REDUCING THE IMPACT OF WEIRS ON AQUATIC HABITAT

NSW DETAILED WEIR REVIEW

REPORT TO THE NEW SOUTH WALES ENVIRONMENTAL TRUST

NAMOI CMA REGION

NSW DEPARTMENT OF PRIMARY INDUSTRIES

Environmental TRUST

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The information contained in this publication is based on knowledge and understanding at the time of writing (July 2006). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check the currency of the information with the appropriate officer of NSW Department of Primary Industries or the user‘s independent adviser.

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Cover photos: Cob-o-corn Weir, Cob-o-corn Creek, Northern Rivers CMA (upper left); Stroud Weir, Karuah River, Hunter/Central Rivers CMA (upper right); Mollee Weir, Namoi River, Namoi CMA (lower left); and Hartwood Weir, Billabong Creek, Murray CMA (lower right).

EXECUTIVE SUMMARY

The highly modified nature of catchments in NSW presents many challenges in the way we protect the environment and manage its natural resources. In particular, setting goals and targets for aquatic habitat conservation in the region requires clear understanding of the extent of aquatic habitat degradation and where the best outcomes can be achieved.

Within lotic systems, native Australian fish have evolved to be reliant on a variety of habitat types to complete their life cycle, thus requiring free movement within rivers and streams and between estuarine and freshwater environments. Unfortunately, riverine connectivity has been severely disrupted within Australia through the installation of numerous instream structures that impede the natural flow regime and act as physical, hydrological, and behavioural barriers to fish movement. In NSW alone, several thousand weirs, dams and poorly designed road crossings exist on waterways, with the majority of these structures impeding fish passage and impacting on aquatic health.

In 1999, NSW Fisheries and the Department of Land and Water Conservation undertook the NSW Initial Weir Review (2002). The Initial Weir Review (2002) was commissioned by the State Weir Review Committee to provide a preliminary overview of the impact of weirs across the State. Due to the sheer number of weirs and dams in NSW, detailed assessments of each structure were not feasible. Therefore, the Initial Weir Review (2002) incorporated a rapid assessment of weirs in the State for the purpose of providing a 'snap shot' view of environmental considerations at each site, as well as to identify and shortlist priority structures that warranted further attention. It is under this premise that the Detailed Weir Review was conducted to provide a comprehensive assessment of the impacts and remediation options available for improving fish passage and waterway health at priority structures highlighted in the Initial Weir Review (2002).

A total of 109 weir structures within the 13 CMA regions of NSW were selected for Detailed Weir Reviews, with a thorough assessment of each structure undertaken. The individual detailed review reports presented in this project provide a comprehensive overview of each structure including operational details, system hydrology, ecological considerations, and the preferred remediation option of NSW DPI for improving fish passage at the weir.

As a primary recommendation, NSW DPI encourages the removal of redundant structures from waterways, with weir removal providing the greatest benefit to the health of the waterway by enabling unrestricted fish passage and reinstatement of natural sediment fluxes within a system. However, due to the requirement for regulation of flows and impoundment of water for irrigation purposes in many areas of NSW, removal of certain structures cannot be proposed as a primary remediation option. Recommendations put forth by NSW DPI to remediate or remove the weirs inspected throughout the NSW catchments as part of the Detailed Weir Review Project are supported by the NSW *State Weirs Policy*.

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TABLE OF CONTENTS

1. INTRODUCTION

The following report outlines the results of the "*Impact of Weirs on Environmental Flows, Water Quality and Fish Passage*" (herein the "NSW Detailed Weir Review Project") for the catchments of NSW. The project was funded in November 2003 through the NSW Environmental Trust and was managed by the NSW Department of Primary Industries (now incorporating NSW Fisheries).

1.1 Project scope and setting

In 1999, NSW Fisheries[1] and the Department of Land and Water Conservation[2] undertook the NSW Initial Weir Review. The process aimed to make a provisional assessment of all licensed dams and weirs within NSW, evaluating their impact on fish passage for the purpose of identifying priority sites for remediation. Catchment-based summary reports were prepared (in accordance with the former Catchment Management Board boundaries) recommending remediation options for priority sites. Following the production of the initial weir reviews, the State Weir Review Committee acknowledged that more comprehensive weir reviews were required to assess additional social, cultural, ecological, and logistical issues pertaining to highlighted priority sites prior to the implementation of on-ground works. NSW DPI therefore initiated the NSW Detailed Weir Review project through funding provided by the NSW Environmental Trust that aimed to conduct thorough investigations into 80 high priority structures across NSW to better determine appropriate remediation actions.

1.2 Study aims and objectives

The current project builds on the outcomes of the NSW Initial Weir Review (NSW, Fisheries, 2002) by undertaking detailed reviews for high-priority structures within the thirteen catchments of NSW. The reviews aim to facilitate future on-ground works by addressing the social, ecological, cultural and logistical issues that surround the modification of existing barriers. This will provide a clear process towards mitigating a structure's environmental impact once funding is secured, with the Detailed Weir Review project also serving to identify those structures where remedial works can achieve the greatest ecological benefit. As a result, these reviews will allow external-funding bodies to have greater confidence in proposed works given that a comprehensive assessment and consultation process has already been undertaken.

The primary objectives of the project were to:

- Identify high priority weir structures within each CMA region that have a major impact on fish passage and aquatic habitat condition;
- Assess high priority weirs by reviewing social, ecological, cultural and logistical issues that are associated with each structure;
- Prioritise high priority weirs within each CMA region, and;
- Recommend remediation options to improve fish passage at each weir structure.

[1] Now NSW Department of Primary Industries
[2] Now NSW Department of Natural Resources

2. BACKGROUND

2.1 Fish passage in NSW

Stream connectivity and habitat diversity are critical components of healthy rivers. Within these systems, native fish have evolved to be reliant on a variety of habitat types to complete their life cycle, thus requiring free movement within rivers and streams and between estuarine and freshwater environments. In south-eastern Australia, approximately half of all freshwater fish species migrate as part of their life cycle (Fairfull and Witheridge 2003) including key species such as Murray cod, golden perch, silver perch, Australian bass, sea mullet, short finned and long-finned eels, freshwater mullet and freshwater herring. Migration distances can vary from a few metres during a fish's lifespan, to over a 1000km on an annual scale for species such as the iconic Murray cod and golden perch.

Impeding fish passage through the construction of dams, weirs, floodgates and waterway crossings can negatively impact native fish by:

- Interrupting spawning or seasonal migrations;
- Restricting access to preferred habitat, available food resources and breeding partners;
- Reducing genetic flow between populations;
- Increasing susceptibility to predation and disease through aggregation below barriers;
- Fragmenting previously continuous communities, and;
- Disrupting downstream movement of adults and impeding larval drift through the creation of still water (lentic) environments.

