic habitat.
- A photographic record of the watercourses was made using a digital camera to assist in description of each site.

### 2.1.3 Water Quality

Water quality was measured at each site using a Yeo-Kal 611 probe. Variables measured included pH, dissolved oxygen (DO), temperature, turbidity and conductivity. Two replicate measures were taken from just below the water surface at each site. Where applicable, the results were compared to ANZECC (2000) water quality guidelines for the protection of aquatic ecosystems.

### 2.1.4 Macroinvertebrates

Aquatic macroinvertebrates were sampled in accordance with the Rapid Assessment Method (RAM) based on the Australian River Assessment Scheme (AUSRIVAS) (Turak *et al.*, 2004). The AUSRIVAS model was developed by NSW EPA (now part of the Department of Environment and Conservation) to assess invertebrate assemblages against reference conditions derived from a range of waterways with similar physical and chemical characteristics. The model produces a rating based on a comparison of the invertebrate assemblage present at a site to the assemblage expected to occur at the site and is indicative of the environmental condition of a waterway (Turak *et al.*, 2004).

#### 2.1.4.1 Field Sampling Methods

Field sampling for macroinvertebrates took place on 13 – 15 June 2006 at 6 sites on the Namoi River downstream of Keepit Dam and two sites on the Peel River. The length of sites for RAM sampling were determined as distance of 10 x mode stream width or to a minimum of 100 metres length, in accordance with the protocol. Dip nets with a mesh size of 250 micro metres were used to collect invertebrates from stream edge and riffle habitats. 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. Riffle habitat is defined as an area of broken water with fair to rapid current, with some cobble or boulder substratum (Turak *et al.*, 2004).

##### *Sampling Methodology - Edge Habitats*

At each site edge habitat was sampled from slow moving pools. 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 invertebrates. Efforts were made to include surface dwelling animals. Samples were collected over a total length of 10 metres, usually in 1-2 metre sections, ensuring all significant edge subhabitats within the site were included in the sample (Turak *et al.*, 2004).

##### *Sampling Methodology - Riffle Habitats*

Riffle habitat was sampled by holding the net into the riffle downstream of the samplers' feet. The sampler started at the lower reaches of the riffle and shuffled upstream actively disturbing the substratum with their feet to dislodge animals. Riffle habitats were sampled to a total length of 10 metres, ensuring different riffles (where available) and riffle subhabitats were included in the sample (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 picked 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, in which picking would cease if no new taxa were found in the ten minute period. Usually, the full hour was required for picking. Care was taken to collect cryptic and fast moving animals in addition to conspicuous or slow moving specimens. Animals collected were placed into a labelled jar containing 70 % Ethanol. The chemical and physical variables required for running the AUSRIVAS predictive model were recorded at each site (Turak *et al.*, 2004).

#### 2.1.4.2 Laboratory Methods

Animals were removed from any sediment residue and identified using a binocular microscope and counted to a maximum of ten animals, as per the AUSRIVAS protocol. In most cases, taxa were identified to family level except for Copepoda, Hydracarina, Nematoda and Oligochaeta. The family Chironomidae was identified to subfamily level as required by the model while some families of Anisoptera (dragonfly larvae) and Gastropoda (snails) were identified to lower taxonomic resolutions (genus and species) as they could potentially include three threatened aquatic species. To validate identification of animals a second experienced scientist performed QA checks on each sample.

### 2.1.5 Fish

#### *Namoi and Peel Rivers downstream of Keepit Dam*

Fish were sampled using dip nets, small baited traps and a back-pack electrofisher (Model LR-24 Smith-Root). Dip nets were used in the edge and riffle habitat at each site as described for AUSRIVAS macroinvertebrate sampling.

Baited traps were deployed at selected sites in a variety of habitats such as amongst aquatic plants and around snags, in deep holes and over plant litter and bare substratum. The traps were 350 mm long, 200 mm wide with an entrance that tapered in to 45 mm, with 3 mm mesh size throughout. The traps were baited with approximately 70 millilitres of a mixture of chicken pellets and sardines and deployed for 1.5 hours.

Backpack electrofishing was undertaken to gain a qualitative overview of fish species present in each location. The reach of the watercourse was electrofished from downstream to upstream. The back-pack electrofisher was operated around the edge of pools, around snags and aquatic vegetation, overhanging banks, rocky crevices and in riffles. Electrofishing was conducted in five second shots. Stunned fish were collected in a small scoop net, identified and measured. In accordance with our NSW DPI (Fisheries) scientific research permit native species were released unharmed whilst alien species were not returned to water.

#### *Lake Keepit*

Gill nets were deployed at selected sites within Lake Keepit. Each gill net was 60 m long and 2 m deep. It was made of monofilament nylon, comprising two 30 m panels, one with 65 m stretched mesh and the other with 100 mm stretched mesh. These sizes have been found to readily sample edible species typical of NSW waters. Each gill net was deployed from a boat with lead weights attached to each end of the net to hold it in position. All gill nets were marked clearly on the surface with polystyrene floats. The nets were set for approximately one hour before clearing and retrieval. Nets were set in a variety of habitats including: amongst large dead standing trees, lake margins, the main channel of the flooded Namoi River, along rocky outcrops, in shallow soft sediment areas and in the upper flood waters of the main channel of the Namoi River.

Native fish were handled carefully to avoid injury (including minimal handling, use of wet hands, cutting out of net). In accordance with our NSW DPI (Fisheries) scientific research permit native species were released whilst alien species were not returned to water.

## 2.2 Statistical Analyses

### *Macroinvertebrates*

Field sample collections for the AUSRIVAS Predictive Model assessment are restricted to spring and/or autumn (Turak *et al.*, 2004). Because field samples were collected for this study in June 2006, the autumn season AUSRIVAS model was applied to these data. The principal outputs of the AUSRIVAS software package are observed/expected (OE) values. The observed values are based on results that were collected. The expected values are derived from an appropriate “reference” condition within the model, selected on the basis of physical and chemical characteristics. The reference conditions were compiled from samples collected at a large number of sites across NSW during the establishment of the model.

AUSRIVAS outputs include the following two types of OE values:

**OE50taxa:** The O (observed) value in OE50taxa parameter is the number of macroinvertebrate families that were predicted to have a probability of occurrence greater than 50 % at the site and were actually collected. The E (expected) value in OE50taxa is the sum of the probabilities of finding the predicted macroinvertebrate families (with greater than 50 % probability of occurrence). OE values closer to a ratio of 1 indicate macroinvertebrates similar to those of reference streams and the smaller the OE50 value, the more impaired the macroinvertebrate community is considered to be.

**OE50SIGNAL:** The Stream Invertebrate Grade Number Average Level (SIGNAL) biotic index was developed by Chessman (1995, 2003) as a means of determining environmental quality of sites based on the presence or absence of macroinvertebrate families. Grade numbers were assigned to each macroinvertebrate family or taxa based largely on their responses to chemical changes in the environment. Grade values range from 1 to 10, with a value of 1 indicating a family tolerant to chemical pollution, while a value of 10 indicates a sensitive family. OE50SIGNAL is the ratio of the observed to expected averaged SIGNAL grades per site for taxa groups recorded with a probability of occurrence of more than 50 %.

AUSRIVAS also assigns bands of impairment to each site based on the OE50 values ranging from much richer than reference condition to far poorer than reference condition and allocates a condition of habitat (BAND) for both edge and riffle (Turak *et al.*, 2004).

The condition of habitat was graded into the following categories:

- Band X = Richer invertebrate assemblage than reference condition.
- Band A = Equivalent to reference condition.
- Band B = Sites below reference condition (i.e. significantly impaired).
- Band C = Sites well below reference condition (i.e. severely impaired).
- Band D = Impoverished.

The lowest band score obtained for the two habitats within each site was taken as the sites overall condition (Overall BAND), as recommended by the AUSRIVAS protocol.

**SIGNAL Index:** Following the guidelines in Chessman (2003) grade numbers were allocated to taxa as described in OE50SIGNAL section above. SIGNAL Index was calculated by the sum of all grade numbers for taxa found at each habitat divided by the total number of taxa recorded in each habitat. SIGNAL Index may be used assess communities independent of the AUSRIVAS Protocol. The SIGNAL Index is an indication of water quality and graded into the following categories (Chessman *et al.*, 1997).

- SIGNAL Index > 6 = Healthy Unimpaired
- SIGNAL Index 5-6 = Mildly Impaired
- SIGNAL Index 4-5 = Moderately Impaired
- SIGNAL Index < 4 = Severely Impaired.

### 3.0 RESULTS

Field work in the Namoi catchment was done over two trips. The first trip consisted of water quality and macroinvertebrate sampling on 13 – 15<sup>th</sup> June, 2006. Macroinvertebrates were sampled in the Namoi and Peel rivers below Keepit Dam using the AUSRIVAS methodology.

The second trip involved fish sampling, habitat assessment and further water quality sampling and took place on 26 -29<sup>th</sup> June, 2006. Fishes were sampled in Lake Keepit and in the Namoi and Peel rivers below the dam while habitat assessments and water quality sampling were also done in the Namoi River upstream of the dam. The weather was fine and mild with light variable winds on both trips.

#### 3.1 Description of Habitats

##### 3.1.1 Namoi River Downstream of Keepit Dam

Six sites (N01 – N06) were selected within the reach of the Namoi River from the pool at the base of the dam wall downstream to Gunnembene crossing (Figure 1, Appendix 1). The river at the point of outflow from the dam was also inspected however no sampling was undertaken as conditions were not suitable.

This reach of the river is set in a broad valley that opens up into a flood plain further downstream. Water level and flow rates are highly variable due to the releases of water from Keepit Dam and this was evident at all sites by the presence of isolated pools above the current water level, distribution of aquatic vegetation and the deposition of sediment and erosion of banks. Throughout this reach of the river, landuse was dominated by grazing (mainly cattle) and stock access to the watercourse and associated bank erosion impacts were common to all sites.

Riparian vegetation was generally continuous along this reach of the river, although it was often restricted to a narrow band along the bank edge. It consisted of a mixture of native casuarina and eucalyptus trees, as well as introduced willows (*Silax* sp.) and pepper trees (*Schinus* sp.) (Plate 1). River bank vegetation consisted of a variety of native and exotic grasses and shrubs. Some of the common species present in the river channel and bank margins were: *Phragmites australis* (common reed) *Persicaria decipiens* (slender knotweed), *Eleocharis sphacelata* (spike rush) and *Juncus usitatus* (common rush). Instream aquatic macrophytes were common throughout this reach of the river and *Azolla* sp. (floating fern), *Myriophyllum* sp. (milfoil) and *Potamogeton perfoliatus* (clasped pondweed) were the dominant species observed. Green filamentous algae were also common throughout this reach of the river.

Two main types of instream habitat were present throughout this reach of the river. There were extensive areas of relatively deep, slow flowing pool sections and these were separated by shorter sections of riffle habitat which consist of shallow, fast flowing water with an increased gradient over a cobble substrate. Numerous fallen trees, overhanging bank vegetation, emergent reed beds, aquatic macrophytes, deep pools and rocky substratum provided a variety of aquatic habitat for fish and invertebrate species. All sites within the reach of the river were graded as Class 1 – major fish habitat.

### *Outflow from Keepit Dam*

The Namoi River at the point of water release from Keepit Dam consisted of a large artificial pool at the base of the dam wall (Plate 2 upper). There was extensive rock wall stabilisation of the banks to prevent erosion from the water discharged at high velocity from the dam. Downstream of this pool the Namoi River channel was approximately six metres wide and flows over a gravel, sand and silt substrata (Plate 2 lower).

The pool at the base of Keepit Dam wall, while highly modified, was a very important area of native fish habitat. The dam wall presented an absolute barrier to fish migration upstream, and fish have been observed to congregate in high densities in this pool. The pool is also considered as a very good (although illegal) fishing area for native species. Dead Golden perch and Silver perch were observed in this pool near the discharge point. It is likely that these fish were transported through the release valve from the main water body of Lake Keepit. It is highly unlikely that large native fish could survive such transportation, however it is possible that the eggs or larvae of some species (such as carp) might survive.

Site N01 was located downstream of the Orange Grove Road bridge over the Namoi River (Plate 3 upper). The site contained two riffles, each approximately 6 metres long and flowing over a cobble substrate. The width of the river at this site varied from 8 to 14 metres. The southern bank of the river at this site appeared to be a regular fishing, picnicking and camping area. The remains of an old weir were present within this site which consisted of concrete rubble and did not create a barrier to fish passage. The RCE score for this site was 38 (Appendix 4).

Site N02 was located on Charcoal Bend within the Keepit State Recreation Area (Figure 1). This site contained one large riffle approximately 50 metres long and 15 – 20 metres wide (Plate 3 lower) which had a boulder and cobble substratum and contained large fallen trees creating a damming effect. Upstream of the riffle was a very long deep pool extending as far as site N01. The RCE score for this site was 35 (Appendix 4).

Site N03 was located approximately 5 kilometres downstream of site N02 on a bend in the river with cobble stone riffle habitat and a deep slow flowing pool (Plate 4 upper). This section of the river contained some steep rocky walls along the right bank of the downstream pool. The RCE score for this site was 35 (Appendix 4).

Site N04 was located approximately 1.5 kilometres upstream of the Peel River confluence (Plate 4 lower). This site contained a cobble-pebble riffle 40 metres long and 6 metres wide in which dense beds of milfoil were growing. Stock damage to the banks was particularly noticeable at this site. Exposed tree roots were present along the banks of the large pool at the top of the site. The RCE score for this site was 32 (Appendix 4).

Site N05 was located at the first riffle downstream of the Peel River confluence. There was extensive erosion of the soil banks on both sides of the river (Plate 5 upper). The distribution of river stones between the flood banks showed that the river channel has altered position in the past, probably due to variable flooding from the Peel and Namoi Rivers. The riffle within this site was approximately 25 metres long, 10 metres wide and a cobble-pebble substratum. The RCE score for this site was 28 (Appendix 4).

Site N06 was located at Gunnembene crossing at the most downstream section of the study area. This site is accessible to the general public and appeared to be regularly used as a fishing, camping and picnic area. The site contained a long cobble stone riffle (70 metres long, 15 metres wide). The slow flowing pool upstream of the riffle was relatively shallow (1.5 metres depth max) and contained accumulated fine sediment with extensive green algal

growth. The riparian vegetation was very sparse at this site and the few trees present were exotic willow species (Plate 5 lower). The RCE score for this site was 31 (Appendix 4).

### 3.1.2 Peel River Downstream of Keepit Dam Subsidiary Dam Wall

The study area contains a reach of approximately 4 kilometres of the Peel River downstream of the inflow from the existing Keepit Dam subsidiary dam wall to the Namoi River confluence in which two sites were selected (Figure 1). All sites within the reach of the river were graded as Class 1 – major fish habitat.

At the confluence of the Namoi River and extending approximately 1 kilometre upstream in the Peel River the channel was straight, with deep water and very low flow. This section was essentially a backwater of Namoi River and contained the site P02 (Plate 6 upper). No riffle habitat was present in this section. The banks along both sides of this site were very steep and vegetated mainly with grasses and the emergent common reed (*Phragmites australis*). Riparian vegetation consisted of a few trees including eucalypts, casuarinas and willows along the right bank. There were cattle grazing along both sides of the river, however the banks were too steep for stock to access the river itself. The left bank was used for agriculture. There was evidence of erosion due to lack of binding bank vegetation where drainage gullies enter the main watercourse. The substratum of this section of the river was mainly fine sediment and there were some large snags within the channel. The RCE score for this site was 26 (Appendix 4).

Upstream the Peel River contains alternating riffle and pool habitat. Riparian vegetation was not as extensive as it was within the lower Namoi River, and bank erosion caused by scouring was much more prominent (Plate 6 lower). Stock access to the river was extensive. Site P01 was located on a bend in river approximately 3 kilometres upstream of the Peel – Namoi Confluence. This site contained both cobble stone riffle and pool habitat. Riparian vegetation was largely absent at this site and banks were vegetated with grass species only. There were very few aquatic macrophytes (instream or emergent) present within the river channel at this site. The water was noticeably more turbid than at other sites in the Peel and Namoi Rivers. The RCE score for this site was 24 (Appendix 4).

### 3.1.3 Lake Keepit

Lake Keepit is a large artificial water body created by the flooding of the Namoi River following the construction of Keepit Dam (Plate 7 upper). The water level in the lake at the time of sampling was 17% of full supply level due to the persistent drought, and the present aquatic habitat was not necessarily representative of that found when the lake is closer to full supply. The lake contained extensive aquatic habitat, particularly along the old channel of the Namoi River and the inflowing tributaries, where large standing dead trees from the original riparian zone provide large woody debris (snags) which support a variety of aquatic fauna (Plate 7 lower). Other habitat types included rocky outcrops (Plate 8 upper), deep holes and extensive shallow areas with fine silt substrata in the upper reaches of the flooded Namoi River channel (Plate 8 lower). Ten sites were selected within the main water body of Lake Keepit (Figure 1) which incorporated the variety of available habitat types. These are summarised in Table 2. All sites within the main water body of the lake were graded as Class 1 – major fish habitat.