Natural flow regimes are essential in maintaining connectivity between upstream and downstream reaches (longitudinal connectivity), and adjacent riparian and floodplain habitats (lateral connectivity). Instream structures that span the whole channel (e.g. weirs and causeways) can impede natural flows, acting as physical and hydrological barriers to fish movement and isolating upstream and downstream habitats (Williams *et al.* 1996; Pethebridge *et al.* 1998; Thorncraft and Harris 2000; Fairfull and Witheridge 2003). Additionally, levees, floodgates and other off-stream structures (e.g. gross pollutant traps) can disrupt lateral connectivity by isolating seasonal or ephemeral habitats on floodplains and wetlands. For fish that have large-scale migrations in their life cycles, particularly anadromous (marine-to-freshwater) and catadromous (freshwater-to-marine) species, preventing passage can cause local extinctions above barriers and reduce population numbers downstream (Thorncraft and Harris 2000).

The installation and operation of in-stream structures and other mechanisms that alter natural flow regimes of rivers and streams has been listed as a *Key Threatening Process* under the *Fisheries Management Act 1994* and the *Threatened Species Conservation Act 1995*. Recommendations put forward by the Acts specifically note the impact of in-stream structures on the life histories of threatened freshwater fish species including silver perch (*Bidyanus bidyanus)*, Macquarie perch (*Macquaria australasica*), purple spotted gudgeon (*Mogurnda adspersa*), olive perchlet (*Ambassis agassizii)*, Murray hardyhead (*Craterocephalus fluviatilis*), southern pygmy perch (*Nannoperca australis*), Murray cod (*Maccullochella peelii peelii)*, and trout cod (*Maccullochella macquariensis*).

2.2 Barriers to fish passage

All native fish need to move between habitat areas at some stage in their life cycle to spawn, seek food, or find shelter; and for many species migrations over long extended distances are required to complete their life cycle (Thorncraft and Harris 1996; Smith and Pollard 1998). Man-made structures that span the width of the waterway can act as barriers to fish passage by creating a physical blockage, a hydrological barrier, or by forming artificial conditions that act as behavioural barriers to fish. The impact of such barriers on fish passage will vary depending on the design of the structure; the nature of flow, debris and sediment movement in the waterway; and the swimming capabilities of resident fish.

In NSW alone, there exist over 4,000 licensed weirs and dams on rivers and streams (NSW Weir Inventory database). Water impoundment structures are classified as being either fixed crest or adjustable release in design. Fixed crest weirs (also known as run-of-the river weirs) have a set height that water is impounded at, with water generally cascading over the crest of the weir at a natural flow rate barring extensive water extraction from the weir pool. As a result, fixed crest structures generally have only a minor impact on a the hydrological flow patterns of a waterway, with the main impact of such structures being the creation of a physical barrier to fish passage and the loss of upstream lotic habitat. Alternatively, adjustable release weirs and dams incorporate gates, valves, removable drop boards, and spillways that allow the flow of water in the system to be regulated to match stakeholder demands. Unlike fixed crest structures, adjustable release weirs can have much more far ranging effects on the ecology of a waterway including altered hydrological flow patterns and reduced water quality parameters (e.g. water temperature and dissolved oxygen). As with fixed crest weirs however, adjustable release structures also impinge upon fish migration either as physical (excessive headloss) or hydrological barriers (high flow velocity).

Until recently, management of fish passage barriers has centred on the effects of weirs and dams while little attention has been given to the extent of the impact of poorly designed road crossings. Similar to weirs: bridges, arch structures, culverts, causeways, and fords can impinge upon fish migration patterns by acting as physical, hydrological, and behavioural barriers. NSW DPI recently completed a detailed audit of road crossings in coastal catchments (NSW DPI 2006), which highlighted in excess of 1,700 barriers to migrating fish in the coastal waterways of NSW.

In tidal reaches, waterway crossings (especially those over irrigation/agricultural drains) commonly incorporate floodgates that restrict fish passage between flood events. Floodgates include hinge-flap, winch, sluice, and auto-tidal designs; with most of these structures acting as passive one-way valves that aid in draining water from low-lying land behind the gate while excluding tidal ingress. When water levels behind the floodgate are higher than the downstream levels, the gates open and the floodwaters discharge into the estuary. When water levels are elevated on the downstream side of the floodgate however, the structure is forced into the closed position, thus restricting the movement of water and fish into the drain.

The vertical walls of dams, weirs, causeways, and floodgates are the most commonly perceived barriers to migrating fish. However, hydrological barriers including excessive water velocity and turbulence that result from poorly designed fishways and culvert structures can further impede fish passage (Mallen-Cooper 1994). The degree to which a structure acts as a hydrological barrier will also be dependent upon the distance over which fish have to swim to negotiate the structure (Videler and Wardle 1991). Fish generally use two different swimming modes: fast burst

swimming for covering short distance and a cruising speed for longer journeys. Depending upon the design of the crossing, fish may be able to ascend part way up barriers or poorly designed fishways, only to be washed back downstream after their energy has been expended (subsequently predisposing them to predation or disease through fatigue).

Changes in habitat features associated with in-stream structures may also present behavioural barriers to migrating fish. Species that are able to pass into weir reservoirs may find the pooled lentic (still water) system unsuitable due to the loss of critical lotic (riverine) habitat features such as riparian vegetation cover, aquatic macrophytes, and large woody debris. Similarly, altered water temperature and aquatic dissolved oxygen regimes within and below weirs, in addition to lowered pH levels behind floodgates, can also deter migrating fish (Gehrke *et al.* 2001).

The location of instream structures within the catchment is another factor determining the impact of barriers on fish. Obstructions located lower in the catchment often drown out several times a year when rising water levels overcome headloss barriers (the difference in water level across the structure), thereby enabling fish to periodically pass (Harris *et al.* 1992). Alternatively, barriers located higher up the catchment generally drown out less frequently due to the steeper topography and comparatively smaller drainage areas present behind the structure.

2.3 Ecological impacts of weirs

The environmental impact of dams and weirs is widely recognised as one of the key contributors to riverine degradation. The impact from alterations to natural hydrology, changes to stream geomorphology, disruption of localised erosion and sedimentation processes, evaporative water loss, creation of still water environments, impediment of larval drift, and extractive water use have had a severe impact on the abundance and diversity of native fish populations and the quality of aquatic habitats throughout the world. They affect fish in a variety of ways, including: disrupting life-cycles, reducing gene pools, and creating conditions where fish become more susceptible to disease and predation. Moreover, exotic species such as carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), gambusia (*Gambusia holbrooki*), and redfin perch (*Perca fluviatilis*) that are considered habitat generalists, thrive in disturbed habitats compared to native fish, which are habitat specialists. As a consequence, flow-modified waterways possess reduced native fish fauna diversity, abundance, breeding success and ratio to introduced species when compared to unregulated streams (Gehrke and Harris 2001).

Water quality in reservoirs pose many problems not only for the supply of water to humans, but also to the survival of native flora and fauna within and along the watercourse. Larger weirs (> 10 metres) can alter temperature regimes within their impoundments through stratification where a warm surface layer forms over a colder, denser layer near the bottom of the reservoir. Given that most regulated weirs and dams release stored water from the bottom of the structure, cold-water pollution results, which can impact upon waterways kilometres downstream. Cold-water pollution significantly decreases an animal's growth rate while also delaying seasonal spawning runs of fish by depressing temperature sensitive metabolic rates. Thermal stratification in reservoirs also impacts upon aquatic oxygen levels by producing an anoxic bottom layer that forms when organic material settles on the bed and is broken down by oxygen-depleting bacteria. Diffusion of oxygen into these bottom layers is prevented by the existing thermal stratification, resulting in the release of hypoxic water below the weir, which can affect the distribution of oxygen-sensitive macroinvertebrates and fish species.

The construction of weirs and dams also results in the inundation of streamside habitat. The drown-out of adjacent riparian zones detrimentally effects the survival of bank-side vegetation communities, resulting in the mortality of riparian flora. Deleterious impacts associated with vegetation dieback along reservoir banks include increased erosion and sedimentation, along with associated water quality reduction, proliferation of weed species, reduced macrophyte growth, especially within the littoral zone, and loss of vegetative shade cover. Additionally, the re-establishment of riparian communities at regulated reservoirs is problematic due to widely fluctuating water levels.

Weirs and floodgates can also alter the way a river channel interacts with its neighbouring floodplain. The design of such structures generally entails flood containment, which can isolate floodplains and wetlands while simultaneously reducing the carbon input entering from lowland rivers (and vice versa). Additionally, access to floodplains is essential to the reproduction of numerous species including silver perch and golden perch (*Macquaria ambigua*) that spawn in such habitats when food resources are abundant. Effective management of floodplain barriers is required to ensure that ecological functioning is maintained.

Weirs and dams also impact on channel geomorphology by trapping sediments from upstream and inadvertently storing them in the reservoir. Without a supply of sediment to replenish areas that have been eroded downstream by increased flow velocities and turbulence below the structure (otherwise known as clearwater erosion), the natural sediment balance is disrupted. Additionally, the manipulation of flows and the associated increased flow velocities below a weir or dam can result in the alteration of natural stream morphology by increasing erosion rates, which can result in the deepening and widening of rivers.

The sedimentation that occurs within weir pools further affects organisms within the stream by filling in fish habitat holes, smothering benthic organisms, and in some cases affecting fish respiration. The reduction in stream depth allows a greater surface area of the waterway to be subjected to sunlight penetration and evaporation, increasing water temperature particularly during the summer months. Turbid conditions resulting from sediments in the weir pool or increased erosion downstream can decrease light penetration into the water column and limit photosynthesis, thereby reducing the overall productivity of the system.

The significance of addressing the environmental impact of dams and weirs is reflected in the attention received across all levels of government and within Natural Resource Management forums. For the Murray Darling Basin Commission's Native Fish Management Strategy, over half of the objectives are directly related to mitigating the impact of weirs on fish habitat through structural modification or improved storage management. The Murray Darling Basin Commission is implementing the strategy by committing funds to improving fish passage along the length of the Murray River as part of the Living Murray Initiative. Additionally, the Commission is seeking ways to improve the management of available resources and maximise the delivery of water to the environment to restore critical variability in the flow regime for major inland rivers.

2.4 Policies and Legislation

The NSW Government recognises the significant impact that barriers present to aquatic biota within estuarine and riverine ecosystems. As part of this approach, the Government released the *State Weirs Policy* in 1997, which aims to mitigate or prevent the environmental impacts of weirs, road crossings, and floodgates in NSW. This goal is supported by the adoption of the following management principles:

1. *The construction of new weirs, or enlargement of existing weirs, shall be discouraged;*
2. *Weirs that are no longer providing significant benefits to the owner or user shall be removed, taking into consideration the environmental impact of removal;*
3. *Where retained, owners shall be encouraged to undertake structural changes to reduce their impact on the environment (e.g. installation of fishway);*
4. *Where retained, owners of weirs with regulatory works shall prepare and adhere to operational plans to reduce the environmental impact of weirs;*
5. *Where retained, gated off-take structures and fishways on all weirs shall be maintained in good working order;*
6. *Wetlands and riparian vegetation adjacent to weirs should be protected from permanent inundation;*
7. *Areas of environmental degradation caused by the impacts of weirs upstream and downstream of the weir pools, should where possible be rehabilitated; and*
8. *A respect for the environmental impact of weirs should be encouraged in all agencies and individuals that own, manage, or derive benefits from weirs.*

The *State Weirs Policy* is a component of the NSW water reforms initiated by the NSW Government in 1995. Implementation of the *State Weirs Policy* is a whole-of-government responsibility with the Department of Natural Resources (DNR) as the lead agency. DNR licences weirs under the *Water Management Act 2000* and *Water Management Amendment Bill 2005*. The Act aims to provide a mechanism for protecting and restoring water sources and their ecosystems, giving priority to environmental water, whilst still allowing improved access rights to watercourses and aiding in the arrangement of water management partnerships between local communities and the government. NSW DPI plays a significant role in the administration of the policy by protecting the interests and aquatic biodiversity of native fish.

In 1994, the *Fisheries Management Act* came into effect and specifically addressed the issue of fish passage. Under Sections 218-220 of *the Act* (1994), NSW DPI has the responsibility to ensure that the construction of any new weir or the modification of an existing structure does not deleteriously impact upon resident fish populations. Fairfull and Witheridge (2003) and NSW Fisheries (2003) provide a comprehensive overview of the legislative and policy requirements that must be observed during the planning, design, and construction of waterway crossings in NSW. Together these legislative tools, and associated NSW Government policies on fish passage, act to regulate the construction of structures that can impede fish passage. In addition, reinstating connectivity between upstream and downstream habitats and adjacent riparian and floodplain areas through the remediation of fish passage barriers has become an essential part of aquatic habitat management and rehabilitation programs in NSW.