### 3.1.4 Namoi River: Upstream of Lake Keepit

The Namoi River upstream of the current water level to the town of Manilla consisted of a variety of habitats including long deep pools and rapid flow over cobble bed riffles. Riparian vegetation was highly variable with some reaches having extensive native trees (mainly eucalypts) along the banks (Plate 9 upper), while others were dominated by introduced species such as willow or have been extensively cleared (Plate 9 lower). Instream and emergent aquatic macrophytes include: *Juncus* sp., *Phragmites* sp. and *Myriophyllum* sp. and were present throughout this section of the river. Stock access to the river was extensive and contributed to bank erosion along with instability due to clearing of riparian vegetation. Flow within this section of the Namoi River was regulated by water releases from Split Rock Dam upstream on the Manilla River.

Connectivity between this reach of the Namoi River and Lake Keepit could allow utilisation of this habitat by fish inhabiting the dam (both naturally occurring and stocked). All sites within the reach of the river were graded as Class 1 – major fish habitat.

Two sites were selected within this reach of the Namoi River. The first (UN01) was located within the full supply level of Lake Keepit, but was well above the current water level (Figure 1). This site did not contain alternating pool and riffle habitat, but was an even gradient, with a moderate shallow flow over a sand-silt substratum. Riparian vegetation consisted of mainly large eucalypt trees on the southern bank, with exotic species including willows on the northern bank. Within the river channel there were a variety of grasses including the native common rush (*Juncus usitatus*). The RCE score for this site was 23 (Appendix 4).

The most upstream site in this reach of the Namoi River (UN02) was located downstream of the McDonald Road bridge at Manilla. This site contained distinct pool and riffle habitat with cobble – boulder substratum dominant. Riparian vegetation was dominated by exotic willow trees, with some casuarina trees also present. Channel margins were vegetated with various grasses. Green algae were prevalent within the river and beds of the milfoil (*Myriophyllum* sp.) were also extensive. The surrounding landuse at this site was a combination of rural grazing land and semi-urban development. The RCE score for this site was 35 (Appendix 4).

## 3.2 Water Quality

The mean ( $\pm$  S.E.) values for water quality variables recorded at the study sites are presented in Table 3 and 4 and compared to ANZECC (2000) guidelines for south-east Australia. For comparisons with ANZECC guidelines, the Namoi and Peel rivers were classified as upland rivers and Lake Keepit as a reservoir.

Electrical conductivity, an indicator of salinity levels, exceeded guidelines at all sites on the Namoi and Peel rivers and was particularly high in the Peel River (both sites were greater than 1000 micro siemens per centimetre) and at Namoi River Site N05 but became diluted further downstream in the Namoi River at Site N06 (Table 4). pH also exceeded guidelines at all sites, particularly in the upper Namoi and Peel rivers where values were approximately 9 pH units.

Dissolved oxygen (DO) levels were slightly below guidelines at most sites in the Namoi River below Keepit Dam and were also outside the guidelines at both sites on the Peel River (Table 3). DO values in the upper Namoi River, however, were within the accepted range at both sites.

Turbidity values were within the accepted range throughout sites on the Namoi River, both above and below Keepit Dam, but exceeded guidelines at both sites on the Peel River. Water temperature decreased slightly down the Namoi River below Keepit Dam from Sites N01 and N02 (values between 12 and 13 °C) to Sites N03 and N04 (11 – 12 °C) to Site N05 and N06 (10 – 11 °C).

Water quality variables were measured from Lake Keepit at the surface and at depth to investigate any stratification of the reservoir water (Table 4). Electrical conductivity and pH values exceeded guidelines at all sites in the lake.

Dissolved oxygen values were within the range considered acceptable by ANZECC (2000) at all sites and depths tested. Turbidity values were generally within the accepted range, the exceptions being the surface waters at Site K06 and at 4 metres depth at Site K10. Water temperature ranged between 9 and 13 °C at all sites and depths within Lake Keepit, with no evidence for temperature stratification within the upper 7.5 metres of the water column (Table 4).

Overall there was little difference between water quality indicators measured at the surface and at depth in Lake Keepit. The most noticeable difference in water quality readings from the surface and at depth in Lake Keepit was apparent in the dissolved oxygen (% saturation) concentrations which were consistently greater at the surface than at depth. The most extreme example of this being at Site K10 where the surface water was 111.3 % saturated with dissolved oxygen compared to only 92.0 % at 4 metres depth (Table 4).

### 3.3 Macroinvertebrates

#### 3.3.1 General Results

RAM sampling yielded a total of 46 macroinvertebrate taxa, 44 from Namoi River (36 from edge and 27 from riffle) and 27 taxa from Peel River (20 from edge and 16 from riffle)(Appendix 7). The fewest taxa were recorded at Site N 02 Riffle on the Namoi and Site P 02 on the Peel (9 taxa in each) and the greatest number at Site N 06 Edge (26 taxa) both in Namoi River (Appendix 7). No specimens belonging to the threatened invertebrate species River Snail (*Notopala sublineata*) were recorded in this data set.

#### 3.3.2 AUSRIVAS Results

Overall, the AUSRIVAS model assessed the ecological condition of most sites using Band classification as poorer than expected (Overall BAND, Table 5), with the exception of site N06 on the Namoi River where the habitat condition was assessed as roughly equivalent to reference sites used in the AUSRIVAS model. In the Namoi River, downstream of the dam, edge sites closest to the dam, N01 and N02, had a low value for OE50 taxa, 0.43 and 0.69 (Table 5) respectively, therefore not as many taxa (with a probability of occurrence of greater than 50 %) were found as expected. The OE50 taxa values for edge sites further downstream of the dam were higher and increased value with distance downstream of the dam wall. The highest OE 50 taxa value was 1.04, at Site N06 on the Namoi where more taxa were found than were expected. The OE50 taxa value for riffle habitats on the Namoi was lower than edge habitats ranging from 0.52 for Site N02, indicating fewer taxa were found than expected, to 0.90 at Site N06 on the Namoi. At edge and riffle sites on the Peel River fewer taxa were found than expected, with values for OE 50 taxa below 0.70 and 0.75, respectively.

OE50 SIGNAL (Table 5) values for the Namoi River in both edge and riffle habitats were between 0.87 and 1.1 indicating more sensitive taxa present than expected (with a 50 % probability). OE50 SIGNAL values for the Peel River edge and riffle sites were slightly less than 1 indicating the SIGNAL grades of the taxa present were similar to or only slightly more tolerant than those found in reference creeks used by the AUSRIVAS model.

### 3.3.3 SIGNAL Index

Both rivers and habitat types had representatives from both tolerant and sensitive families as graded by Chessman (2003) (Table 5). The most sensitive taxon Leptophlebiidae and Hydrobiosidae (SIGNAL2 grade of 8) were found in both the Namoi and Peel Rivers. However, SIGNAL scores at all sites in both rivers were lower than 5 indicating that overall, water quality was moderately to severely impaired and the macroinvertebrate communities were composed of tolerant animals (Appendix 7).

### 3.4 Fish

A combination of fish sampling methods including dip netting, bait trapping and electrofishing were used to sample fish in the Namoi and Peel Rivers downstream of Keepit Dam. Observations of fish that were not actually sampled were also included within results. These results have been summarised in Table 6, the full set of results is included as Appendix 5. Six species were recorded within this part of the study area which comprised three exotic and three native species. No listed threatened species were sampled in this part of the study area. The freshwater catfish (*Tandanus tandanus*) is considered as a species of conservation concern because of its apparent reduction in abundance and distribution within its natural range and was found within this reach of the Namoi River.

Within Lake Keepit fish sampling was undertaken using gillnets. Results are summarised in Table 6, the full set of results is included as Appendix 6. Photos of some of the fish sampled are shown in plates 10, 11 and 12. The six species recorded within the lake comprised two exotic species and four native species. Native species collected included the federally listed endangered; Murray Cod (*Maccullochella peelii*), the NSW listed vulnerable; Silver Perch (*Bidyanus bidyanus*), and species of concern; freshwater catfish. The two listed species (Murray Cod and Silver Perch) as well as Golden Perch (*Macquaria ambigua*) are regularly stocked within the lake by the local recreational fishing club in conjunction with NSW DPI Fisheries.

The introduced species; Common Carp (*Cyprinus carpio*) and Goldfish (*Carassius auratus*), were found both upstream and downstream of Keepit Dam, indicating that their current distribution is throughout the study area despite the presence of the barrier to fish passage created by the dam.

It is also noted that dead Golden perch and Silver perch were observed in the pool at the base of the Keepit Dam wall. It is likely that these fish were transported through the release valve from the main water body of Lake Keepit. It is highly unlikely that such large native fish could survive such transportation; however it is possible that the eggs or larvae of some species (such as carp) might survive.

## 4.0 ASSESSMENT OF IMPACTS AND RECOMMENDATIONS FOR MITIGATIVE MEASURES

### 4.1 Assessment of Potential Impacts due to Upgrade Construction Works and Appropriate Mitigation Measures

The recommendations outlined below are designed to be incorporated into a site specific environmental management plan (EMP) when final upgrade options are determined and detailed construction plans are available.

#### 4.1.1 Peninsula Reshaping

Extensive earthworks involving blasting and the removal of rock (peninsula reshaping) is proposed for all long-term dam upgrade options (B1, D2 and D3). This work is likely to result in significant mobilisation of sediment in close proximity to Lake Keepit. Impacts on the aquatic habitat and biota in the vicinity of the peninsula works could occur if mobilised sediment were to enter the main waterbody of Lake Keepit. Such impacts could include:

- Reduction of water quality including increased turbidity and increased nutrient levels.
- Increased turbidity within the lake could result in the reduction of light penetration and subsequent reduction of aquatic macrophyte, altering existing aquatic habitat.
- Increased nutrient levels may encourage algal growth with potential toxic algal blooms resulting in negative impacts on aquatic fauna.

The above impacts can be effectively minimised or eliminated by the incorporation of mitigation measures during the construction phase of the project. Such mitigation measures should include:

- Where possible, sediment should be prevented from entering the main body of Lake Keepit. This can be achieved by the use of sediment fences or bunding between earthworks and the lake.
- Where sediment fences are not appropriate because construction activities occur on the waterline, sediment dispersal within the lake should be contained within a limited area in the vicinity of works by the use of a floating silt curtain. The silt curtain should be deployed to enclose all works along the waterline, and should enclose as small an area of the water body as possible.
- Where practical works should be undertaken when the storage is at a level that will minimise impacts, and this may require a lowered maximum storage level during the construction and stabilisation period.

Peninsula reshaping activities for all three options are identical, and therefore potential impacts resulting from this construction activity on the aquatic ecology of the main waterbody of Lake Keepit are equivalent for each option.

#### 4.1.2 Right-Hand Abutment Spillway and Dam Wall Rising

All long-term dam upgrade options being assessed (B1, D2 and D3) incorporate the construction of a right-hand abutment spillway on the north side of the main dam wall and

the raising of the dam wall (by varying heights with each option). Earthworks will be involved in the construction of the spillway and the dam wall raising and these could result in runoff of sediment into the Namoi River downstream of the dam wall, and into the main water body of Lake Keepit during periods of wet weather. Such increased sediment loads could result in negative impacts on the aquatic habitat and biota downstream of construction works. These impacts may include:

- Reduction of water quality including increased turbidity and increased nutrient levels.
- Increased turbidity within the lake could result in the reduction of light penetration and subsequent reduction of aquatic macrophytes, altering existing aquatic habitat.
- Increased nutrient levels may encourage algal growth with potential toxic algal blooms resulting in negative impacts on aquatic fauna.
- Increased sedimentation within water courses which can result in the reduction of available deep water refuge areas for aquatic biota and smothering of important habitat features such as beds of aquatic macrophytes and rocky substratum.

The above impacts can be effectively minimised or eliminated by the incorporation of mitigation measures during the construction phase of the project. Such mitigation measures should include:

- The prevention of sediment from entering the lower Namoi River and Lake Keepit. This can be achieved by the use of sediment fences or bunding between earthworks, stockpiles and access roads and the natural drainages to the river.
- Revegetation of disturbed areas such as access roads and stockpile sites following completion of construction to prevent ongoing erosion and resultant runoff into the lower Namoi River and Lake Keepit.
- Where practical works should be undertaken when the storage is at a level that will minimise impacts, and this may require a lowered maximum storage level during the construction and stabilisation period.

Potential impacts resulting from the construction of the right-hand abutment spillway, dam wall rising and associated stockpile sites, access roads and other works, on the aquatic ecology downstream in the Namoi River and in Lake Keepit can be considered as identical for all three options. Although the raising of the dam wall varies with each option, potential impacts are dependent upon the construction footprint, which remains the same for all options.

#### **4.1.3 Subsidiary Dam Wall Raising / Spillway Construction**

All long-term dam upgrade options being assessed (B1, D2 and D3) incorporate upgrade works on the subsidiary dam wall. Option B1 involves the construction of a new spillway on the subsidiary dam wall and involves significantly more earthworks than options D2 and D3. Options D2 and D3 involve the raising of the subsidiary dam wall and some associated works including stockpile areas and road realignment.

Earthworks associated with all upgrade options could result in runoff of sediment into the Peel River downstream of the subsidiary dam wall, and into the main water body of Lake Keepit during periods of wet weather. Such increased sediment loads could result in negative impacts on the aquatic habitat and biota downstream of construction works. These impacts may include:

- Reduction of water quality including increased turbidity and increased nutrient levels.
- Increased turbidity within the lake could result in the reduction of light penetration and subsequent reduction of aquatic macrophytes, altering existing aquatic habitat.
- Increased nutrient levels may encourage algal growth with potential toxic algal blooms resulting in negative impacts on aquatic fauna.
- Increased sedimentation within water courses which can result in the reduction of available deep water refuge areas for aquatic biota and smothering of important habitat features such as beds of aquatic macrophytes and rocky substratum.

The above impacts can be effectively minimised or eliminated by the incorporation of mitigation measures during the construction phase of the project. Such mitigation measures should include:

- The prevention of sediment from entering the Peel River and Lake Keepit. This can be achieved by the use of sediment fences or bunding between earthworks, stockpiles and access roads and the natural drainages to the river.
- Revegetation of disturbed areas such as access roads and stockpile sites following completion of construction to prevent ongoing erosion and resultant runoff into the Peel River and Lake Keepit.
- Where practical works should be undertaken when the storage is at a level that will minimise impacts, and this may require a lowered maximum storage level during the construction and stabilisation period.

Potential impacts on the aquatic ecology of Lake Keepit and the Peel River resulting from the construction of the subsidiary dam wall spillway (option B1) are greater than those associated with the subsidiary dam wall raising (options D2 and D3) because of the more extensive earthworks involved.

#### **4.1.4 Boat Ramp, Sailing Club and Caravan Park Saddle Dam / Spillway Construction**

All long-term dam upgrade options being assessed (B1, D2 and D3) incorporate construction of saddle dams and/or spillways at the existing boat ramp, sailing club and caravan park. Option B1 consists of the construction of small saddle dams at all locations and does not include spillway construction. This option involves the smallest area of earthworks of the three. Options D2 and D3 involve the construction of a saddle dam at the caravan park, and spillways at both the boat ramp and the sailing club. They also require the relocation of the sailing club and a central stockpile area.

Earthworks will be involved in the construction of the spillways and the saddle dam walls and these could result in runoff of sediment into the Namoi River downstream of the dam wall, and into the main water body of Lake Keepit during periods of wet weather. Such increased sediment loads could result in negative impacts on the aquatic habitat and biota downstream of construction works. These impacts may include:

- Reduction of water quality including increased turbidity and increased nutrient levels.
- Increased turbidity within the lake could result in the reduction of light penetration and subsequent reduction of aquatic macrophytes, altering existing aquatic habitat.

- Increased nutrient levels may encourage algal growth with potential toxic algal blooms resulting in negative impacts on aquatic fauna.
- Increased sedimentation within water courses which can result in the reduction of available deep water refuge areas for aquatic biota and smothering of important habitat features such as beds of aquatic macrophytes and rocky substratum.

The above impacts can be effectively minimised or eliminated by the incorporation of mitigation measures during the construction phase of the project. Such mitigation measures should include:

- The prevention of sediment from entering the lower Namoi River and Lake Keepit. This can be achieved by the use of sediment fences or bunding between earthworks, stockpiles and access roads and the natural drainages to the river.
- Revegetation of disturbed areas such as access roads and stockpile sites following completion of construction to prevent ongoing erosion and resultant runoff into the lower Namoi River and Lake Keepit.
- Where practical works should be undertaken when the storage is at a level that will minimise impacts, and this may require a lowered maximum storage level during the construction and stabilisation period.

Potential impacts resulting from the construction of the spillways, saddle dams and associated stockpile sites, access roads and other works, on the aquatic ecology downstream in the Namoi River and in Lake Keepit are much greater for options D2 and D3 because of the greater earthworks involved than in option B1.