3. PROJECT METHODOLOGY

3.1 Initial Weir Review

The Initial NSW Weir Review (2002) was commissioned by the State Weir Review Committee to provide a preliminary overview of the impact of weirs across the State, and to identify and shortlist priority structures that warranted further attention. The review consisted of a desktop database assessment followed by a subsequent field investigation of all identified weirs. The desktop assessment initially involved accessing the Licensing Administration Database System (LAS) created by the Department of Land and Water Conservation to identify the location and contact details for licensed weirs on named waterways. Adjacent landholders and structural owners were subsequently contacted and informed of the Weir Review Program, upon which permission was gained to inspect the structures. Where possible, meetings were arranged on-site with the relevant stakeholders to discuss the social, ecological, and hydrological issues associated with the weir/dam.

Following desktop and field data collection, weirs were prioritised and ranked on a catchment scale using criteria developed by Pethebridge *et al.* (1998) that included such factors as: river size, location in catchment, presence of threatened species, available upstream habitat, number of downstream obstructions, presence of a fishway, and whether anthropogenic impacts such as thermal pollution were present. It should be noted that the initial ranking of barriers was based only on fish passage considerations for the purpose of highlighting high priority weirs that have a significant, deleterious impact upon NSW native fish species. Although not included in the initial prioritisation process, socio-economic issues were investigated and reported upon in the initial weir review to provide guidance in future assessments. The outcomes of the prioritisation process were subsequently presented, reviewed, and accepted with comment by the relevant River Management Committees.

3.2 Selection of weirs for detailed review

Due to the sheer number of weirs and dams in NSW, detailed assessment of every structure was not feasible. As a result, the Initial Weir Review incorporated a rapid assessment of weirs in the State for the purpose of providing a ‘snap shot’ view of environmental considerations at each site relative to fish passage. The application of a rapid assessment technique was a simple and effective way of highlighting the extent of the problem and determining broad regional priorities to aid in informing future planning directives. However numerous environmental, social, cultural, and economic considerations need to be considered by natural resource managers when reviewing the operational status of water impoundment structures. It is under this premise that the Detailed Weir Review was conducted to provide a comprehensive assessment of the impacts and remediation options available for improving fish passage and waterway health at priority structures highlighted in the Initial Weir Review (2002).

A total of 1,163 weirs were inspected and assessed in the thirteen NSW catchments as part of the Initial Weir Review (2002), of which 355 were designated as structures requiring further investigation. Of these 355 identified weirs, 109 structures were selected for detailed reviews for this study. Information gathered during the initial reviews pertaining to environmental, social, cultural, and economic factors was considered in the selection of structures to incorporate into the Detailed Weir Review.

Additionally, consultation occurred with regional NSW DPI Conservation Managers, State Water representatives, and regional staff from the Department of Natural Resources, to further highlight regional issues that would influence the selection of priority structures.

Following the selection of structures, detailed assessments were performed on priority weirs to supplement and augment information previously obtained in the Initial Weir Review (2002). Detailed analysis involved field and desktop assessment, which required consultation with structure owners, local community members, adjacent landholders, and fishing groups that held a vested interest in the weir and adjoining reaches.

3.3 Desktop assessment and consultation

Prior to the site visit, a detailed desktop investigation was conducted to determine location information (e.g. section of the catchment), structural details (e.g. required uses and interested stakeholders, available upstream habitat), hydrological patterns, and further environmental considerations (ranges of threatened and protected species and archived water quality information). Structure owners, respective state government departments, fishing clubs, and community groups were consulted during this process to ascertain: construction dates, average flows, frequency of structural drown out[3] events, previous occurrence of blue-green algae in the weir pool, fish caught or observed in the vicinity of the weir, licensing information, and water extraction devices linked to the works of each weir. Where possible, volume of water discharged (ML/day) on the date of the field assessment, average yearly flows, and drown out event data were acquired from the nearest Department of Natural Resources river gauge.

3.4 Field assessment

Fieldwork in the region was conducted from April 2004 – May 2005. On-site visits were conducted where feasible with structure owners (e.g. State Water), which allowed queries to be answered and sites normally inaccessible to the public to be entered. A detailed assessment proforma (Appendix A) was completed for each structure, with location details and digital photographs also recorded.

Information obtained in addition to fields previously recorded during the Initial Weir Review included: extent of barrier impact (e.g. headloss); structural stability; position of the weir relative to upstream and downstream man-made barriers; hydrological information (including the length of the weir pool and depth behind the structure); evidence of siltation behind the structure; adjacent bank stability; occurrence of riparian fencing or stock access; riparian vegetation condition; presence of aquatic and riparian weeds; and class of waterway on which the weir was located (Table 3.1).

NSW DPI applies a ‘Class’ system to assign aquatic habitat values to waterways, as outlined in Table 3.1 (Fairfull and Witheridge 2003). Due to the previous prioritisation of weirs in the initial review the majority of structures assessed during this study were located on Class 1 waterways or high quality Class 2 systems.

[3] **Drown out** refers to when a structure is no longer having an impact on the passage of fish within a waterway. At this time, water levels are higher than the structure itself, allowing minimal disruption to water movement, and providing free passage of fish within a system. Compare with **over topped**, which refers to when a structure has water flowing over the top of the weir crest.

All data recorded in the Detailed Weir Review Project was downloaded into the NSW Department of Primary Industries Fish Habitat Database prior to comparative analysis to determine regional remediation priorities for each catchment.

Table 3.1. Classification of fish habitat in NSW waterways (Fairfull and Witheridge 2003).

Classification	Characteristics of Waterway Type
CLASS 1 Major fish habitat	Major permanently or intermittently flowing waterway (e.g. river or major creek), habitat of a threatened fish species.
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.
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.
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 flow or free standing water or pools after rain events (e.g. dry gullies or shallow floodplain depressions with no permanent aquatic flora present).

3.5 Prioritisation process

A weir prioritisation scheme was developed to assist in ranking priority structures requiring remediation in NSW (Appendix B). Although weirs included in the Detailed Weir Review Project had previously been assessed and prioritised as a component of the Initial Weir Review, it was deemed necessary to further rank these priority structures to incorporate the additional data collected, thereby providing regional CMAs with targeted, informed data when selecting structures for remediation. The prioritisation scheme was developed to determine regional priorities by ranking weirs based on the following categories: a) stream habitat value; b) structural impact; c) environmental criteria; and d) modification criteria.

An initial prioritisation was conducted based on stream habitat and structural impact criteria, which were viewed as the primary variables affecting fish passage. Stream habitat criteria were based on habitat class, location of the barrier in the catchment, number of downstream obstructions, and the amount of habitat (i.e. stream length in kilometres) opened to unimpeded fish passage. Table 3.1 outlines the characteristics of each waterway class that was used in the weir prioritisation scheme, with Class 1 systems receiving a high ranking while Class 4 systems recorded the lowest score. Location of the barrier in the catchment (e.g. tidal / lower / middle / upper) was determined by geomorphological and hydrological characteristics of the system, in addition to stream order and elevation. Barriers located within the tidal or lower reaches of the catchment with few-to-no obstructions downstream were ranked higher than weirs positioned in the upper headwaters. Moreover, a higher weighting was placed on weirs that, if remediated, would provide longer sections of unimpeded fish passage.

Structural impact criteria assessed whether the weir was a physical or hydrological barrier to migrating fish. Headloss over a structure, otherwise known as the ‘waterfall effect’, was the only major physical barrier recorded during the project. This parameter was measured under low flow conditions, with larger values representing a greater fish passage barrier and receiving a higher weighting. Hydrological barriers were categorised as displaying excessive water velocity and were assessed in association with the drown out occurrence of the structure.

Drown out values for structures were calculated from relevant time weighted flow duration data, with structures that rarely drowned out receiving a higher weighting than those structures that readily drowned out.

In association with the structural impacts assessed during the review, it was also noted if the weir was an undershot structure where the water is released from below the weir. These types of structures are known to have negative impacts on fish larvae (Marttin and Graaf 2002; Baumgartner 2005), and were given a higher weighting value during the prioritisation process.

Following the initial prioritisation, a secondary prioritisation incorporating environmental and structural modification criteria was conducted to further delineate rankings. Environmental criteria incorporated aquatic and riparian habitat condition (i.e. good / fair / poor), sedimentation in the weir pool, and threatened species habitat. Within the known ranges of species of conservation concern, priority rankings were determined by the quality of the surrounding aquatic habitat based on habitat class (Class 1-2: high ranking; Class 3: low ranking; Class 4: no ranking).

Modification criteria assessed structural use and the ease of remediating the weir. Occasionally structures were recorded during the Detailed Weir Review that were no longer used by the licensee or adjacent property owners. These obsolete weirs received a higher priority score due to the ease (e.g. low costs and short timescales) associated with remediation. Additionally, weir inspections noted that a number of structures required immediate maintenance that would enact the *Fisheries Management Act* 1994, which stipulates for the remediation of fish passage if repair works are undertaken. Weirs that were noted as candidates for removal received a higher ranking than weirs requiring fishways or structural modification to remediate fish passage due to the reduced costs and short timescales associated with the former option.

The weir prioritisation scheme was applied to all structures investigated, with results for each catchment displayed in their respective summary tables. Included in the summary tables are details of priority structures where remediation works have been completed or commenced. These structures have not been reviewed in this report, however information has been included in the tables to highlight the number of priority structures within each catchment. It should also be noted that the prioritisation of barriers carried out in this investigation is provisional in nature. Although social, cultural, and economic issues were considered during the Detailed Weir Reviews in order to provide an objective outcome, a degree of subjectivity is still required when assessing structures prior to the allocation of funding for remediation.

4. INDIVIDUAL DETAILED WEIR REVIEW REPORTS

Information used to prioritise each weir is detailed in the Individual Detail Weir Review reports for each catchment that appear in the following sections. Individual weir reports provide comprehensive accounts of the structures operational details, system hydrology, ecological considerations, proposed remediation options (along with projected costs), and preferred NSW DPI option for improving fish passage at the weir. A complete data set for each weir is stored in the NSW Department of Primary Industries Fish Habitat Database – this data can be accessed by contacting NSW DPI staff.

5. Namoi CMA - Detailed Weir Review Sites

Namoi CMA Summary Table

Rank	Barrier Name	Latitude	Longitude	Structure Type	Watercourse	Ownership	Operational Fishway	Recommendation	Estimated Cost of preferred option ($)	Estimated Cost of alternative option ($)	Potential Increase in Habitat Area (km)
1	Mollee Weir	-30.266666	149.700000	Adjustable crest (vertical lift gates)	Namoi River	State Water	No (Submerged Orifice Fishway present)	Fishlock	500K - 1M	>1M	220
2	Gunidgera Weir	-30.200000	149.440000	Adjustable crest (vertical lift gates)	Namoi River	State Water	No Submerged Orifice Fishway present)	Fishlock	500K - 1M	>1M	50
3	Weeta Weir	-30.288611	149.339444	Adjustable crest (leaf gates and vertical lift gate)	Namoi River	State Water	No (Submerged Orifice Fishway present)	Vertical Slot Fishway	250 – 500K	50 - 150K	70
4	Walgett Shire Council Weir	-30.019006	148.119497	Fixed crest (sheet piling and rock fill)	Namoi River	Walgett Shire Council	No	Removal	<50K	150 - 250K	70
5	Jewry Street Weir	-30.081711	150.917486	Fixed crest causeway (concrete)	Peel River	Tamworth Regional Council	No	Removal	<50K	250 - 500K	230
6	Barraba Weir	-30.372578	150.607158	Fixed crest (concrete)	Manilla River	Tamworth Regional Council	No (Vertical Slot Fishway present)	Removal	<50K	<50K	30
7	Calala Gauging Weir	-31.133629	150.965947	Fixed crest water gauging structure (concrete)	Peel River	State Water/DNR	No	Removal	<50K	250 - 500K	40
N/A	Manilla Weir # 1	-30.744823	150.726554	Fixed crest	Manilla River	Tamworth Regional Council	Yes	N/A (Rock Ramp Fishway Present)	N/A	N/A	N/A
N/A	Manilla Weir # 2	-30.743195	150.732126	Fixed crest	Manilla River	Tamworth Regional Council	Yes	N/A (Rock Ramp Fishway Present)	N/A	N/A	N/A
N/A	Namoi Weir (d/s Keepit Dam)	-32.897666	151.708333	Fixed crest	Namoi River	State Water	N/A	Removal Completed May 2005	25K	N/A	N/A

MOLLEE WEIR, NAMOI RIVER

Figure 1. Mollee Weir, Namoi River (08.09.2005, 604ML/day).

Figure 2. Mollee Weir, submerged orifice fishway, Namoi River (08.09.2005, 604ML/day).

Description and Setting

Mollee Weir (Figure 1) is located approximately 20km West of Narrabri on the Namoi River in the lower end of the Namoi catchment. The site is accessed via the Wee Waa Road. The weir is approximately 5 metres in height and is approximately 60 metres across the length of the crest. Mollee Weir is a regulating structure with three bays that act as a barrier to fish passage in all but flooding conditions, when the gates are opened to prevent drown out of the weir. Below flooding flows, the weir restricts fish passage due to excessive head loss and increased turbulence across the face of the structure. Currently there is an ineffective submerged orifice fishway (Figure 2) at this site that does not pass fish.