#### 4.1.5 Other Potential Impacts

It is possible that some minor removal of riparian vegetation and/or large in-stream woody debris (snags) may be required as part of construction works at various stages. These processes require consideration as they are listed as Key Threatening Processes (KTP) under the *NSW Fisheries Management Act 1994* as they can result in habitat degradation for aquatic species. To minimise such potential impacts the following it is proposed that construction procedures observe the following recommendations:

- To avoid wherever there is a practicable alternative the disturbance or removal of large woody debris or native riparian vegetation.
  - In cases when large woody debris must be removed, it is recommended that following the required activity it be returned to its previous position.
  - If permanent removal is required it is recommended that large woody debris be relocated to a nearby section of the watercourse with similar hydrological characteristics (i.e. deep pool, river bank habitat).
  - In cases where native riparian vegetation must be removed, it is recommended that following the required activity revegetation with appropriate native species be undertaken.
- To avoid undertaking work involving disturbance of soils during periods of high rainfall.
- To have an incident management plan for spill response prepared for all construction areas where fuel, oil or chemicals are being used to prevent the contamination of water courses.

#### **4.1.6 Option Ranking Summary**

The three different long term options are considered as having equivalent potential impacts on the aquatic ecology of the Namoi-Peel River system downstream of Keepit Dam and in the main water body of Lake Keepit itself. It is important however to recognise that option B1 has a greater potential impact on the lower Peel River (if considered independently of the lower Namoi River) because of the construction of the subsidiary dam wall spillway. Options D2 and D3 have a greater potential impact on the Namoi River below the dam because of the construction of the boat ramp and sailing club spillways.

#### **4.2 Assessment of Potential Impacts on Threatened Species**

Listed threatened species and communities that are known to or may exist within the study area have been discussed in Section 1.3.4. Assessments of significance for these species have been undertaken in accordance with state and federal legislation and are included in Appendix 8 and Appendix 9. The existing presence of Keepit Dam creates a significant impact on threatened fish fauna within this area as it creates an absolute barrier to upstream and downstream fish passage. The current releases of water from the dam also have impacts on the downstream aquatic fauna including threatened species due to the altered flow regime and cold water pollution. These impacts will not be altered by the proposed upgrade works and are not considered as impacts associated with the current proposal.

Impacts resulting from the construction of the upgraded Keepit Dam have been discussed above, and provided that recommended mitigation measures are incorporated into final construction plans with through the production of a site specific EMP these impacts should be greatly minimised or eliminated altogether and are unlikely to have any significant impact on threatened species, populations and communities that may be present within the study area.

## **5.0 ACKNOWLEDGEMENTS**

This report was written by Doug Hazell and Marcus Schnell and was reviewed by Dr Peggy O'Donnell. Doug Hazell, Marcus Schnell and Simon Sharp undertook field work. Marcus Schnell and Belinda Parkes identified macroinvertebrate samples.

## 6.0 REFERENCES

- Allen, G.R., Midgley, S.H. and Allen, M. (2002). Field Guide to the Freshwater Fishes of Australia. Western Australian Museum, Perth, WA.
- ANZECC and ARMCANZ (2000). *Introduction to the Australian and New Zealand guidelines for fresh and marine water quality. National water quality management strategy, No.4A.* Prepared for: Australian & New Zealand Governments. ANZECC/ARMCANZ, Australia.
- Chessman, B. C. (1995) Rapid assessment of rivers using macroinvertebrates: A procedure based on habit-specific sampling, family level identification and a biotic index. *Australian Journal of Ecology*, **20**: 122-129.
- Chessman, B.C. (2003). New sensitivity grades for Australian river macroinvertebrates. *Marine and Freshwater Research* **54**: 95-103
- Chessman, B. C., Grown, J. E. and Kotlash, A. R. (1997). Objective derivation of macroinvertebrate family sensitivity grade numbers for the SIGNAL biotic index: Application to the Hunter River system, New South Wales. *Marine and Freshwater Research* **48**, pp. 159-172.
- Diplock and van der Walt (2005). *A guide to the stocked lakes and dams in New South Wales.* NSW Department of Primary Industries and Australian Fishing Network.
- Fairfull, S. and Witheridge, G. (2003). Why do Fish Need to Cross the Road? Fish Passage requirements for Waterway Crossings. Prepared for: Natural Heritage Trust - Murray Darling Basin Fish Rehab Program. NSW Fisheries, Cronulla NSW.
- Harris, J. (2001). Cold water pollution: Barren, wintry rivers in Mid-summer. *Watershed* **9**, pp. 3-4.
- Harris, J. H. and Gehrke, P. C. (1997). *Fish & Rivers in Stress: The NSW Rivers Survey.* NSW Fisheries, Cronulla, NSW, 298 pp.
- McDowall (1996). *Freshwater Fishes of South-Eastern Australia.* Reed Books, NSW.
- Petersen, R. C. J. (1992). The RCE: a Riparian, Channel and Environmental Inventory for small streams in the agricultural landscape. *Freshwater Biology* **27**, pp. 295-306 .
- Preece, R. (2004). Cold Water Pollution Below Dams in New South Wales. Prepared for: Department of Infrastructure, Planning and Natural Resources. Department of Infrastructure, Planning and Natural Resources, NSW.
- Preece, R. M. and Jones, H. A. (2002). *The effect of Keepit Dam on the temperature regime of the Namoi River, Australia.* River Research and Applications **18**, pp. 397-414.
- Sainty, G.R., and Jacobs, S.W.L. (1987). *Waterplants in Australia : A field guide.* Sainty and Associates, Potts Point, NSW.
- Thoms (1998). The condition of the Namoi River System. A report to: NSW Department of Land and Water Conservation. CRC for Freshwater Ecology, University of Canberra.
- Thoms, M., Norris, R., Harris, J., Williams, D. and Cottingham, P. (1999). Environmental Scan of the Namoi River Valley. Prepared for: Department of Land and Water Conservation/Namoi Management Committee. Cooperative Research Centre for Freshwater Ecology, Canberra ACT.

Turak, E, Waddell, N., Johnstone, G. (2004). New South Wales Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual. Department of Environment and Conservation, Sydney, Australia.

Web reference 1. Department of Environment and Heritage, Threatened Species web pages: <http://www.deh.gov.au/biodiversity/threatened/index.html>.

Web reference 2. NSW Department of Primary Industry – Fisheries, Threatened Species web pages: [http://www.fisheries.nsw.gov.au/threatened\\_species](http://www.fisheries.nsw.gov.au/threatened_species).

Web reference 3. BioNet Database: <http://www.bionet.nsw.gov.au>.

Web Reference 4. NSW Department of Environment and Conservation. Threatened Species, Populations and Ecological Communities of NSW. Bell's Turtle - Profile. Available from:  
<http://threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10266>  
Accessed 16/1/2007.

**Table 1: Fish of the Namoi Catchment**

Compiled from NSW government records from the BioNet database (Web Reference 3).

Order	Family	Scientific Name	Common Name	Conservation Status
<b>Atheriniformes</b>	<b>Atherinidae</b>	<i>Craterocephalus amniculus</i>	Darling River Hardyhead	
		<i>Craterocephalus stercusmuscarum</i>	Freshwater Hardyhead	
	<b>Melanotaeniidae</b>	<i>Melanotaenia fluviatilis</i>	Crimson-spotted Rainbowfish	
<b>Clupeiformes</b>	<b>Clupeidae</b>	<i>Nematalosa erebi</i>	Bony herring	
<b>Cypriniformes</b>	<b>Cyprinidae</b>	<i>Carassius auratus</i>	Goldfish	Introduced
		<i>Cyprinus carpio</i>	Common Carp	Introduced
<b>Cyprinodontiformes</b>	<b>Poeciliidae</b>	<i>Gambusia holbrooki</i>	Gambusia	Introduced
<b>Osmeriformes</b>	<b>Galaxiidae</b>	<i>Galaxias olidus</i>	Mountain Galaxias	
	<b>Retropinnidae</b>	<i>Retropinna semoni</i>	Australian Smelt	
<b>Perciformes</b>	<b>Ambassidae</b>	<i>Ambassis agassizi</i>	Olive Perchlet	Endangered Population (FM Act)
	<b>Eleotridae</b>	<i>Hypseleotris galii</i>	Firetail Gudgeon	
		<i>Hypseleotris klunzingeri</i>	Western Carp Gudgeon	
		<i>Hypseleotris sp</i>	Carp Gudgeon	
	<b>Percichthyidae</b>	<i>Gadopsis marmoratus</i>	Freshwater Blackfish	
		<i>Maccullochella macquariensis</i>	Trout cod	Endangered Species (FM Act)
		<i>Maccullochella peelii</i>	Murray Cod	Vulnerable Species (EPBC Act)
		<i>Macquaria ambigua</i>	Golden Perch	
	<b>Terapontidae</b>	<i>Bidyanus bidyanus</i>	Silver Perch	Vulnerable Species (FM Act)
		<i>Leiopotherapon unicolor</i>	Spangled Perch	
<b>Salmoniformes</b>	<b>Salmonidae</b>	<i>Oncorhynchus mykiss</i>	Rainbow trout	Introduced
		<i>Salmo trutta</i>	Brown Trout	Introduced
		<i>Salvelinus fontinalis</i>	Brook Char	Introduced
<b>Siluriformes</b>	<b>Plotosidae</b>	<i>Tandanus tandanus</i>	Freshwater Catfish	

**Table 2. Summary of habitat types at sites in Lake Keepit**

Site	Depth (m)	Sampling	Habitat Description
K01	18	Water quality	Deepest part of the dam near the main dam wall.
K02	8 – 13	Fish	Old quarry used for dam construction materials, contains vertical rock walls, deep holes and a variety of rocky outcrops.
K03	10 – 16	Fish	Main Namoi River channel. Numerous large snags from original riparian vegetation.
K04	10 – 13	Fish	Mouth of small embayment created by inflowing gully to main lake. Dense standing dead trees, a popular fishing location.
K05	5 – 10	Fish & water quality	Main Namoi River channel in front of the recreational fishing club. Numerous large snags from original riparian vegetation including some very large trees. Popular fishing location.
K06	0.5	Water quality	Main Namoi River channel near the Manilla Ski Gardens. This was the upper limit of navigation under existing supply level. Shallow with fine silt sediment and snags along channel margin. Green algal bloom observed.
K07	1 – 1.5	Fish	Main Namoi River channel. This was most upstream site suitable for fish sampling. Shallow with fine silt sediment and snags along channel margin.
K08	1 – 2	Fish	Main Namoi River channel. This was most upstream site with water level above the original river banks. Shallow with fine silt sediment and snags along channel margin.
K09	2 – 3	Fish	Confluence of the main Namoi River channel and Wongo Creek (largest tributary to lake other than Namoi River). Numerous standing dead trees. Relatively shallow with fine sediment.
K10	4 – 6	Fish & water quality	Main Namoi River channel. Numerous large snags from original riparian vegetation including some very large trees. Popular fishing location. Deep hole (10m) located near this site.

Table 3: Mean ( $\pm$ SE) values for surface water quality indicators recorded at study sites on the Namoi and Peel rivers in June 2006. Bolded values fell outside the guidelines recommended by ANZECC (2000) for upland rivers (>150 m altitude) in southeast Australia. Relevant guidelines are: electrical conductivity (30-350  $\mu$ S/cm); pH (6.5-7.5); dissolved oxygen (DO) (90-110%); and turbidity (2-25 ntu). A single measure of alkalinity was taken at each site. \* indicates dissolved oxygen % saturation values converted from mg/L value.

Watercourse Site Date	Namoi River below Keepit Dam											
	N01		N02		N03		N04		N05		N06	
	13/06/2006		13/06/2006		14/06/2006		14/06/2006		14/06/2006		15/06/2006	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
Conductivity ( $\mu$ S/cm)	<b>414.0</b>	2.0	<b>413.5</b>	2.5	<b>424.0</b>	2.0	<b>417.0</b>	0.0	<b>881.5</b>	15.5	<b>723.0</b>	1.0
pH	<b>8.76</b>	0.01	<b>8.56</b>	0.07	<b>8.34</b>	0.03	<b>8.43</b>	0.05	<b>8.88</b>	0.00	<b>8.83</b>	0.00
DO (mg/L)	9.55	0.05	9.15	0.05	8.50	0.10	9.40	0.00	10.55	0.05	9.55	0.05
DO (% saturation)	<b>88.25</b> *	0.5	<b>85.5</b> *	0.4	<b>76.75</b> *	0.9	<b>86.7</b>	1.1	95.1	0.4	<b>84.8</b>	0.5
Turbidity (ntu)	7.75	0.18	10.37	2.10	5.70	0.53	5.88	0.02	18.78	0.45	16.32	0.35
Temperature ( $^{\circ}$ C)	12.51	0.00	12.69	0.04	11.02	0.06	11.43	0.00	10.78	0.01	10.03	0.04
Alkalinity (CaCO <sub>3</sub> ppt)	140		140		135		140		220		185	

Watercourse Site Date	Peel River				Upper Namoi River			
	P01		P02		UN1		UN2	
	15/06/2006		14/06/2006		28/06/2006		28/06/2006	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
Conductivity ( $\mu$ S/cm)	<b>1110.5</b>	0.5	<b>1142.0</b>	1.0	<b>472.5</b>	0.5	<b>393.0</b>	3.0
pH	<b>8.97</b>	0.01	<b>9.03</b>	0.00	<b>9.09</b>	0.01	<b>9.09</b>	0.01
DO (mg/L)	9.05	0.05	13.35	0.35	10.20	0.10	11.45	0.05
DO (% saturation)	<b>78.3</b>	0.3	<b>121.7</b>	3.8	96.7	0.8	105.6	0.3
Turbidity (ntu)	<b>43.65</b>	1.15	<b>26.72</b>	1.45	19.28	0.22	20.77	0.90
Temperature ( $^{\circ}$ C)	8.86	0.01	11.31	0.08	12.99	0.01	11.68	0.00
Alkalinity (CaCO <sub>3</sub> ppt)	250		230		150		110	

Table 4: Mean ( $\pm$ SE) values for water quality indicators recorded from the surface and at depth in Keepit Dam on 27 June 2006. Bolded values fell outside the guidelines recommended by ANZECC (2000) for lakes and reservoirs in southeast Australia. Relevant guidelines are: electrical conductivity (20-30  $\mu$ S/cm); pH (6.5-8.0); dissolved oxygen (DO) (90-110%); and turbidity (1-20 ntu).

Site Depth	K01		K05		K06		K10	
	Surface		Surface		Surface		Surface	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
Conductivity ( $\mu$ S/cm)	<b>417.0</b>	0.0	<b>421.0</b>	0.0	<b>516.0</b>	1.0	<b>452.0</b>	0.0
pH	<b>8.98</b>	0.00	<b>9.18</b>	0.00	<b>8.76</b>	0.04	<b>9.56</b>	0.01
ORP (mV)	386.0	2.0	381.0	1.0	353.5	7.5	340.5	14.5
DO (mg/L)	8.65	0.05	9.25	0.05	11.90	0.40	11.85	0.15
DO (% saturation)	<b>80.25</b>	0.45	<b>86.55</b>	0.55	104.40	2.20	111.30	1.50
Turbidity (ntu)	6.32	0.05	8.50	0.17	<b>32.50</b>	3.73	15.22	0.12
Temperature ( $^{\circ}$ C)	12.00	0.01	12.22	0.04	9.38	0.07	12.70	0.03

Site Depth	K01		K05		K10	
	7.5m		7.5m		4m	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
Conductivity ( $\mu$ S/cm)	<b>419.5</b>	0.5	<b>431.0</b>	3.0	<b>483.0</b>	3.0
pH	<b>8.74</b>	0.01	<b>9.00</b>	0.01	<b>9.35</b>	0.01
ORP (mV)	378.0	3.0	375.5	1.5	305.5	21.5
DO (mg/L)	7.20	0.10	7.95	0.05	10.00	0.10
DO (% saturation)	<b>66.55</b>	0.75	<b>74.20</b>	0.60	92.00	0.90
Turbidity (ntu)	6.57	0.03	9.93	0.23	<b>21.22</b>	0.12
Temperature ( $^{\circ}$ C)	11.75	0.00	12.08	0.00	11.82	0.01

Table 5: AUSRIVAS scores for edge and riffle habitats sampled June 2006. Outputs include observed versus expected taxa (OE50Taxa) based on those taxa predicted with a greater than 50% probability of occurring. AUSRIVAS bands: A = Similar to AUSRIVAS references; B = poorer than ASIRIVAS references; C = Much poorer than ASURIVAS references. Bands of biological condition based on OE50 taxa. OE50SIGNAL is the ratio of expected to observed average SIGNAL grades based on Chessma (2003). No suitable riffle habitat was available at site P02.

A) Edge Habitats

	Namoi River						Peel River	
	N01	N02	N03	N04	N05	N06	P01	P02
Band	B	B	A	A	A	A	B	C
Expected no of taxa (NTE50)	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5
Observed/expected no of taxa (OE50)	0.6	0.6	1.0	0.9	0.9	1.0	0.7	0.4
Observed SIGNAL (O50SIGNAL)	3.7	4.0	3.9	4.1	4.1	3.3	3.5	3.2
Expected SIGNAL (E50SIGNAL)	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
Observed/Expected SIGNAL scores (OE50SIGNAL)	1.0	1.1	1.1	1.1	1.1	0.9	0.9	0.9

B) Riffle Habitats

	Namoi River						Peel River	
	N01	N02	N03	N04	N05	N06	P01	P02
Band	C	C	B	B	B	A	B	*
Expected no of taxa (NTE50)	13.4	13.4	13.4	13.4	13.4	13.4	13.4	
Observed/expected no of taxa (OE50)	0.6	0.5	0.8	0.8	0.8	0.9	0.8	
Observed SIGNAL (O50SIGNAL)	4.6	4.9	4.9	4.7	4.8	4.6	4.5	
Expected Signal (E50SIGNAL)	5.1	5.1	5.1	5.1	5.1	5.1	5.0	
Observed/Expected SIGNAL scores (OE50SIGNAL)	0.9	1.0	1.0	0.9	1.0	0.9	0.9	

C) Edge and Riffle habitats combined

	Namoi River						Peel River	
	N01	N02	N03	N04	N05	N06	P01	P02
Overall Band	C	C	B	B	B	A	B	C

## **FIGURES**

Figure 1: Map of the study area and sampling sites.

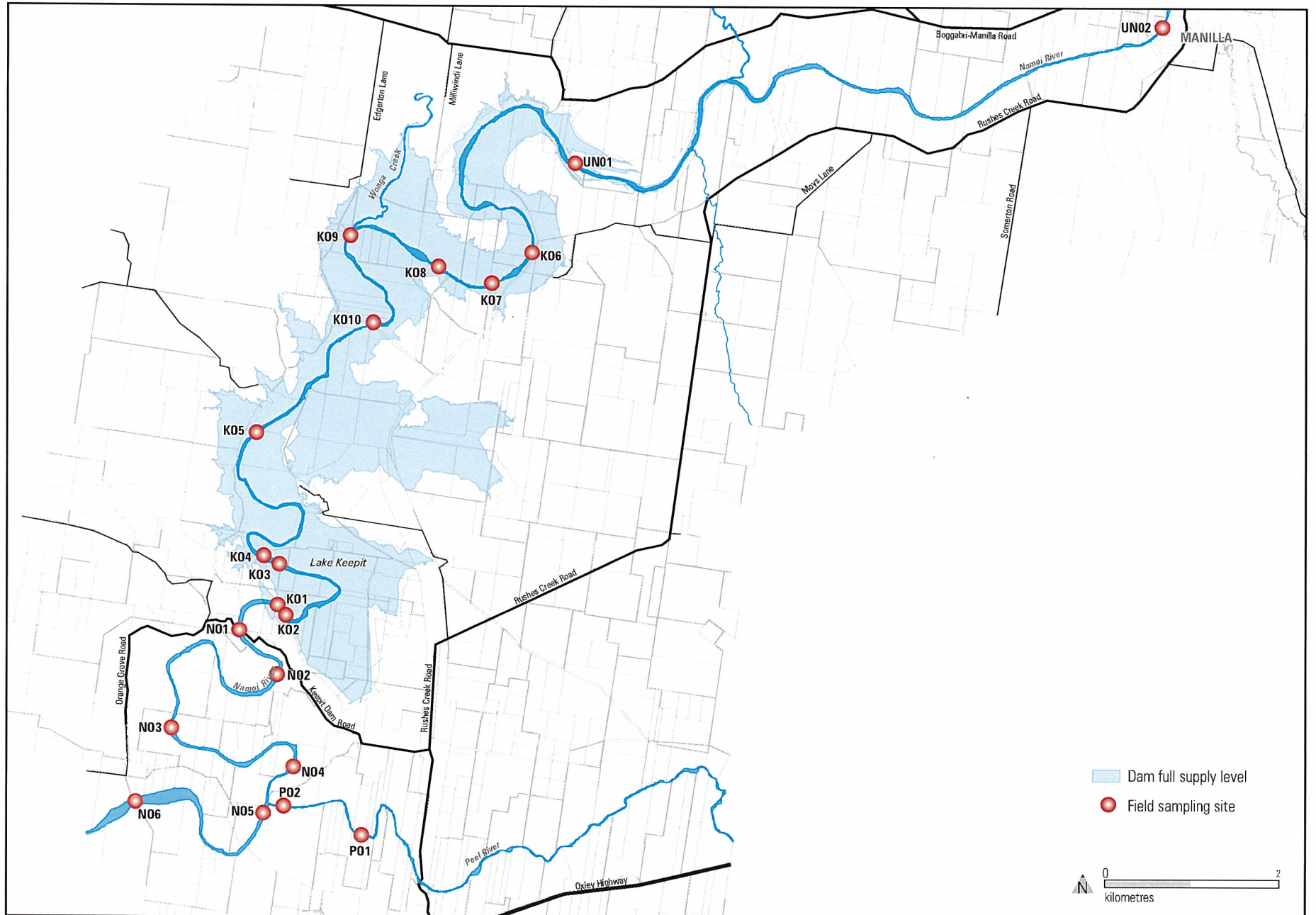


Figure 1 **Field sampling sites**

## PLATES

Plate 1 upper: Riparian vegetation along the Namoi River downstream of Keepit Dam.

Plate 1 lower: The riparian vegetation at Site N06 was typical in having both native and introduced species.

Plate 2 upper: The large pool at the base of Keepit Dam wall

Plate 2 lower: View of the Namoi River channel below Keepit Dam.

Plate 3 upper: View facing upstream through Site N01 while Ecology Lab personnel sample macroinvertebrates in riffle habitat.

Plate 3 lower: Facing downstream over Site N02.

Plate 4 upper: Site N03.

Plate 4 lower: Site N04.

Plate 5 upper: Site N05.

Plate 5 lower: Site N06.

Plate 6 upper: Lower reaches of the Peel River at Site P02.

Plate 6 lower: View facing upstream at the open and eroded banks of the Peel River at Site P01.

Plate 7 upper: Keepit Dam viewed from within the reservoir.

Plate 7 lower: Standing trees on Lake Keepit.

Plate 8 upper: Rocky outcrop at the edge of Lake Keepit at site of old quarry.

Plate 8 lower: The shallow upstream area of Lake Keepit.

Plate 9 upper: Native riparian vegetation along the upper Namoi River.

Plate 9 lower: Exotic riparian vegetation along the upper Namoi River near Manilla.

Plate 10 upper: Freshwater Catfish (*Tandanus tandanus*)

Plate 10 lower: Bony Herring (*Nematalosa erebi*)

Plate 11 upper: Golden Perch (*Macquaria ambigua*)

Plate 11 lower: Silver Perch (*Bidyanus bidyanus*)

Plate 12 upper: Murray Cod (*Maccullochella peeli*)

Plate 12 lower: Common Carp (*Cyprinus carpio*) mirrored form.



Plate 1 upper: Riparian vegetation along the Namoi River downstream of Keepit Dam.



Plate 1 lower: The riparian vegetation at Site N06 was typical in having both native and introduced species.



Plate 2 upper: The large pool at the base of Keepit Dam wall.



Plate 2 lower: View of the Namoi River channel below Keepit Dam.



Plate 3 upper: View facing upstream through Site N01 while Ecology Lab personnel sample macroinvertebrates in riffle habitat.



Plate 3 lower: Facing downstream over Site N02.



Plate 4 upper: Site N03.



Plate 4 lower: Site N04.



Plate 5 upper: Site N05.



Plate 5 lower: Site N06.



Plate 6 upper: Lower reaches of the Peel River at Site P02.



Plate 6 lower: View facing upstream at the open and eroded banks of the Peel River at Site P01.



Plate 7 upper: Keepit Dam viewed from within the reservoir.



Plate 7 lower: Standing trees on Lake Keepit.



Plate 8 upper: Rocky outcrop at the edge of Lake Keepit at site of old quarry.



Plate 8 lower: The shallow upstream area of Lake Keepit.



**Plate 9 upper: Native riparian vegetation along the upper Namoi River.**



**Plate 9 lower: Exotic riparian vegetation along the upper Namoi River near Manilla.**



Plate 10 upper: Freshwater Catfish (*Tandanus tandanus*)



Plate 10 lower: Bony Herring (*Nematalosa erebi*)



Plate 11 upper: Golden Perch (*Macquaria ambigua*)



Plate 11 lower: Silver Perch (*Bidyanus bidyanus*)



Plate 12 upper: Murray Cod (*Maccullochella peelii*)



Plate 12 lower: Common Carp (*Cyprinus carpio*) mirrored form.

## APPENDICES

- Appendix 1: GPS positions and descriptions of sampling sites for watercourses in and around Lake Keepit.
- Appendix 2: Classification scheme for watercourse crossings over fish habitat types (Source: Fairfull and Witheridge, 2003).
- Appendix 3. Site descriptors used to calculate RCE scores (after Chessman et al. 1997)
- Appendix 4: Habitat descriptors for sampling sites in the study area.
- Appendix 5: Fish sampled or observed in the study area in June 2006.
- Appendix 6: Fish sampled in Keepit Dam on 27 June 2006 using 60m gill nets.
- Appendix 7: Macroinvertebrate families identified from AUSRIVAS samples, collected from Edge and Riffle habitats from Namoi and Peel rivers, 13-15th June 2006.
- Appendix 8: Assessment of Significance: Potential Effects of the Keepit Dam Upgrade on the Murray Cod and the Namoi River Turtle
- Appendix 9: Assessment of Significance: Potential Effects of Keepit Dam Upgrade on Aquatic Species, Populations and Communities Listed Under the NSW *Fisheries Management Act 1994*

Appendix 1: GPS positions and descriptions of sampling sites in the study area. Datum: WGS84 Zone 56J.

Site	Easting	Northing	Watercourse	Location Description
N01D	259736	6580288	Namoi River	Orange Grove Rd Bridge
N01U	259667	6580349		
N02D	260445	6579195	Namoi River	Charcoal Bend: Keepet
N02U	260506	6579315		
N03D	258076	6578016	Namoi River	"Cashel"
N03U	258075	6578148		
N04D	260955	6577336	Namoi River	"Tinibri"
N04U	260997	6577461		
N05D	260246	6576131	Namoi River	Cobble riffle and pool
N05U	260237	6576233		
N06D	257068	6576329	Namoi River	Gunnembene Crossing
N06U	257071	6576393		
P01D	262503	6575674	Peel River	Long shallow riffle
P01U	262627	6575669		
P02D	260794	6576319	Peel River	Wide deep steep sided
P02U	260919	6576331		
K01	260400	6581081	Keepit Dam	Dam Wall
K02	260808	6580620	Keepit Dam	Quarry
K03	260156	6582194	Keepit Dam	Inlet channel with snags
K04	259796	6582407	Keepit Dam	Inlet with standing trees
K05	260181	6585306	Keepit Dam	Fishing club, shallow
K06	266502	6589326	Keepit Dam	Upper limit of navigation
K07	265689	6588595	Keepit Dam	Upstream shallow
K08	264349	6588894	Keepit Dam	Wider channel between
K09	262312	6589858	Keepit Dam	Wungo ck confluence
K10	263050	6587635	Keepit Dam	Sea eagle nest
UN1	267459	6591331	Upper Namoi	Manilla Ski Club (back
UN2	281424	6595358	Upper Namoi	Manilla Road/Rail bridge

Appendix 2: Classification scheme for watercourse crossings over fish habitat types (Source: Fairfull and Witheridge, 2003).

Classification	Characteristics of Waterway Type	Minimum [1] 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 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 [2] 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 [3] or ford.
Class 4 – Unlikely fish habitat	Named or unnamed waterway with intermittent flow following rain events only, little or no defined drainage channel, little or no free standing water or pools after rain events(e.g. dry gully, shallow floodplain depressions with no permanent wetland aquatic flora present.	Culvert [4], causeway or ford.

- [1] In all cases bridges are preferred to arch structures, culverts, fords and causeways (in that order).
- [2] High priority given to the “High Flow Design” procedures presented for the design of these culverts – refer to Design Considerations section of Fairfull and Witheridge (2003).
- [3] Minimum culvert design using the “Low Flow Design” procedures; however “High Flow Design” and “Medium Flow Design” should be given priority where affordable (refer to Witheridge (2002)).
- [4] Fish friendly waterway crossing designs possibly unwarranted. Fish passage requirements should be confirmed with the local fisheries department/authority.

Appendix 3. Site descriptors used to calculate RCE scores (after 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
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 4: Habitat descriptors for sampling sites in the study area. Riparian Channel Environmental (RCE) Inventory scores according to Chessman *et al.* (1997).

Date	13/06/2006		13/06/2006	
Watercourse	Naomi River		Naomi River	
Site	N01		N02	
Wetted width mode (m)	10		15	
RCE score	38		35	
Habitat type	Riffle	Edge	Riffle	Edge
Depth mode (m)	0.4	-	0.3	-
Depth of flow (m)	-	-	0.1	0.3
Flow (m/s)	1.15	0.2 (pool)	1.155	0.095 (pool)
% cover:				
bedrock	0	0	0	0
boulder	5	0	40	20
cobble	80	60	60	35
pebble	10	10	0	20
gravel	5	10	0	10
sand	0	10	0	5
silt	0	10	0	10
clay	0	0	0	0
Date	14/06/2006		14/06/2006	
Watercourse	Naomi River		Naomi River	
Site	N03		N04	
Wetted width mode (m)	8		6	
RCE score	35		32	
Habitat type	Riffle	Edge	Riffle	Edge
Depth mode (m)	0.4	-	0.3	-
Depth of flow (m)	0.15	0.5	0.15	0.4
Flow (m/s)	0.815	0.155 (pool)	0.69	0.215 (pool)
% cover:				
bedrock	0	5	0	0
boulder	0	5	5	5
cobble	65	40	25	50
pebble	0	5	45	0
gravel	15	5	15	25
sand	10	15	5	10
silt	10	25	5	10
clay	0	0	0	0
Date	14/06/2006		15/06/2006	
Watercourse	Naomi River		Naomi River	
Site	N05		N06	
Wetted width mode (m)	10		15	
RCE score	28		31	
Habitat type	Riffle	Edge	Riffle	Edge
Depth mode (m)	0.4	-	0.25	-
Depth of flow (m)	0.3	0.5	0.1	0.5
Flow (m/s)	0.94	0.195 (pool)	0.575	0.175 (pool)
% cover:				
bedrock	0	0	0	0
boulder	0	0	5	2
cobble	25	40	60	18
pebble	35	5	30	20
gravel	20	5	5	30
sand	10	5	0	10
silt	10	5	0	10
clay	0	0	0	10

Continued....

Appendix 4 (Continued).

Date	15/06/2006		14/06/2006	
Watercourse	Peel River		Peel River	
Site	P01		P02	
Wetted width mode (m)	8		20	
RCE score (from 2005)	24		26	
Habitat type	Riffle	Edge	Riffle	Edge
Depth mode (m)	0.3	-	-	-
Depth of flow (m)	0.25	0.5	-	-
Flow (m/s)	0.64	0.23 (pool)	-	-
% cover:				
bedrock	0	0	-	0
boulder	3	5	-	0
cobble	17	50	-	0
pebble	35	15	-	0
gravel	15	10	-	0
sand	10	5	-	0
silt	10	10	-	100
clay	10	5	-	0

Date	28/06/2006		28/06/2006	
Watercourse	Upper Namoi River		Upper Namoi River	
Site	UN01		UN02	
Wetted width mode (m)	12		35	
RCE score (from 2005)	24		35	
Habitat type	Riffle	Edge	Riffle	Edge
Depth mode (m)	-	-	-	-
Depth of flow (m)	-	0.1	0.15	-
Flow (m/s)	-	0.65 (pool)	0.765	-
% cover:				
bedrock	-	-	-	-
boulder	-	-	-	-
cobble	-	-	-	-
pebble	-	-	-	-
gravel	-	-	-	-
sand	-	-	-	-
silt	-	-	-	-
clay	-	-	-	-

Appendix 5: Fish sampled or observed in the study area in June 2006. A) Bait traps: 6 replicates set for 90 minutes, B) dip net and observations: presence marked as P, C) electrofishing: 5 second shots within 100 m.

Family	Common Name	Scientific Name																
A) Bait traps																		
			Watercourse				Namoi River				Namoi River							
			Date				28/06/2006				28/06/2006							
			Site				N01				N02							
			Replicate				1 2 3 4 5 6 7 8				1 2 3 4 5 6 7 8							
Eleotridae	Carp Gudgeon	<i>Hypseleotris</i> sp.					8 1 100				4 10 2 1 1 3							
Plotosidae	Freshwater Catfish	<i>Tandanus tandanus</i>																
			Watercourse				Namoi River				Namoi River							
			Date				28/06/2006				26/06/2006							
			Site				N05				N06							
			Replicate				1 2 3 4 5 6 7 8				1 2 3 4 5 6 7 8							
Eleotridae	Carp Gudgeon	<i>Hypseleotris</i> sp.									1 1							
Plotosidae	Freshwater Catfish	<i>Tandanus tandanus</i>									1							
			Watercourse				Peel River											
			Date				28/06/2006											
			Site				P01											
			Replicate				1 2 3 4 5 6 7 8											
Eleotridae	Carp Gudgeon	<i>Hypseleotris</i> sp.																
Plotosidae	Freshwater Catfish	<i>Tandanus tandanus</i>																

Continued...