Mollee Weir is ranked as a high remediation priority within the Namoi CMA region due to the following factors:

- Class 1 fish habitat - major permanently flowing waterway and presence of one or more threatened fish species (this site is within the expected distribution of silver perch (*Bidyanus bidyanus*), olive perchlet (*Ambassis agassizii*), and purple spotted gudgeon (*Mogurnda adspersa*), in addition to the endangered river snail (*Notopala sublineata*));
- Located within the Aquatic Endangered Ecological Community of the Lowland Catchment of the Darling River;
- Location within the catchment (fish habitat located in the mid–lower end of the catchment generally has a higher conservation need due to the greater prevalence of spawning grounds 'core habitats');
- Diverse range of native fish (High Conservation Value);
- Improved stream connectivity: the next upstream fish passage barrier is Keepit Dam on the Namoi River approximately 180km away by river; the next barrier downstream on the Namoi River is Gunidgera Weir, which is approximately 40km away. Both structures are owned and operated by State Water; and
- Low frequency of drown out (flow at which fish passage is possible, where headloss and velocity are minimal).

Hydrology

Flows in the Namoi catchment are controlled by Keepit, Split Rock, Chaffey, and Dungowan Dams. Split Rock Dam, located at the headwaters of the Manilla River was built to augment the supply to Keepit Dam and also supplies stock, domestic, and irrigation waters to users along the Manilla River. These two dams collectively regulate flows within the mid-lower end of the catchment. Chaffey and Dungowan Dams are primarily used for town water supply, some riparian use, and irrigation within the Peel Valley.

The closest DNR river gauge is on the Namoi River at Mollee (station 419039). Information referred to in this report regarding flows in the Namoi River at Mollee were sourced from the DNR website and staff, using data acquired between 01.10.1965 – 31.08.2005.

Regardless of flow conditions, Mollee Weir does not drown out. The undershot gates are slowly raised to allow water to pass under the gates during flood conditions, however they are only raised free of the water during maintenance – it is at this time when fish passage may be possible past the weir.

Operational Details

Mollee Weir was built in 1974 and is owned and operated by State Water. The weir is used to store water for later release to stock and for irrigation use when required. The weir is a regulating structure, consisting of three bays with three vertical lift steel gates, which are electronically operated and can be monitored remotely. The structure never drowns out and no fish passage is possible while the gates are closed (currently occurring throughout the year in all but flooding conditions). The gates are gradually opened when high flows are expected down the Namoi River to prevent overtopping and potential structural failure. It is only at this time that some fish passage may be possible past the structure.

The weir currently has a non-functioning submerged orifice fishway located on the right hand side, similar in design to that of the fishway located at Gunidgera Weir. This fishway was built in 1974 during the construction of the weir and was based on the European designs which were built to pass salmonoid fish species. These designs have since been recognised to be ineffective in passing Australian native fish species due to their poorer swimming abilities.

Ecological Considerations

Harris (2004) identified Mollee Weir on the Namoi River as one of several "important artificial barriers to (fish) migration" within the Namoi catchment.

Mollee Weir is an undershot weir, which is known to have a negative impact on fish larvae (up to 40% mortality of larvae passing through an undershot weir, compared to only 16% in an overshot weir) (Marttin and Graaf 2002; Baumgartner 2005). It is therefore important that we understand the effect of weirs on fish communities so that they can be better managed to assist in the protection of native fish and their habitats in the entire Namoi catchment.

Anecdotal evidence from local anglers, landholders and NSW DPI Fisheries officers indicates that fish species including freshwater catfish, golden and silver perch, and Murray cod occur in the area and have recently been caught. The High Conservation Value (HCV) database (NSW DPI accessed 10.08.05) states that the following native species are expected to occur within the Lower Namoi River: freshwater catfish, golden perch, Murray cod, spangled perch, bony herring, Australian smelt, Darling River hardyhead, fly specked hardyhead, crimson spotted rainbow fish, carp gudgeon, with the threatened silver perch and olive perchlet also expected to be present. Introduced species including common carp, goldfish and eastern gambusia are also present in the Lower Namoi River.

The Namoi River contains important fish habitat components including instream woody debris, which provides valuable shelter for fish from strong water currents and larger avian and aquatic predators. Woody debris also provides an important substrate for fish to lay eggs as well as for the growth of algae.

The weir site has well vegetated banks both upstream and downstream of the site (Figure 3). The riparian vegetation is dominated by eucalypts and at the time of the inspection there was a well established grassy understorey.

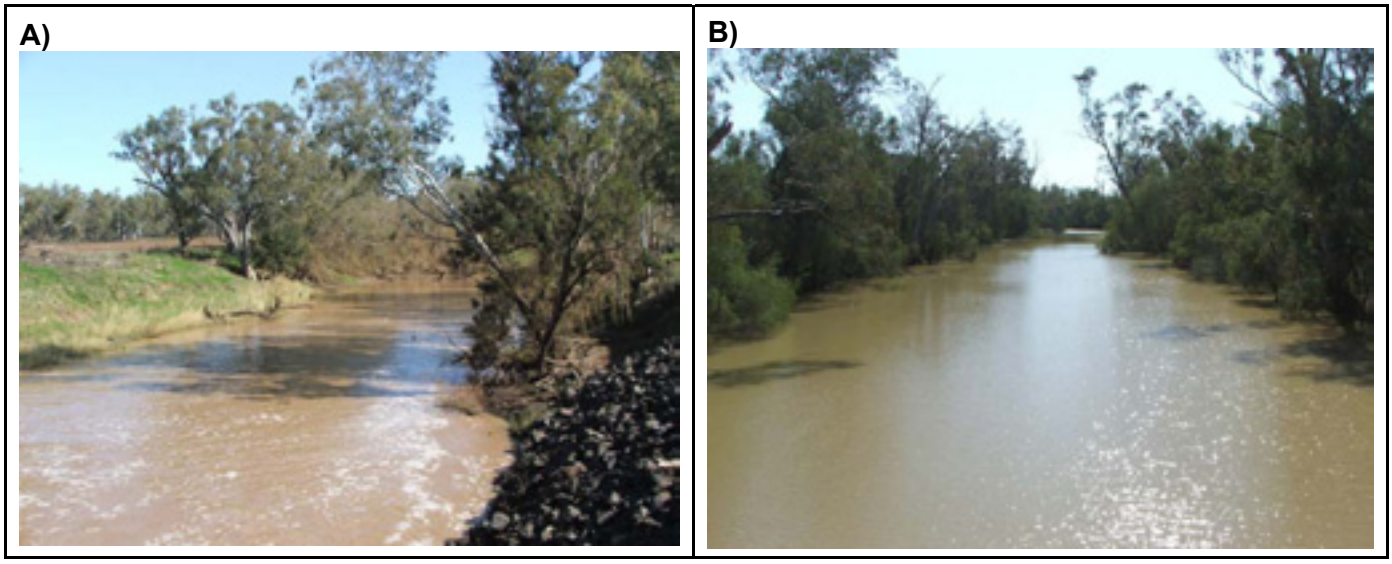

Figure 3. Namoi River A) downstream and B) upstream of Mollee Weir (08.09.2005, 604ML/day).