Appendix 5 (Continued).

Family Common Name Scientific Name  
c) Electrofishing

			Date	28/06/2006	28/06/2006	
			Watercourse	Namoi River	Namoi River	
			Site	N01	N02	
			Total time (sec)	-	-	
			Number	Size Range (mm)	Number	Size Range (mm)
Eleotridae	Carp Gudgeon	<i>Hypseleotris sp.</i>				
Cyprinidae	Goldfish	<i>Carassius auratus</i>				
Plotosidae	Freshwater Catfish	<i>Tandanus tandanus</i>				
Cyprinidae	Carp	<i>Cyprinus carpio</i>				
Percichthyidae	Murray Cod	<i>Maccullochella peelii</i>	1	600		
			Date	28/06/2006	26/06/2006	
			Watercourse	Namoi River	Namoi River	
			Site	N05	N06	
			Total time (sec)	703	761	
			Number	Size Range (mm)	Number	Size Range (mm)
Eleotridae	Carp Gudgeon	<i>Hypseleotris sp.</i>			2	20
Cyprinidae	Goldfish	<i>Carassius auratus</i>				
Plotosidae	Freshwater Catfish	<i>Tandanus tandanus</i>			1	70
Cyprinidae	Carp	<i>Cyprinus carpio</i>				
Percichthyidae	Murray Cod	<i>Maccullochella peelii</i>				
			Date	28/06/2006		
			Watercourse	Peel River		
			Site	P01		
			Total time (sec)	525		
			Number	Size Range (mm)		
Eleotridae	Carp Gudgeon	<i>Hypseleotris sp.</i>				
Cyprinidae	Goldfish	<i>Carassius auratus</i>	1	160		
Plotosidae	Freshwater Catfish	<i>Tandanus tandanus</i>				
Cyprinidae	Carp	<i>Cyprinus carpio</i>	2	250-260		
Percichthyidae	Murray Cod	<i>Maccullochella peelii</i>				

Appendix 6: Fish sampled in Keepit Dam on 27 June 2006 using 60m gill nets. Fishing time = 30 minutes.

Family	Common Name	Scientific Name	Site	K02			K03		
				Size Range (mm)			Size Range (mm)		
				Number	TL (mm)	LCF (mm)	Number	TL (mm)	LCF (mm)
Clupeidae	Bony Bream	<i>Nematalosa erebi</i>		6	330-395	290-342	35	180-295	215-350
Percichthyidae	Golden Perch	<i>Macquaria ambigua</i>		13	310-400		3	290-310	
Cyprinidae	Carp	<i>Cyprinus carpio</i>		2	390-400	325-338			
Percichthyidae	Murray Cod	<i>Maccullochella peelii</i>		1	440				
Plotosidae	Freshwater Catfish	<i>Tandanus tandanus</i>		2	470-510				
Cyprinidae	Goldfish	<i>Carassius auratus</i>		1	250	235			
Terapontidae	Silver Perch	<i>Bidyanus bidyanus</i>							
			Site	K04			K05		
				Size Range (mm)			Size Range (mm)		
				Number	TL (mm)	LCF (mm)	Number	TL (mm)	LCF (mm)
Clupeidae	Bony Bream	<i>Nematalosa erebi</i>		6	205-295	250-340	23	230-405	270-415
Percichthyidae	Golden Perch	<i>Macquaria ambigua</i>		18	260-370		2	340-380	
Cyprinidae	Carp	<i>Cyprinus carpio</i>		1	360	410	1	375	420
Percichthyidae	Murray Cod	<i>Maccullochella peelii</i>							
Plotosidae	Freshwater Catfish	<i>Tandanus tandanus</i>							
Cyprinidae	Goldfish	<i>Carassius auratus</i>							
Terapontidae	Silver Perch	<i>Bidyanus bidyanus</i>		5	290-320	300-330	1	460	

Continued...

Appendix 6 (Continued).

Family	Common Name	Scientific Name	Site	K07			K08		
				Size Range (mm)			Size Range (mm)		
				Number	TL (mm)	LCF (mm)	Number	TL (mm)	LCF (mm)
Clupeidae	Bony Bream	<i>Nematalosa erebi</i>							
Percichthyidae	Golden Perch	<i>Macquaria ambigua</i>							
Cyprinidae	Carp	<i>Cyprinus carpio</i>				3	450-500	510-570	
Percichthyidae	Murray Cod	<i>Maccullochella peelii</i>							
Plotosidae	Freshwater Catfish	<i>Tandanus tandanus</i>							
Cyprinidae	Goldfish	<i>Carassius auratus</i>							
Terapontidae	Silver Perch	<i>Bidyanus bidyanus</i>							
			Site	K09			K10		
				Size Range (mm)			Size Range (mm)		
				Number	TL (mm)	LCF (mm)	Number	TL (mm)	LCF (mm)
Clupeidae	Bony Bream	<i>Nematalosa erebi</i>		10	320-390	365-450	8	185-210	215-250
Percichthyidae	Golden Perch	<i>Macquaria ambigua</i>		1	390		1	335	
Cyprinidae	Carp	<i>Cyprinus carpio</i>		11	335-510	370-560			
Percichthyidae	Murray Cod	<i>Maccullochella peelii</i>							
Plotosidae	Freshwater Catfish	<i>Tandanus tandanus</i>							
Cyprinidae	Goldfish	<i>Carassius auratus</i>							
Terapontidae	Silver Perch	<i>Bidyanus bidyanus</i>							

Appendix 7: Macroinvertebrate families identified from AUSRIVAS samples, collected from Edge and Riffle habitats from Namoi and Peel rivers, 13-15th June 2006. The Signal2 Grade based on Chessman (2003). No entry in SIGNAL2 Grade column indicates no assigned grade for that group. Summary statistics are given for the number of different taxonomic groups.

<b>Order or Family</b>	<b>Habitat Site Location</b>	Namoi N01	Namoi N02	Namoi N03	Namoi N04	Namoi N05	Namoi N06	Peel P01	Peel P02	Namoi N01 Riffle	Namoi N02 Riffle	Namoi N03 Riffle	Namoi N04 Riffle	Namoi N05 Riffle	Namoi N06 Riffle	Peel P01 Riffle	Signal2 Grade
Animalia Unidentified A																	
Atyidae		10	9	6	10	10	4	10	10	2				1			3
Baetidae				5	10	10	2	10		5		7	10	4	10	10	5
Caenidae		1	5	5	5	10	2		1				1	6	3	2	4
Ceratopogonidae															1		4
Chironomidae/Chironominae		9	10	5	10	10	10	4	2	10	10	6	4	1	10	4	3
Chironomidae/Orthoclaadiinae		7	1	7	4	6	4			10	10	5	5	8	9	4	4
Chironomidae/Tanypodinae			5		3	1	1	1	1				1				4
Cirolanidae					1		1		1								2
Cladocera			1	1	10	1	6	10								1	
Coenagrionidae			1	1	6	1	5										2
Copepoda		1		1	10	1	2	5	2	6			2				
Corbiculidae				2		2				3	6	5	4	1	10	5	4
Corixidae		1	10	6	10	10	10	10	9								2
Culicidae								1									1
Dugesiiidae															4		2
Dytiscidae				2	1		1	2									2
Ecnomidae										2	10	10	7	3	2		4
Entomobryidae/Isotomidae							2	5							1		
Ephydriidae										1							2
Erpobdellidae			1				2								2	6	1
Gomphidae				1													5
Gyrinidae														2			4
Hydracarina			1														6
Hydraenidae (= Limnebiidae)							2		1								3
Hydrobiosidae												1		1	1		8
Hydrophilidae		1				1	2										2
Hydropsychidae				1		5		2		10	3	10	3	8	10	10	6
Hydroptilidae				2		1		1								2	4
Hypogastruridae					1												
Leptoceridae				10	10	10	10								1		6
Leptophlebiidae		4	1	10	3	8		3		6	5	10	10	10	10	10	8
Nematoda												1					3
Notonectidae				1			3	3									1
Oligochaeta		2	1	4	1	1	10			1		1		5	10	8	2
Ostracoda			3					1						1	2	10	
Palaemonidae		1	1		5	10	3	2	1		3	4	2	10	3	3	4
Parastacidae				2		1											4
Physidae					2		4	3							1		1
Pleidae			2	1													2
Protoneuridae				6		6	1										4
Pyralidae							1										3

Simuliidae	2	2	6	2	7				10	10	10	10	9	10	10	5
Tabanidae										1					1	3
Temnocephalidae			2		1									2	2	5
Veliidae					1											3
<b>Number of taxa</b>	10	16	22	20	21	26	12	9	12	12	15	20	17	9	16	
Number of worm taxa	2	3	5	6	5	6	2	1	3	3	3	6	3	1	4	
Number of crustacean taxa	4	5	6	5	5	9	2	2	2	3	3	2	6	4	2	
Number of mollusc taxa	4	7	6	7	7	8	4	2	3	3	5	6	6	4	6	
Number of insect taxa	0	0	3	1	3	2	2	2	3	2	3	4	2	0	2	
Number of mayfly taxa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Number of damselfly/dragonfly	0	0	1	0	1	0	0	0	1	0	1	1	1	0	1	
Number of bug taxa	0	0	1	0	1	0	1	1	1	1	1	1	1	0	1	
Number of beetle taxa	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	
Number of true fly taxa	0	0	1	1	1	2	0	0	0	0	0	1	0	0	0	
Number of caddis-fly taxa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Number of other insect taxa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Number of other taxa	0	1	1	1	1	1	2	2	1	1	1	2	0	0	2	

*Report to:*  
Parsons Brinckerhoff

**Appendix 8**  
**Assessment of Significance**  
**Potential Effects of Keepit Dam Upgrade on the Murray Cod and the**  
**Namoi River Turtle**

**FINAL**  
April 2007

**The Ecology Lab** Pty Ltd

**Marine and Freshwater Studies**



**Appendix 8**  
**Assessment of Significance**  
**Potential Effects of Keepit Dam Upgrade on the Murray Cod and the**  
**Namoi River Turtle**

April 2007

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Report Number 36/0203 B  
Report Status – Final 30/04/07

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Appendix 5 (Continued).

Family            Common Name        Scientific Name

B) Dip Nets and Observations

			Watercourse	Namoi River	Namoi River
			Date	28/06/2006	28/06/2006
			Site	N01	N02
Poeciliidae	Mosquito Fish	<i>Gambusia holbrooki</i>		✓	✓
Eleotridae	Carp Gudgeon	<i>Hypseleotris sp.</i>		✓	✓
Clupeidae	Bony Bream	<i>Nematalosa erebi</i>		✓	
			Watercourse	Namoi River	Namoi River
			Date	28/06/2006	26/06/2006
			Site	N05	N06
Poeciliidae	Mosquito Fish	<i>Gambusia holbrooki</i>		✓	
Eleotridae	Carp Gudgeon	<i>Hypseleotris sp.</i>		✓	
Clupeidae	Bony Bream	<i>Nematalosa erebi</i>			
			Watercourse	Peel River	
			Date	28/06/2006	
			Site	P01	
Poeciliidae	Mosquito Fish	<i>Gambusia holbrooki</i>		✓	
Eleotridae	Carp Gudgeon	<i>Hypseleotris sp.</i>		✓	
Clupeidae	Bony Bream	<i>Nematalosa erebi</i>			

Continued...

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## 1.0 ASSESSMENT OF SIGNIFICANCE: POTENTIAL EFFECTS OF KEEPIT DAM UPGRADE.

Assessments of significance were conducted for the potential impact of the proposed Keepit Dam upgrade options on two threatened species; the Namoi River turtle (*Elseya bellii*) and the Murray cod (*Maccullochella peelii peelii*). Where relevant, assessments were made in accordance with the Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act (1999) guidelines and the heads of consideration as specified in the Department of Environment and Conservation/Department of Primary Industries (2005) Draft Guidelines for Threatened Species Assessment which require consideration under Part 3A of the Environmental Planning and Assessment (EP&A) Act of NSW (1979).

All three options to upgrade Keepit Dam involve raising the existing main and subsidiary dam walls, modification of the peninsula near the dam wall, and construction of new saddle dams and spillways. The main potential impacts on the aquatic habitat and biota that could result from the upgrade options are associated with the mobilisation of sediment into the main water body of Lake Keepit and into the Namoi and Peel Rivers downstream of the dam, resulting from earthworks and/or the erosive scour from new spillways.

Impacts on the aquatic ecology that may result from increased sediment runoff into aquatic habitats include:

- Increased sedimentation within water courses which can result in the reduction of available deep water refuge areas for aquatic biota and smothering of important habitat features such as beds of aquatic macrophytes and rocky substratum.
- Reduction of water quality including increased turbidity and increased nutrient levels.
  - Increased turbidity within the lake could result in the reduction of light penetration and subsequent reduction of aquatic macrophytes, altering existing aquatic habitat.
  - Increased nutrient levels may encourage algal growth with potential toxic algal blooms resulting in negative impacts on aquatic fauna.

Impacts from earthworks can be effectively minimised or eliminated by the incorporation of standard mitigation measures during the construction phase of the project. Such mitigation measures should include:

- Where possible, sediment should be prevented from entering the main body of Lake Keepit and the Namoi and Peel Rivers. This can be achieved by the use of sediment fences or bunding between earthworks and waterbodies.
- Where sediment fences are not appropriate because construction activities occur on the waterline, sediment dispersal within the lake should be contained within a limited area in the vicinity of works by the use of a floating silt curtain. The silt curtain should be deployed to enclose all works along the waterline, and should enclose as small an area of the water body as possible.

- Revegetation of disturbed areas such as access roads and stockpile sites following completion of construction to prevent ongoing erosion and resultant runoff into the Namoi and Peel Rivers and Lake Keepit.
- Where possible, work should be conducted during periods of low rainfall and river flow.

For most flow levels the three upgrade options are considered as having equivalent potential impacts on the aquatic ecology of the Keepit storage and the Namoi-Peel River system downstream of the Keepit Dam. However an assessment of erosion and sedimentation potential (Parsons Brinckerhoff, 2006) found that during extreme flood events Option B1 would result in a significantly greater volume of eroded sediment than the other options due to the more susceptible soils found downstream of the subsidiary dam wall spillway. However the impacts of this increased erosion would be restricted to the Peel River downstream to confluence of the Namoi River. Beyond this point, sedimentation impacts from this option would be indistinguishable from other options.

## 1.1 Preliminary Assessment Under Part 3A of the EP&A Act

### 1.1.1 Namoi River Turtle, *Elseya bellii*

The Namoi River turtle, *Elseya bellii*, is known to inhabit watercourses of the upper Namoi River catchment (Wilson and Swan 2004, Web Reference 1, Department of the Environment and Heritage 2007, Web Reference 3). This species is currently listed as Vulnerable on Schedule 2 of the NSW Threatened Species Conservation (TSC) Act (1995). This species is also listed as Vulnerable under the EPBC Act. As such it must be considered in accordance with the Draft Guidelines for Threatened Species Assessment Part 3A of the EP&A Act. The first step of this assessment is to conduct a preliminary assessment to determine the likelihood of the study area supporting this threatened species.

*E. bellii* has been recorded in the narrow upper reaches of the Namoi and MacDonald Rivers, above 700 – 800m ASL. (Wilson and Swan 2004, Web Reference 1, Department of the Environment and Heritage 2007, Web Reference 3). Although found at few sites it is relatively abundant when present (NSW Scientific Committee 1997).

The Keepit Dam lies at an elevation of approximately 300m ASL (Preece and Jones, 2002). The maximum design level of inundation upstream under present conditions is 333.5m AHD (Parsons Brinckerhoff 2005) which would not increase appreciably following the upgrade, as the greatest proposed change to dam wall height is an increase of 5.5m under option D3. Therefore, it would appear that the existing populations of the Namoi River turtle do not inhabit watercourses potentially impacted by the proposed upgrade options for Keepit Dam.

It is possible that the distribution of *E. bellii* has not been fully resolved as relatively few surveys have been conducted and little is known about the species' biology and ecology. There have been reported sightings from the Macquarie Marshes (NSW Scientific Committee 1997, Web Reference 2) and, if verified, this would expand the distribution of *E. bellii* westwards, and it would be necessary to treat the watercourses below Keepit Dam as potential habitat. However these putative sightings appear to have been discredited. The turtle's habitat requirements appear to restrict its distribution to the cold, clear waters of higher altitude tributaries. The NSW TSC Act lists *E. bellii* as occurring only in the Eastern Nanewars sub-section of the Namoi Catchment (Web Reference 1), upstream of the Keepit Dam which is located in the adjacent Peel sub-section to the west.

Considering all available information relating to the distribution of this species, it is unlikely that populations of the Namoi River turtle occur within the area potentially impacted by the Keepit Dam upgrade, and no further assessment of this species is considered necessary.

### **1.1.2 Murray Cod, *Maccullochella peelii peelii***

Murray cod is not listed as a Threatened species in NSW and as such it is not necessary to assess the potential impacts of the upgrade under the Draft Guidelines for Threatened Species Assessment (Department of Environment and Conservation/Department of Primary Industries 2005). The species is listed as Vulnerable in the EPBC Act and therefore an assessment of significance has been completed in Section 1.2.2.

Murray cod do comprise part of the endangered ecological community of the natural drainage of the lowland catchment of the Darling River, listed in the NSW Fisheries Management (FM) Act (1994). Threats to this community include river regulation, water extraction, introduced pests and degradation of riverine habitat. Any potential impact on this community due to an upgrade of Keepit Dam requires consideration under the Draft Guidelines for Threatened Species Assessment (Department of Environment and Conservation/Department of Primary Industries 2005). Given that the Murray cod is a large apex predator within this community it is possible that a severe decline of its population could have a flow-on effect that would modify the composition of the community.

## 1.2 EPBC Act Impact Assessments

### 1.2.1 Namoi River Turtle, *Elseya bellii*

The Namoi River turtle is listed as a Vulnerable Species under the EPBC Act.

The assessment under the Draft Guidelines for Threatened Species Assessment (Department of Environment and Conservation/Department of Primary Industries 2005) for *E. bellii* concluded that none of the three proposed upgrade options for the Keepit Dam are likely to have a significant impact on existing populations or habitat (see Section 1.1.1).

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

The proposed upgrade to Keepit Dam is unlikely to result in any decrease of *E. bellii* populations as the species does not appear to inhabit any watercourses that might potentially be affected.

***Will the action reduce the area of occupancy of an important population?***

The proposal will not reduce the area of occupancy of *E. bellii* as no populations are known from areas that may be potentially affected by an increase in sediment loads.

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

The proposed upgrade will not fragment existing populations of the Namoi River turtle.

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

No critical habitat of *E. bellii* is known to occur in the area potentially affected by the proposed upgrade to Keepit Dam.

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

The proposal will not disrupt the breeding cycle of Namoi River turtle as no part of the area potentially affected by the upgrade is utilised by *E. bellii* populations.

***Will the action modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?***

No known habitat of *E. bellii* is known to occur in the area that might be affected by the proposed upgrade options to the Keepit Dam.

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

The red fox (*Vulpes vulpes*) has been known to dig up the nests of *E. bellii* and feed on its eggs. Domestic livestock can trample river banks and riparian vegetation reducing the

availability of turtle nesting habitat. These animals are already well established within the range of the Namoi River turtle and they would not be affected by the proposal. Keepit Dam represents an impassable barrier upstream to aquatic fauna and this will not be affected by the various upgrade options. It is unlikely that the proposal would lead to a dangerous invasive species becoming established in the habitat of *E. bellii*.

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

It is unlikely that the nature of the proposed upgrade would result in the introduction of new pathogens which could adversely affect *E. bellii* populations further upstream. Some *E. bellii* individuals already suffer from an eye disease that is related to poor water quality, but the proposed upgrade to Keepit Dam would have no affect on water quality in creeks where *E. bellii* populations are found.

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

The potentially impacts of the proposal will not interfere with recovery plans for *E. bellii*.

**Conclusion:**

The proposed upgrade options for Keepit Dam are unlikely to have an impact on this species as it does not appear to inhabit or utilise any potentially affected areas. The upgrade need not be modified to accommodate the requirements of the Namoi River turtle. Referral of the proposed upgrade in relation to this species to the Department of the Environment and Heritage as prescribed by the EPBC Act is therefore not required.

**1.2.2 Murray Cod, *Maccullochella peelii peelii***

The Murray cod is listed as a Vulnerable Species under the EPBC Act. It was not considered under Draft Guidelines for Threatened Species Assessment (Department of Environment and Conservation/Department of Primary Industries 2005) as it is not a listed threatened species in the NSW FM Act.

Fish sampling undertaken in this study, and the results of previous surveys, have demonstrated that populations of Murray cod exist within the Namoi River, up and downstream of Keepit Dam, in the Peel River and within the dam storage (Web Reference 3, Harris and Gehrke 1997). As such, the watercourses potentially impacted by the proposed dam upgrades should be considered as habitat for existing populations of *M. peelii peelii*.

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

Historically, Murray cod numbers have experienced a long-term decline as a result of combined factors including; overfishing, regulated river flows, barriers to passage, thermal pollution and the loss of instream habitat (Morris *et al.*, 2001). Whilst the commercial fishery in NSW was closed in 2001 and the removal of large woody debris has been listed as a Key Threatening Process, Keepit Dam represents an absolute barrier to fish passage, regulates

environmental flows and releases cold water downstream. These continuing impacts will not be altered by the upgrade options and are not considered as part of the current proposal.

There have been anecdotal accounts of increases in some NSW Murray cod populations over the last 5 -10 yrs (Rowland 2005) although it is difficult to assess the health of populations in the Namoi region as (i) there is no longer any formal stock assessment in NSW, and (ii) it is difficult to tell whether identified fish represent natural populations or have been stocked as part of a widespread and longstanding enhancement program (NSW Fisheries 2003). Regardless of the local status of Murray cod, all populations require the same consideration under federal threatened species legislation.

High sediment loads from either earthwork or the erosive flows below new spillways can potentially cause a decline in cod populations in a number of ways. For example; degradation of spawning and foraging habitat, fragmentation of populations (especially during periods of low flow) and declines in prey abundance (see relevant criteria below).

Large volumes of suspended sediments can also be a direct cause of mortality. Fish kills from clogged gills is a lethal response to the inability to respire (Web Reference 4). However the Murray cod may be more resilient to this type of stress as they are often found to inhabit turbid environments. This is also unlikely to cause long-term declines in populations as the incidents will only last as long as the duration of the high sediment loads.

The upgrade proposal is unlikely to cause a long-term decrease in Murray cod populations if the suggested safeguards to mitigate sediment mobilisation are implemented.

***Will the action reduce the area of occupancy of an important population?***

The presence of Murray cod has been well documented throughout watercourses that may be affected by the proposed actions (Web Reference 3, Harris and Gehrke 1997). A temporary reduction in occupancy is possible in some areas during construction, or an extreme flood event, if there is a large increase in the volume of suspended sediments. The speed of re-colonisation from unaffected areas would depend on the severity of the episode. Any lingering or permanent degradation of habitat could result in a longer-term reduction in occupancy.

It is considered unlikely that occupancy would be reduced by the effect of earthworks providing the suggested safeguards are implemented.

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

It is unlikely the proposal would significantly increase long-term fragmentation of existing populations if suggested mitigation measures are adopted and upgrade options are selected to minimise erosive potential.

Populations of Murray cod are already effectively separated by the various barriers to fish passage. The Keepit Dam is an absolute barrier to fish migrating upstream and most probably downstream as well.

It is possible that siltation could cause existing shallow sections or features to become more effective barriers to fish movement during periods of low flow and similarly diminish the frequency and/or effectiveness of deeper areas to provide refuge. However, variable flow and the resulting seasonal fragmentation of populations are natural phenomena in Australian inland freshwater systems. If suggested safeguards to minimise sediment loads

are implemented it is unlikely that the isolation of currently interconnecting areas of habitat would be greater than is currently experienced.

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

Deep holes containing cover (e.g. rocks and fallen trees) constitute important foraging habitat for the Murray cod and important shelter, especially as refuges during low flows. Potential impacts on this habitat from increased sediment loads and eutrophication can be minimised if mitigation measures are implemented.

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

When water temperatures reach ~20°C adult Murray cod migrate large distances upstream to spawn in small tributaries (Morris *et al.*, 2001). Their eggs are adhesive and are often spawned onto hard surfaces such as rocks and submerged logs. Adults then return back to their pre-spawning locations and upon attaining 9 – 14mm in length the larvae begin their own migration downstream (McDowall 1996). Recruitment is optimised when larvae are able to utilise productive inundated floodplains during periods of high flow (Morris *et al.*, 2001). However, elements of this breeding cycle are severely disrupted by the current operation of various dams in the region. River flows are regulated, reducing frequency and intensity of inundation of wetlands, warm water spawning cues are obscured by cold dam releases and the presence of numerous in-stream barriers limit spawning migrations.

Increased turbidity can disrupt the ability of some freshwater fish to migrate for spawning. However this would appear less likely to affect the Murray cod which are fairly well adapted to living in turbid environments. Existing barriers to migration constitute a much larger impact.

Increased sediment loads in spawning habitat could potentially reduce recruitment as available hard surfaces for eggs are smothered in silt. Studies have also demonstrated that suspended sediments can negatively impact egg and fry development and the survival of macroinvertebrate prey (Web Reference 4). But as adults migrate into narrower tributaries to spawn it is unlikely that sediment from construction would find into these upstream habitats (except during flood events). All upgrade options result in an increase of inundation in areas upstream of the dam wall. Spawning grounds in these areas could become affected by siltation during flood flows but conversely the inundation of habitat adjacent to streams could provide extra productivity for larval fish.

Effective management of exposed sediments during earthworks would minimise or eliminate any of these potential effects.

***Will the action modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?***

High sediment loads can potentially modify and degrade spawning and foraging habitat, reduce the number and effectiveness of deep pool refugia, thereby increasing fragmentation of populations during periods of low flow. Siltation can also degrade the habitat of prey species causing a decline in abundance.

However, it is unlikely the proposed upgrade would significantly affect habitat if suggested measures are implemented to trap sediment and prevent it entering the waterway.

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

Morris *et al.* (2001) suggest that competition with alien species may have a detrimental effect on cod larvae and juveniles. It is unlikely that the proposed upgrade would be responsible for introducing or establishing harmful invasive species. Introduced freshwater fish species such as the common carp (*Cyprinus carpio*), mosquitofish (*Gambusia holbrooki*) and goldfish (*Carassius auratus*) are already well established in watercourses both above and below the dam (Web Reference 3, Harris and Gehrke 1997). Keepit Dam represents an absolute barrier to fish movement and the proposed upgrade will have no effect on this.

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

It is unlikely that the proposed upgrade activities would introduce a new pathogen to Murray cod populations. Increased levels of suspended sediments may decrease the resistance of fish to disease (Web Reference 4) but the chance of this can be minimised by effective management of earthworks during construction.

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

Priority recovery objectives for the Murray cod include the restoration of key elements to natural flow regimes, restoration of habitat and the removal of barriers to fish passage for breeding migration (Morris *et al.*, 2001).

The potential impacts from the proposed upgrade, namely, increased levels of suspended sediments, are not one of the major threats to the Murray cod. Measures taken to minimise the mobilisation of sediment should ensure that the upgrade will have little to no impact on the cod's potential recovery.

**Conclusion:**

Key threats faced by Murray cod include barriers to passage, regulated river flows, thermal pollution and loss of in-stream habitat. The upgrade to Keepit Dam has the potential to degrade habitat and affect populations of Murray cod by increasing sediment loads in adjacent and downstream watercourses. However, the proposal is unlikely to have an impact on this species if the suggested measures to mitigate the mobilisation of sediment are adopted. In the case of extreme flood events, options D2 and D3 are preferable to option B1 with respect to minimising sediment loads within the Peel River. However downstream of the Namoi – Peel River confluence there no difference between these options is anticipated. Therefore while option B1 is expected to have a slightly greater impact because it influences the Peel River, this impact is expected to be limited in the context of the large scale environmental change associated with such an extreme flood event. Referral of this proposed upgrade in relation to this species to the Department of the Environment and Heritage as prescribed by the EPBC Act is not required.

## **2.0 ACKNOWLEDGEMENTS**

This report was written by Bob Hunt and Doug Hazell, reviewed by Dr Peggy O'Donnell.

### 3.0 REFERENCES

Department of the Environment and Heritage (2007). *Elseya bellii* in Species Profile and Threats Database, Department of the Environment and Heritage, Canberra. Available from: <http://www.deh.gov.au/sprat>. Accessed 16/1/2007.

Harris, J. H. and Gehrke, P. C. (1997). *Fish & Rivers in Stress: The NSW Rivers Survey*. NSW Fisheries, Cronulla, NSW, 298 pp.

McDowall, R. (1996). *Freshwater Fishes of South-Eastern Australia*. Reed Books, Sydney NSW, 1-247 pp.

Morris, S. A., Pollard, D. A., Gehrke, P. and Pogonoski, J. J. (2001). *Threatened and Potentially Threatened Freshwater Fishes of Coastal New South Wales and the Murray-Darling Basin*. Prepared for: Commonwealth Government's Fisheries Action Program/ /World Wide Fund for Nature. NSW Fisheries Office of Conservation, NSW.

NSW Fisheries (2003). *Freshwater fish stocking in NSW. Environmental Impact Assessment. Public consultation document*. NSW Fisheries, Cronulla Fisheries Centre, NSW.

NSW Scientific Committee (1997) Bell's turtle - Vulnerable species determination - final. DEC (NSW), Sydney. Available from: <http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Bells+turtle+vulnerable+species+listing> Accessed 16/1/2007.

Parsons Brinckerhoff (2006). *Keepit Dam Upgrade Environmental Assessment, Technical paper 6, Erosion and Sedimentation. Draft*. Report by Parsons Brinckerhoff for State Water Corporation.

Preece, R. M. and Jones, H. A. (2002). The effect of Keepit Dam on the temperate regime of the Namoi River, Australia. *River Research and Applications* **18**: 397 – 414.

Rowland, S.J. (2005) Overview of the history, fishery, biology and aquaculture of Murray cod (*Maccullochella peelii peelii*). In: *Management of Murray cod in the MDB. Statements, recommendations and supporting papers*. Workshop, 3–4 June, 2004, Canberra.

Web Reference 1. NSW Department of Environment and Conservation. Threatened Species, Populations and Ecological Communities of NSW. Bell's Turtle - Profile. Available from: <http://threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10266> Accessed 16/1/2007.

Web Reference 2. Department of Environment and Heritage. Threatened Species Publications. The Action Plan for Australian Reptiles – Namoi River Elseya. Available from: <http://www.deh.gov.au/biodiversity/threatened/publications/action/reptiles/4.html> Accessed 16/1/2007.

Web Reference 3. BioNet. Collaborative database combining records of the Australian Museum, NSW Department of Environment and Conservation and NSW Department of Primary Industries. [http://www.bionet.nsw.gov.au/BioNet.cfm?is\\_ie5up](http://www.bionet.nsw.gov.au/BioNet.cfm?is_ie5up)

Web Reference 4. Fisheries and Oceans Canada. (2003). Fact Sheet T-1: Fish Habitat and the effects of silt and sediment. Fisheries and Oceans Canada. Available from: [http://www.dfo-mpo.gc.ca/regions/CENTRAL/pub/fact-fait/t1\\_e.htm](http://www.dfo-mpo.gc.ca/regions/CENTRAL/pub/fact-fait/t1_e.htm) Accessed 16/1/2007.

Wilson, S. and Swan, G. (2004). *A complete Guide to Reptiles of Australia*. Reed New Holland, Sydney, Australia.

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**Appendix 9**  
**Assessment of Significance**  
**Potential Effects of Keepit Dam Upgrade on Aquatic Species,  
Populations and Communities Listed Under the NSW Fisheries  
Management Act 1994**

**FINAL**  
November 2007

**The Ecology Lab** Pty Ltd

**Marine and Freshwater Studies**



**Appendix 9**  
**Assessment of Significance**  
**Potential Effects of Keepit Dam Upgrade on Aquatic Species,  
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November 2007

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Report Number 36/0203 C  
Report Status – Final 12/11/07

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## 1.0 BACKGROUND.

### 1.1 Listed Species, Populations and Communities

Assessments of significance were conducted for the potential impact of the proposed Keepit Dam upgrade options on threatened species, populations and ecological communities listed under the *NSW Fisheries Management Act 1994* that have a distribution that may include the study area. The following species, populations and ecological communities were assessed:

#### Endangered Species

- River snail (*Notopala sublineata*)

#### Endangered Populations

- Olive perchlet (*Ambassis agassizii*)
- Purple spotted gudgeon (*Mogurnda adspersa*)

#### Vulnerable Species

- Silver perch (*Bidyanus bidyanus*)

#### Endangered Ecological Communities

- Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River.

Assessments were made in accordance with the heads of consideration as specified in the Department of Environment and Climate Change (2007) *Threatened Species Assessment Guidelines* which require consideration under Part 3A of the *Environmental Planning and Assessment (EP&A) Act of NSW 1979*.

### 1.2 Overview of Potential Impacts

All three options to upgrade Keepit Dam involve raising the existing main and subsidiary dam walls, modification of the peninsula near the dam wall, and construction of new saddle dams and spillways. The main potential impacts on the aquatic habitat and biota that could result from the upgrade options are associated with the mobilisation of sediment into the main water body of Lake Keepit and into the Namoi and Peel Rivers downstream of the dam, resulting from earthworks and/or the erosive scour from new spillways.