Proposed Remediation Actions

Mollee Weir is a total barrier to fish passage except when the gates are lifted free of the water. As a result it is recommended that fish passage options be further investigated at this site, management of the vertical lift gates be re-assessed, and investigations be undertaken to improve the functionality of the existing fishway.

- **Option 1 –** Fishlock (Deelder or similar)

A fishlock operates in a similar manner to a boat lock. The fishway works by attracting fish through an entrance similar to that of a pool type fishway, but instead of swimming up a channel the fish accumulate in a holding area at the base of the lock (Thorncraft and Harris 2000). The holding area where the fish accumulate is sealed and water is directed into the chamber until water levels are equal to the upstream weir pool. Fish are encouraged to swim through the lock using a series of attraction flows and crowding screens. The only lock fishway built in NSW to date is at Yarrawonga Weir on the River Murray. This fishlock has been shown to be effective in transporting fish over the 12 metre high weir, although several operating and exit arrangements require modification (Thorncraft and Harris 2000).

For smaller structures (less than 5 metres), the Deelder fishlock is considered a cost effective option for fish passage, and up until 2002 had not been applied to Australian rivers. The Deelder fishlock was trialled in Australia at Balranald Weir on the Murrumbidgee River and has proven to be effective in passing a range of fish species and size classes including Australian smelt, juvenile bony bream, crimson spotted rainbowfish, golden perch, and the threatened silver perch. The outcome of the subsequent monitoring at this site has proved that “the Deelder fishlock was extremely effective at providing passage for Australian native fish under low flow conditions” (Baumgartner 2003). Monitoring of fish passage at this site continues and will observe fish passage under various flow conditions to determine whether this design is applicable for other sites across NSW.

Further investigations for Deelder fishlocks have been recommended by Thorncraft and Harris (2000) at other sites along the Murrumbidgee River, including Berembed and Yanco Weirs, which currently have ineffective submerged orifice fishways. As with Balranald Weir, the Deelder fishlock could be incorporated into the existing fishway at Mollee Weir at a relatively low cost.

- **Option 2 –** Replacement of the existing fishway with a vertical slot fishway

The removal of the old fishway and replacement with a vertical slot fishway is a viable option at Mollee Weir. With varying headloss the vertical slot fishway would be more effective in passing a greater range of fish size classes. Vertical slot fishways are considered one of the most effective fishway designs and are the preferred option when located on the main stem or major tributary of a waterway or where threatened species are present (this site is within the expected distribution of silver perch, olive perchlet, and purple spotted gudgeon).

The concrete construction of the weir makes it an ideal anchor for securing the vertical slot fishway and its associated infrastructure, with the preferred location being on the right hand bank. Adequate attraction flow would need to be created by increasing flows through the fishway during low flow periods.

The cost of the vertical slot fishway is based on a broad estimate of $150,000 per vertical metre, although this amount is dependant on site location and access, along with various structural and hydrological constraints. The construction of a vertical slot fishway is therefore the most expensive option for this site. It should be noted that vertical slot fishways are as yet untried on weirs greater than 4.5 metres in Australia. This is largely been related to cost as lock and lift-style fishways become more viable as structure height increases. In addition, the major structural modifications potentially required to allow for the construction of a vertical slot fishway may be unrealistic, and may outweigh the benefits to fish passage.

- **Option 3 –** Retrofit existing fishway with a Denil insert

At present Mollee Weir is a total barrier to fish passage alienating fish from the Upper Namoi River. During several site inspections by NSW DPI, fish were observed congregating below the weir, unable to negotiate the highly turbulent conditions and high velocities experienced at the entrance to the fishway. Currently the fishway consists of an enclosed concrete channel with an estimated gradient of 1:6. There are many cells within this channel, which are created by wooden baffles with a single submerged orifice. The fishway is fully enclosed which has created a behavioural barrier to many fish as a result of poor lighting.

There is some scope for improvements to the existing fishway that may allow it to function more effectively, such as through the installation of a Denil insert.

A Denil fishway is a channel incorporating U-shaped baffles that reduce velocity and turbulence so that fish can ascend without undue stress. Denil fishways are cheaper than vertical slot fishways because they can be constructed on steeper slopes thereby requiring less materials for their construction (Baumgartner 2005). The required gradient to allow native fish passage through Denil fishways is currently estimated as 1:12 or less (a more conservative slope).

The modifications that would be required to improve fish passage at this site would include the following:

- Retrofitting the existing fishway channel with U-shaped baffles that reduce velocity and turbulence so that fish can ascend without undue stress;
- Establishing natural lighting along the concrete channel. This may be achieved by opening the channel roof, replacing the concrete with steel mesh grates, or by installing skylight holes along the length of the fishway channel.

There are limitations with the use of Denil inserts, however, with Larinier (1990) identifying Denil fishways as only being effective in passing fish greater than 200mm in length. Mallen-Cooper (2000) recommended Denil fishways be constructed on slope no greater than 1:12, as slopes greater than this (less conservative slopes) limit the movement of smaller fish. Experimental work undertaken in NSW has shown that bony herring could ascend Denil fishways with a slope of 1:12, however their movement was greatly restricted on steeper slopes. Mallen-Cooper (2000) further recommended that Denil fishway design should not be used where adult Murray cod are present, as it has not yet been established whether this species will use the Denil design.

The NSW Fish and Rivers in Stress survey (Harris and Gehrke 1997) identified a high abundance of both bony herring and Murray cod in the Namoi River. The Denil fishway as described above is not conducive for the fish passage requirements of these species, however it would improve fish passage for some species, and is likely to be the most cost effective remediation option for this site.