Impacts on the aquatic ecology that may result from increased sediment runoff into aquatic habitats include:

- Increased sedimentation within water courses which can result in the reduction of available deep water refuge areas for aquatic biota and smothering of important habitat features such as beds of aquatic macrophytes and rocky substratum.
- Reduction of water quality including increased turbidity and increased nutrient levels.

- Increased turbidity within the lake could result in the reduction of light penetration and subsequent reduction of aquatic macrophytes, altering existing aquatic habitat.
- Increased nutrient levels may encourage algal growth with potential toxic algal blooms resulting in negative impacts on aquatic fauna.

Impacts from earthworks can be effectively minimised or eliminated by the incorporation of standard mitigation measures during the construction phase of the project. These recommendations for mitigation measures have been outlined in Section 4.1 of the main report.

For most flow levels during the operation phase of the upgraded dam the three upgrade options are considered as having equivalent potential impacts on the aquatic ecology of the Keepit storage and the Namoi-Peel River system downstream of the Keepit Dam. However an assessment of erosion and sedimentation potential (Parsons Brinkerhoff, 2006) found that during extreme flood events Option B1 would result in a significantly greater volume of eroded sediment than the other options due to the more susceptible soils found downstream of the subsidiary dam wall spillway. However the impacts of this increased erosion would be restricted to the Peel River downstream to confluence of the Namoi River. Beyond this point, sedimentation impacts from this option would be indistinguishable from other options.

## 2.0 ASSESSMENTS OF SIGNIFICANCE

### 2.1 River snail (*Notopala sublineata*)

A recovery plan for the endangered river snail has recently been produced by the NSW DPI (2007). This document contains important information about the biology and ecology of this species, and the current issues and threats being faced. These have been summarised below.

The distribution of the river snail was once extensive throughout the Murray-Darling Basin, associated with habitat features such as logs, rocks and muddy banks. Three sub-species (*N. sublineata hanleyi*, *N. sublineata alisoni* and *N. sublineata sublineata*) have been described within the Murray Darling Basin, of which *N. sublineata sublineata* is known to have a range incorporating tributaries of the Darling River including the Namoi and Peel rivers. *N. sublineata sublineata* (hereafter referred to as the river snail) is considered to be virtually extinct throughout its natural range, however populations have recently been found surviving in artificial habitats such as irrigation pipelines. The decline in the distribution and abundance of the river snail has been attributed to:

- (i) Habitat modification due to widespread and extensive river regulation, mainly weir building, which has altered the food supply.
- (ii) Removal of large woody debris which provided habitat and grazing surfaces.
- (iii) Increased sedimentation resulting in reduced habitat diversity.
- (iv) The introduction of European Carp (*Cyprinus carpio*) resulting in habitat alteration and possible predation.

Although the river snail is currently considered to be extinct within the study area, there does exist potential appropriate habitat within the reaches of the Peel and Namoi Rivers downstream of the proposed dam upgrade. These habitats could be considered as important for the river snail if a reintroduction program within this area was to be

incorporated into the recovery plan for this species. Although it is considered highly unlikely that a population of this species is present within the study area, and hence is unlikely to experience any direct or indirect impacts, an assessment of significance has been undertaken as a precautionary approach.

### **Assessment of Significance for the River Snail**

*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.*

Current understanding of the distribution of the river snail within the Namoi and Peel rivers (within the Murray Darling Basin) strongly suggests that the species is extinct throughout its natural range, with living specimens having only recently been found within artificial environments such as irrigation pipelines (NSW DPI, 2007). As such, potential impacts from the proposed action including possible limited increased sedimentation during construction, and possible flow modification during operation will not have an adverse effect on the life cycle of the species because there will be no direct or indirect impact upon artificial habitats such as irrigation pipelines resulting from this proposed action. In the unlikely event that an unidentified population exists, or that a reintroduction program is undertaken within the study area, mitigation measures outlined above to minimise sediment runoff and erosion would minimise any negative impact on this species lifecycle resulting from habitat modification.

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

To date, there are no threatened populations of river snail listed on the Schedules of the FM Act 1994. Thus, the action will not affect a threatened population as currently listed.

*In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

- 1. 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*
- 2. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

The river snail is part of the listed endangered ecological community: 'the lowland Darling River aquatic ecological community'. This has been considered in section 2.5 below.

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

- 1. the extent to which habitat is likely to be removed or modified as a result of the action proposed*

Current understanding of the distribution of the river snail within the Namoi and Peel rivers (within the Murray Darling Basin) strongly suggests that the species is extinct throughout its natural range, with living specimens having only recently been found within artificial environments such as irrigation pipelines (NSW DPI, 2007). As such, potential impacts from the proposed action including possible limited increased sedimentation during construction,

and possible flow modification during operation will not have an adverse effect on the existing habitat of the species because there will be no direct or indirect impact upon artificial habitats such as irrigation pipelines resulting from this proposed action. In the unlikely event that an unidentified population exists, or that a reintroduction program is undertaken within the study area, mitigation measures outlined in Section 4.1 of the main report to minimise sediment runoff and erosion would minimise changes to this habitat.

2. *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*

As for above

3. *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*

As for above

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

No areas of critical habitat in relation to river snail have yet been listed on the Threatened Species Schedules of the FM Act 1994.

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

The recovery plan for the endangered river snail was produced by NSW DPI in June 2007. Relevant objectives and actions of the recovery plan for the proposed action are outlined as Research and Investigation Activities and Management Activities, these include:

- Protect habitats known to support, or with the potential to support river snail populations.

It is considered that if appropriate sediment control measures are incorporated into the construction and operation design of the proposed action as outlined Section 4.1 of the main report, the proposed action is consistent with the actions and objectives of the river snail recovery plan.

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

Key Threatening Process's under the FM Act 1994, relevant to the proposed action include:

- Removal of large woody debris from NSW rivers and streams
- Degradation of native riparian vegetation along NSW water courses
- Instream structures and other mechanisms that alter natural flows

A 'Threat Abatement Plan' (TAP) has been prepared by DPI for the 'Removal of large woody debris' KTP (NSW DPI, 2005). This document details the ecological importance of large woody debris within NSW river ecosystems and outlines strategies for managing this KTP. TAPs have not yet been prepared for the 'Degradation of native riparian vegetation' or 'Mechanisms that alter natural flows' KTPs.

Recommendations made for this proposed action outlined in Section 4.1 of the main report include specific reference to the minimisation of the removal of large woody debris, and protocols for realignment and relocation in circumstances when removal of large woody debris is unavoidable for the required works. The incorporation of these recommendations will greatly minimise or altogether avoid the temporal and spatial extent of any impacts from removal of large woody debris. As such, the proposed action is not considered as a KTP or to result in the operation of, or increase the impact of, a KTP.

Recommendations made for this proposed action outlined in Section 4.1 of the main report include specific reference to the avoidance of the removal of native riparian vegetation, and protocols for minimisation in circumstances when removal of native riparian vegetation is unavoidable for the required works. In such circumstances, complementary mitigation measures including erosion control, revegetation and weed management are also recommended. The incorporation of these recommendations will greatly minimise the impacts of the degradation of native riparian vegetation. As such, the proposed action is not considered as a KTP or to result in the operation of, or increase the impact of, a KTP.

The construction of new spillways for this proposed action will result in the alteration of existing flows. It should be noted that flows within the potentially impacted reaches of the Namoi and Peel Rivers downstream of these new spillways are already in a highly modified state due to the existing dam, and irrigation releases into these rivers. As such, the proposed action is not considered to have a significant impact on natural flows in the context of the existing highly modified flow regime. The proposed action is not considered as a KTP or to result in the operation of, or increase the impact of, a KTP.

## Conclusion

It is highly unlikely that a population of the river snail exists within the study area. However because of the presence of suitable habitat this species has been considered. The proposed upgrade of Keepit Dam does not pose a significant threat to a potential population provided recommendations for mitigation of impacts during construction and operation outlined in Section 4.1 of the main report are incorporated into management of the upgraded dam. As such the preparation of a Species Impact Statement as prescribed under the *EP&A Act* is not required for this species

## 2.2 Olive perchlet (*Ambassis agassizii*)

The western population of the olive perchlet was historically distributed throughout much of the Murray-Darling drainage of NSW and southern QLD. Its distribution is now understood to be restricted to a few sites within the Darling River system. The decline of this population has been attributed to a number of factors including: predation by introduced fish; habitat degradation; fluctuations in river levels due to flow regulation; and, spawning failures due to cold water releases (NSW DPI, 2002).

The reaches of the Namoi and Peel Rivers potentially impacted by the proposed upgrade of Keepit Dam incorporate the historical distribution of the listed endangered population of the olive perchlet. Bionet search (Web Reference 1) revealed only one record for this species within the Namoi River at Walgett (Namoi-Barwon River confluence) and this predates 1920. The species is known to exist within the Namoi catchment management authority

(CMA) region (Web Reference 2), however not within the sub-regions (Liverpool Plains and Peel) that incorporate the study area.

Although the olive perchlet is considered to be highly unlikely to be present within the study area, there does exist potential appropriate habitat within the reaches of the Peel and Namoi Rivers downstream of the proposed dam upgrade. These habitats could be considered as important for the olive perchlet if a reintroduction program within this area was to be incorporated into the recovery plan for this species. Although it is considered highly unlikely that a population of this species is present within the study area, and hence is unlikely to experience any direct or indirect impacts, an assessment of significance has been undertaken as a precautionary approach.

### **Assessment of Significance for the olive perchlet**

*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.*

The olive perchlet is listed as an endangered population, and as such is considered below.

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

Current understanding of the distribution of the western population of olive perchlet within the Namoi and Peel rivers (within the Murray Darling Basin) strongly suggests that the species is no longer present within this part of its natural range. As such, potential impacts from the proposed action including habitat degradation through sedimentation and snag removal during construction, and possible flow modification during operation will not have an adverse effect on the life cycle of the species. In the unlikely event that an unidentified population exists, or that a reintroduction program is undertaken within the study area, mitigation measures outlined in Section 4.1 of the main report to minimise sediment runoff and erosion, and large woody debris management would minimise any negative impact on this species lifecycle resulting from habitat modification. Cold water releases and rapid flow fluctuations from dams have been identified as causing spawning failures in this species. Current operation of Keepit Dam incorporates cold water releases and rapid river level fluctuations, however this is an existing situation and outside the scope of the proposed upgrade.

*In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

- 1. 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*
- 2. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

The olive perchlet is part of the listed endangered ecological community: 'the lowland Darling River aquatic ecological community'. This has been considered in Section 2.5.

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

1. *the extent to which habitat is likely to be removed or modified as a result of the action proposed*

Current understanding of the distribution of the western population of the olive perchlet within the Namoi and Peel rivers strongly suggests that the species is no longer present in this part of its historical range (NSW DPI, 2002). As such, potential impacts from the proposed action including possible limited increased sedimentation and removal of snags during construction, and possible flow modification during operation will not have an adverse effect on the existing habitat. In the unlikely event that an unidentified population exists, or that a reintroduction program is undertaken within the study area, mitigation measures outlined in Section 4.1 of the main report to minimise sediment runoff, snag removal and erosion would minimise changes to this habitat.

2. *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*

As for above

3. *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*

As for above

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

No areas of critical habitat in relation to olive perchlet have yet been listed on the Threatened Species Schedules of the FM Act 1994.

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

Neither a recovery plan, nor threat abatement plan, has been prepared for the olive perchlet at this time.

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

Key Threatening Process's under the FM Act 1994, relevant to the proposed action include:

- Removal of large woody debris from NSW rivers and streams
- Degradation of native riparian vegetation along NSW water courses
- Instream structures and other mechanisms that alter natural flows

A 'Threat Abatement Plan' (TAP) has been prepared by DPI for the 'Removal of large woody debris' KTP (NSW DPI, 2005). This document details the ecological importance of large woody debris within NSW river ecosystems and outlines strategies for managing this KTP. TAPs have not yet been prepared for the 'Degradation of native riparian vegetation' or 'Mechanisms that alter natural flows' KTPs.

Recommendations made for this proposed action outlined in Section 4.1 of the main report include specific reference to the minimisation of the removal of large woody

debris, and protocols for realignment and relocation in circumstances when removal of large woody debris is unavoidable for the required works. The incorporation of these recommendations will greatly minimise or altogether avoid the temporal and spatial extent of any impacts from removal of large woody debris. As such, the proposed action is not considered as a KTP or to result in the operation of, or increase the impact of, a KTP.

Recommendations made for this proposed action outlined in Section 4.1 of the main report include specific reference to the avoidance of the removal of native riparian vegetation, and protocols for minimisation in circumstances when removal of native riparian vegetation is unavoidable for the required works. In such circumstances, complementary mitigation measures including erosion control, revegetation and weed management are also recommended. The incorporation of these recommendations will greatly minimise the impacts of the degradation of native riparian vegetation. As such, the proposed action is not considered as a KTP or to result in the operation of, or increase the impact of, a KTP.

The construction of new spillways for this proposed action will result in the alteration of existing flows. It should be noted that flows within the potentially impacted reaches of the Namoi and Peel Rivers downstream of these new spillways are already in a highly modified state due to the existing dam, and irrigation releases into these rivers. As such, the proposed action is not considered to have a significant impact on natural flows in the context of the existing highly modified flow regime. The proposed action is not considered as a KTP or to result in the operation of, or increase the impact of, a KTP.

## Conclusion

It is highly unlikely that a population of the olive perchlet exists within the study area. However, because of the presence of suitable habitat this species has been considered. The proposed upgrade of Keepit Dam does not pose a significant threat to a potential population provided recommendations for mitigation of impacts during construction and operation outlined in Section 4.1 of the main report are incorporated into management of the upgraded dam. As such the preparation of a Species Impact Statement as prescribed under the EP&A Act is not required for this species.

### 2.3 Purple Spotted Gudgeon (*Mogurnda adspersa*).

The western population of the purple spotted gudgeon was historically distributed throughout much of the Murray, Murrumbidgee, Lachlan and Darling River drainages of NSW. It is now extremely rare in inland NSW having only been recorded once since 1983. The decline of this population has been attributed to a number of factors including: predation by introduced fish; habitat degradation; and, fluctuations in river levels due to flow regulation (NSW DPI, 2002).

The reaches of the Namoi and Peel Rivers potentially impacted by the proposed upgrade of Keepit Dam incorporate the historical distribution of the listed endangered population of the purple spotted gudgeon. Bionet search (Web Reference 1) and the DECC threatened species website (Web Reference 2) revealed no records for this species within the Namoi CMA.

Although the purple spotted gudgeon is considered to be highly unlikely to be present within the study area, there does exist potential appropriate habitat within the reaches of the Peel and Namoi Rivers downstream of the proposed dam upgrade. These habitats could be considered as important for this species if a reintroduction program within this area was to be incorporated into the recovery plan for this species. Although it is considered highly unlikely that a population of this species is present within the study area, and hence is unlikely to experience any direct or indirect impacts, an assessment of significance has been undertaken as a precautionary approach.

### **Assessment of Significance for the purple spotted gudgeon**

*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.*

The purple spotted gudgeon is listed as an endangered population, and as such is considered below.

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

Current understanding of the distribution of the western population of purple spotted gudgeon within the Namoi and Peel rivers (within the Murray Darling Basin) strongly suggests that the species is no longer present within this part of its natural range. As such, potential impacts from the proposed action including habitat degradation through sedimentation and snag removal during construction, and possible flow modification during operation will not have an adverse effect on the life cycle of the species. In the unlikely event that an unidentified population exists, or that a reintroduction program is undertaken within the study area, mitigation measures outlined in Section 4.1 of the main report to minimise sediment runoff and erosion, and large woody debris management would minimise any negative impact on this species lifecycle resulting from habitat modification. Rapid flow fluctuations from dams have been identified as causing reproduction and recruitment impacts in this species. Current operation of Keepit Dam results in some rapid river level fluctuations, however this is an existing situation and outside the scope of the proposed upgrade.

*In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

- 1. 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*
- 2. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

The purple spotted gudgeon is part of the listed endangered ecological community: 'the lowland Darling River aquatic ecological community'. This has been considered in section 2.5.

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

1. *the extent to which habitat is likely to be removed or modified as a result of the action proposed*

Current understanding of the distribution of the western population of the purple spotted gudgeon within the Namoi and Peel rivers strongly suggests that the species is no longer present in this part of its historical range (NSW DPI, 2002). As such, potential impacts from the proposed action including possible limited increased sedimentation and removal of snags during construction, and possible flow modification during operation will not have an adverse effect on the existing habitat. In the unlikely event that an unidentified population exists, or that a reintroduction program is undertaken within the study area, mitigation measures outlined in section 4.1 of the main report to minimise sediment runoff, snag removal and erosion would minimise changes to this habitat.

2. *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*

As for above

3. *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*

As for above

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

No areas of critical habitat in relation to the purple spotted gudgeon have yet been listed on the Threatened Species Schedules of the FM Act 1994.

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

Neither a recovery plan, nor threat abatement plan, has been prepared for the purple spotted gudgeon at this time.

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

Key Threatening Process's under the FM Act 1994, relevant to the proposed action include:

- Removal of large woody debris from NSW rivers and streams
- Degradation of native riparian vegetation along NSW water courses
- Instream structures and other mechanisms that alter natural flows

A 'Threat Abatement Plan' (TAP) has been prepared by DPI for the 'Removal of large woody debris' KTP (NSW DPI, 2005). This document details the ecological importance of large woody debris within NSW river ecosystems and outlines strategies for managing this KTP. TAPs have not yet been prepared for the 'Degradation of native riparian vegetation' or 'Mechanisms that alter natural flows' KTPs.

Recommendations made for this proposed action outlined in section 4.1 of the main report include specific reference to the minimisation of the removal of large woody

debris, and protocols for realignment and relocation in circumstances when removal of large woody debris is unavoidable for the required works. The incorporation of these recommendations will greatly minimise or altogether avoid the temporal and spatial extent of any impacts from removal of large woody debris. As such, the proposed action is not considered as a KTP or to result in the operation of, or increase the impact of, a KTP.

Recommendations made for this proposed action outlined in Section 4.1 of the main report include specific reference to the avoidance of the removal of native riparian vegetation, and protocols for minimisation in circumstances when removal of native riparian vegetation is unavoidable for the required works. In such circumstances, complementary mitigation measures including erosion control, revegetation and weed management are also recommended. The incorporation of these recommendations will greatly minimise the impacts of the degradation of native riparian vegetation. As such, the proposed action is not considered as a KTP or to result in the operation of, or increase the impact of, a KTP.

The construction of new spillways for this proposed action will result in the alteration of existing flows. It should be noted that flows within the potentially impacted reaches of the Namoi and Peel Rivers downstream of these new spillways are already in a highly modified state due to the existing dam, and irrigation releases into these rivers. As such, the proposed action is not considered to have a significant impact on natural flows in the context of the existing highly modified flow regime. The proposed action is not considered as a KTP or to result in the operation of, or increase the impact of, a KTP.

## Conclusion

It is highly unlikely that a population of the purple spotted gudgeon exists within the study area. However, because of the presence of suitable habitat this species has been considered. The proposed upgrade of Keepit Dam does not pose a significant threat to a potential population provided recommendations for mitigation of impacts during construction and operation outlined in section 4.1 of the main report are incorporated into management of the upgraded dam. As such the preparation of a Species Impact Statement as prescribed under the EP&A Act is not required for this species

## 2.4 Silver Perch (*Bidyanus bidyanus*)

Silver perch were historically widespread and abundant throughout the Murray - Darling Basin. They have now declined to low numbers or disappeared from most of their former range. The decline of this population has been attributed to a number of factors including: modification of natural river flow regimes; barriers to passage; cold water pollution; habitat degradation; and, competition from introduced species and disease. Silver perch have also been successfully bred for aquaculture, conservation and recreational stocking of rivers and dams. (NSW DPI, 2005).

The reaches of the Namoi and Peel Rivers potentially impacted by the proposed upgrade of Keepit Dam incorporate the historical distribution of the silver perch. Bionet search (Web Reference 1) and the DECC threatened species website (Web Reference 2) revealed 10 records for this species within the Namoi CMA since 2000 from DPI surveys. The closest of

these to the proposed Keepit Dam works were within Lake Keepit, downstream in the Namoi River near Carrol, and upstream in the Manilla River at Split Rock dam. Other records in the Namoi River were further downstream at Boggabri and Wee Waa. Also within the Namoi catchment silver perch have been found in the Peel River at Chaffey dam and in the Mooki River at Carroona. According to the DPI stocking data base major stocking of silver perch has been undertaken in Lake Keepit in recent years for recreational fishing. Six individual silver perch were sampled within Lake Keepit in June of 2006 as part of this study (Appendix 6).

The presence of stocked silver perch in the immediate vicinity of the proposed works for the upgrade of Keepit Dam is known, and it is considered possible that a non-stocked population may be present within the Namoi River immediately downstream of the existing dam and within the Peel River forming part of the study area for this proposed upgrade. As such, an assessment of significance has been undertaken for this species. A recovery plan for silver perch (NSW DPI, 2006) has been prepared and much of the information about the biology, ecology and current status of this species used in the assessment of significance draws on information within this recovery plan.

#### **Assessment of Significance for the silver perch.**

*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.*

Viable populations of silver perch (natural and/or stocked) are potentially present within the study area for the Keepit Dam upgrade, including Lake Keepit and the Namoi and Peel Rivers downstream. There is very little information on the reproductive biology and habitat requirements of silver perch, although it is thought that river flows and water temperature are important factors in spawning behaviour. The current presence and operation of Keepit Dam and the associated water releases are likely to have had an impact upon the spawning behaviour and life cycle of silver perch downstream and restricted upstream migration. However, construction and operation of the upgraded dam will not significantly change the nature of flow releases (volume and temperature) to downstream environments, or barriers to fish passage. Degradation of water quality and habitat through sedimentation, degradation of riparian vegetation and removal of woody debris are factors that may contribute to the decline of natural populations of silver perch through impacts on life cycle factors including loss of food sources, refuge habitats, egg/larvae survival, and feeding efficiency. Degradation of riparian vegetation and removal of large woody debris are listed KTP and have been specifically considered below. Mitigation measures to minimise and prevent increased sedimentation of downstream environments during earthworks associated with construction of the dam upgrade have been recommended in section 4.1 of the main report. The adoption of these recommendations will effectively minimise or eliminate any impact on the life cycle of any populations of silver perch present such that a local population is not likely to be placed at risk of extinction.

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

There are no populations of silver perch currently listed as endangered.

*In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

- 1. 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*
- 2. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

The silver perch is part of the listed endangered ecological community: 'the lowland Darling River aquatic ecological community'. This has been considered in Section 2.5.

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

- 1. the extent to which habitat is likely to be removed or modified as a result of the action proposed*

Potential impacts from the proposed action on silver perch habitat including possible limited increased sedimentation, degradation of riparian vegetation and removal of snags during construction, and possible flow modification during operation have been identified. Incorporation of recommended mitigation measures outlined in Section 4.1 of the main report to minimise sediment runoff, snag removal, riparian disturbance and erosion would minimise or eliminate changes to this habitat. As such, the extent to which habitat is likely to be removed or modified as a result of this action is considered negligible.

- 2. 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*

Fragmentation of silver perch habitat currently occurs in the study area due to the presence of Keepit Dam. This will not change as a result of the proposed upgrade.

- 3. 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*

There may be important habitat for silver perch within the study area, however the proposed upgrade of Keepit Dam will not significantly remove, modify, fragment or isolate any of this habitat provided recommendations for mitigation of impacts are incorporated into the construction works.

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

No areas of critical habitat in relation to the silver perch have yet been listed on the Threatened Species Schedules of the FM Act 1994.

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

The specific objectives of the silver perch recovery plan are listed below:

- Increase the awareness of the current status of silver perch throughout its range
- Increase scientific knowledge of the current distribution, ecological and habitat requirements and population genetics of silver perch
- Protect and enhance remaining natural populations of silver perch

- Ameliorate the impacts of known major threats to silver perch
- Minimise any fishing impacts on natural populations through enhanced compliance with fishing regulations and involvement of recreational fishers
- Improve management of aquaculture and fish stocking programs
- Encourage and support the involvement of indigenous communities in the implementation of recovery actions
- Establish a program to monitor the status of silver perch and evaluate the effectiveness of recovery actions.

The proposed upgrade of Keepit Dam is consistent with these objectives provided recommendations for the mitigation of impacts on silver perch habitat outlined in section 4.1 of the main report are incorporated into the construction phase of the project.

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

Key Threatening Process's under the FM Act 1994, relevant to the proposed action include:

- Removal of large woody debris from NSW rivers and streams
- Degradation of native riparian vegetation along NSW water courses
- Instream structures and other mechanisms that alter natural flows

A 'Threat Abatement Plan' (TAP) has been prepared by DPI for the 'Removal of large woody debris' KTP (NSW DPI, 2005). This document details the ecological importance of large woody debris within NSW river ecosystems and outlines strategies for managing this KTP. TAPs have not yet been prepared for the 'Degradation of native riparian vegetation' or 'Mechanisms that alter natural flows' KTPs.

Recommendations made for this proposed action outlined in Section 4.1 of the main report include specific reference to the minimisation of the removal of large woody debris, and protocols for realignment and relocation in circumstances when removal of large woody debris is unavoidable for the required works. The incorporation of these recommendations will greatly minimise or altogether avoid the temporal and spatial extent of any impacts from removal of large woody debris. As such, the proposed action is not considered as a KTP or to result in the operation of, or increase the impact of, a KTP.

Recommendations made for this proposed action outlined in Section 4.1 of the main report include specific reference to the avoidance of the removal of native riparian vegetation, and protocols for minimisation in circumstances when removal of native riparian vegetation is unavoidable for the required works. In such circumstances, complementary mitigation measures including erosion control, revegetation and weed management are also recommended. The incorporation of these recommendations will greatly minimise the impacts of the degradation of native riparian vegetation. As such, the proposed action is not considered as a KTP or to result in the operation of, or increase the impact of, a KTP.

The construction of new spillways for this proposed action will result in the alteration of existing flows. It should be noted that flows within the potentially impacted reaches

of the Namoi and Peel Rivers downstream of these new spillways are already in a highly modified state due to the existing dam, and irrigation releases into these rivers. As such, the proposed action is not considered to have a significant impact on natural flows in the context of the existing highly modified flow regime. The proposed action is not considered as a KTP or to result in the operation of, or increase the impact of, a KTP.

## Conclusion

The proposed upgrade of Keepit Dam does not pose a significant threat to populations of silver perch (stocked or natural) that exist within the study area, provided recommendations for mitigation of impacts during construction and operation outlined in Section 4.1 of the main report are incorporated into management of the upgraded dam. As such the preparation of a Species Impact Statement as prescribed under the *EP&A Act* is not required for this species

## 2.5 The Lowland Darling River Aquatic Ecological Community

The aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River has been listed as an endangered ecological community under the *FM Act 1994*. This listing has been in recognition of the extensive and significant modification of the Darling River and its tributaries since European settlement, through activities such as river regulation, invasive fish species, agricultural practices and over fishing. As a result of this pressure, many aquatic habitats have become degraded and many native species have experienced declines in abundance and distribution, including some species having become listed as vulnerable and endangered (NSW DPI, 2007). The regulated tributaries of the Darling River including the Namoi and Peel Rivers within the study area for the Keepit Dam upgrade are part of this endangered community.

### Assessment of Significance for the Lowland Darling River Aquatic Ecological Community

*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.*

Not applicable

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

Not applicable

*In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

- 1. 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*

2. *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*

Keepit Dam is likely to have historically had a significant adverse effect on the extent and composition of the local occurrence of the lowland Darling River aquatic ecological community as a result of:

- habitat fragmentation,
- flow regulation,
- cold water pollution; and,
- habitat inundation, loss and degradation.

The proposed upgrade of Keepit Dam will not further exacerbate these problems (neither will it rectify them) provided recommended mitigation measures outlined in Section 4.1 of the main report are incorporated into the construction and operation of the upgraded dam. As such, the local occurrence of this community is unlikely to be placed at further risk of extinction because of the proposed action.

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

1. *the extent to which habitat is likely to be removed or modified as a result of the action proposed*

Potential impacts from the proposed action on lowland Darling River aquatic ecological community including possible limited increased sedimentation, degradation of riparian vegetation and removal of snags during construction, and possible flow modification during operation have been identified. Incorporation of recommended mitigation measures outlined in Section 4.1 of the main report to minimise sediment runoff, snag removal, riparian disturbance and erosion would minimise or eliminate changes to this habitat. As such, the extent to which habitat is likely to be removed or modified as a result of this action is considered negligible.

2. *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*

Fragmentation of ecological habitat currently occurs in the study area due to the presence of Keepit Dam. This will not change as a result of the proposed upgrade.

3. *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*

There is likely to be important lowland aquatic ecological habitat for this community within the study area, however the proposed upgrade of Keepit Dam will not further significantly remove, modify, fragment or isolate any of this habitat provided recommendations for mitigation of impacts are incorporated into the construction works.

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

No areas of critical habitat in relation to the silver perch have yet been listed on the Threatened Species Schedules of the FM Act 1994.

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

There is no recovery plan for the endangered lowland Darling River aquatic ecological community to date.

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

Key Threatening Process's under the FM Act 1994, relevant to the proposed action include:

- Removal of large woody debris from NSW rivers and streams
- Degradation of native riparian vegetation along NSW water courses
- Instream structures and other mechanisms that alter natural flows

A 'Threat Abatement Plan' (TAP) has been prepared by DPI for the 'Removal of large woody debris' KTP (NSW DPI, 2005). This document details the ecological importance of large woody debris within NSW river ecosystems and outlines strategies for managing this KTP. TAPs have not yet been prepared for the 'Degradation of native riparian vegetation' or 'Mechanisms that alter natural flows' KTPs.

Recommendations made for this proposed action outlined in Section 4.1 of the main report include specific reference to the minimisation of the removal of large woody debris, and protocols for realignment and relocation in circumstances when removal of large woody debris is unavoidable for the required works. The incorporation of these recommendations will greatly minimise or altogether avoid the temporal and spatial extent of any impacts from removal of large woody debris. As such, the proposed action is not considered as a KTP or to result in the operation of, or increase the impact of, a KTP.

Recommendations made for this proposed action outlined in Section 4.1 of the main report include specific reference to the avoidance of the removal of native riparian vegetation, and protocols for minimisation in circumstances when removal of native riparian vegetation is unavoidable for the required works. In such circumstances, complementary mitigation measures including erosion control, revegetation and weed management are also recommended. The incorporation of these recommendations will greatly minimise the impacts of the degradation of native riparian vegetation. As such, the proposed action is not considered as a KTP or to result in the operation of, or increase the impact of, a KTP.

The construction of new spillways for this proposed action will result in the alteration of existing flows. It should be noted that flows within the potentially impacted reaches of the Namoi and Peel Rivers downstream of these new spillways are already in a highly modified state due to the existing dam, and irrigation releases into these rivers. As such, the proposed action is not considered to have a significant impact on natural flows in the context of the existing highly modified flow regime. The proposed action is not considered as a KTP or to result in the operation of, or increase the impact of, a KTP.

## **Conclusion**

The proposed upgrade of Keepit Dam does not pose a significant threat to the lowland Darling River ecological community that exists within the study area, provided recommendations for mitigation of impacts during construction and operation outlined in Section 4.1 of the main report are incorporated into management of the upgraded dam. As such the preparation of a Species Impact Statement as prescribed under the EP&A *Act* is not required for this community.

### **3.0 ACKNOWLEDGEMENTS**

This report was written by Doug Hazell, reviewed by Dr Peggy O'Donnell.

## 4.0 REFERENCES

NSW Department of Primary Industries (2002). *Threatened Species in NSW – Olive Perchlet (Western Population)*. NSW DPI Fishnote No. 1085

NSW Department of Primary Industries (2002). *Threatened Species in NSW – Purple spotted gudgeon (Western Population)*. NSW DPI Fishnote No. 1089

NSW Department of Primary Industries (2005). *Key Threatening Processes in NSW – Instream Structures and Other Mechanisms That Alter Natural Flows*. NSW DPI Primefacts No. 10

NSW Department of Primary Industries (2005). *Key Threatening Processes in NSW – Removal of Large Woody Debris from NSW Rivers and Streams*. NSW DPI Primefacts No. 11

NSW Department of Primary Industries (2005). *Key Threatening Processes in NSW – Degradation of Native Riparian Vegetation Along NSW Water Courses*.

NSW DPI Primefacts No. 12 NSW Department of Primary Industries (2006). *Silver Perch Recovery Plan (Bidyanus bidyanus)*. Threatened Species Unit, Fisheries Conservation and Aquaculture. NSW DPI

NSW Department of the Environment and Climate Change (2007). *Threatened Species Assessment Guidelines: The Assessment of Significance*

NSW Department of Primary Industries (2007). *Recovery Plan for the Endangered River Snail (Notopala sublineata)*. Threatened Species Unit, Fisheries Conservation and Aquaculture. NSW DPI.

Parsons Brinckerhoff (2006). *Keepit Dam Upgrade Environmental Assessment, Technical paper 6, Erosion and Sedimentation. Draft*. Report by Parsons Brinckerhoff for State Water Corporation.

Web Reference 1. BioNet. Collaborative database combining records of the Australian Museum, NSW Department of Environment and Conservation and NSW Department of Primary Industries. <http://www.bionet.nsw.gov.au>

Web Reference 2. Department of Environment and Climate Change. Threatened Species Threatened Species, Populations and Ecological Communities of NSW. <http://www.threatenedspecies.environment.nsw.gov.au>.