Projected Remediation Costs

Projected cost	< $50K	$50K - $150K	$150K - $250K	$250K - $500K	$500K - $1M	> $1M
Option 1					✔	
Option 2						✔
Option 3			✔			

Recommendation

It is recommended that the installation of a Deelder fishlock into the existing submerged orifice fishway be investigated along with an appropriate lighting source to dispel potential behavioural aversion to the fishlock (Option 1). In addition, appropriate management of the vertical lift gates to minimise their effect on fish larvae is also a priority for this site.

During low diversion periods (winter months), the vertical lift gates should be raised clear of the water to reinstate a natural flow regime and effective fish passage. Where possible, investigations should be undertaken to determine if this management option is available during peak fish migration periods (late spring/summer).

Benefits Associated with Remediation

The Namoi River contains important fish habitat that should be protected, and the reinstatement of fish passage along the entire system would generate substantial benefits to the ecology of the catchment.

The Lower Namoi River has been classified as having a High Conservation Value (HCV) by the Department of Environment and Conservation (DEC) and NSW DPI due to its high species diversity and presence of one or more threatened species.

Harris (2004) identifies areas downstream of Narrabri (lowland river reaches) as ‘core habitats’, which are crucial for fish recruitment and migration. The reinstatement of fish passage at Mollee Weir on the Namoi River would provide unimpeded access to approximately 320km of potential core habitat, benefiting particular species such as the golden perch and Murray cod.

GUNIDGERA WEIR, NAMOI RIVER

Figure 1. Gunidgera Weir, Namoi River (08.09.2005, 365ML/day).

Figure 2. Gunidgera Weir, submerged orifice fishway, Namoi River (08.09.2005, 365ML/day).

Description and Setting

Gunidgera Weir (Figure 1) is located 3km North of Wee Waa and can be accessed via Tulladunna Lane. The weir is situated on the Namoi River in the lower end of the catchment. The weir is approximately 5 metres in height and is approximately 50 metres across the length of the crest. The weir is a regulating structure with two bays. Gunidgera Weir acts as a barrier to fish passage throughout the year due to excessive head loss during all flow conditions except flooding flows, when the gates are opened to prevent drown out of the weir. There is currently an ineffective fishway (Figure 2) at this site, which does not meet NSW DPI standards and restricts the passage of fish.

Gunidgera Weir is ranked as a high remediation priority within the Namoi CMA region due to the following factors:

- Class 1 fish habitat - major permanently flowing waterway and presence of one or more threatened fish species (this site is within the expected distribution of silver perch (*Bidyanus bidyanus*), olive perchlet (*Ambassis agassizii*), purple spotted gudgeon (*Mogurnda adspersa*), and the endangered river snail (*Notopala sublineata*));
- Distributed within the Aquatic Endangered Ecological Community of the Lowland Catchment of the Darling River;
- Location within the catchment (fish habitat located in the mid – lower end of the catchment generally have a higher conservation need due to the higher prevalence of spawning grounds as 'core habitats');
- Diverse range of native fish (High Conservation Value);
- Improved stream connectivity: the next upstream barrier to fish is Mollee Weir located on the Namoi River approximately 40km away by river, the next barrier downstream is Weeta Weir on the Namoi River approximately 20km away. Both of these structures are owned and operated by State Water; and
- Low frequency of drown out (flow at which fish passage is possible, where headloss and velocity are minimal).

Hydrology

Flows in the Namoi catchment are controlled by Keepit, Split Rock, Chaffey and Dungowan Dams. Split Rock Dam, located at the headwaters of the Manilla River, was built to augment the supply to Keepit Dam and also supplies stock, domestic and irrigation waters to diverters along the Manilla River. These two dams collectively regulate flows within the mid-lower end of the catchment. Chaffey and Dungowan Dams are primarily used for town water supply, some riparian use, and irrigation within the Peel Valley.

The closest DNR river gauge is on the Namoi River down stream of Gunidgera Weir (station 419059). Information referred to in this report regarding flows in the Namoi River downstream of Gunidgera Weir were sourced from the DNR website and staff, using data acquired between 01.01.1976 – 31.08.2005. Mollee Weir and Keepit Dam are two other major barriers to fish passage located upstream from Gunidgera Weir on the Namoi River, with both being owned and operated by State Water.

Operational Details

Gunidgera Weir is owned and operated by State Water and was built in 1976. The weir is used to store water for release for stock and irrigation use when required. Water is diverted from the Namoi River into the Gunidgera Creek system for stock, irrigation, and domestic use.

Gunidgera Weir is a regulating structure, which consists of two bays with two vertical lift steel gates. These gates are electronically operated and can be monitored remotely. The structure never drowns out, there is no fish passage possible while the gates are closed. The gates currently remain closed throughout the year during all but flooding conditions, when they are gradually opened to prevent overtopping and potential structural failure of the weir.

The weir currently has a non-functioning submerged orifice fishway located on the right hand bank. This fishway was built during construction of the weir in 1976, and was based on European designs built to pass salmonoid fish species. These designs have since been recognised as ineffective in passing our native fish species due to the greater swimming ability of salmonid species, and the poorer swimming ability of native fish species.

Ecological Considerations

Harris (2004) identifies the Gunidgera Weir on the Namoi River as one of several "important artificial barriers to (fish) migration" within the Namoi catchment.

The weir is an undershot weir, which is known to have a negative impact on fish larvae (up to 40% mortality of larvae passing through an undershot weir, compared to only 16% in an overshot weir) (Marttin and Graaf 2002; Baumgartner 2005). It is therefore important that we understand the effect of weirs on fish communities so that they can be better managed to assist in the protection of native fish and their habitats in the entire Namoi catchment.

Anecdotal evidence from local anglers, landholders, and NSW DPI Fisheries officers indicates that fish species including freshwater catfish, golden and silver perch, and Murray cod occur in the area and have been caught recently. The High Conservation Value (HCV) database (NSW DPI accessed 10.08.05) indicates that the following native species are expected to occur within the Lower Namoi River: freshwater catfish, golden perch, Murray cod, spangled perch, bony herring, Australian smelt, Darling River hardyhead, fly specked hardyhead, crimson spotted rainbow fish, carp gudgeon, with the threatened species silver perch and olive perchlet also expected. Introduced species including common carp, goldfish, and eastern gambusia are also present in the Lower Namoi River.

At the time of inspection, the Namoi River upstream and downstream of the weir was well vegetated (Figure 3). The presence of large woody debris downstream from this site is an important component of fish habitat that must be maintained. Snags provide hiding places from predators, shelter fish from strong currents and act as a suitable substrate for the attachment of sticky fish eggs. Snags also act as a surface for the growth of algae, providing a food source for aquatic invertebrates, which in turn provide food sources for fish and other aquatic organisms.

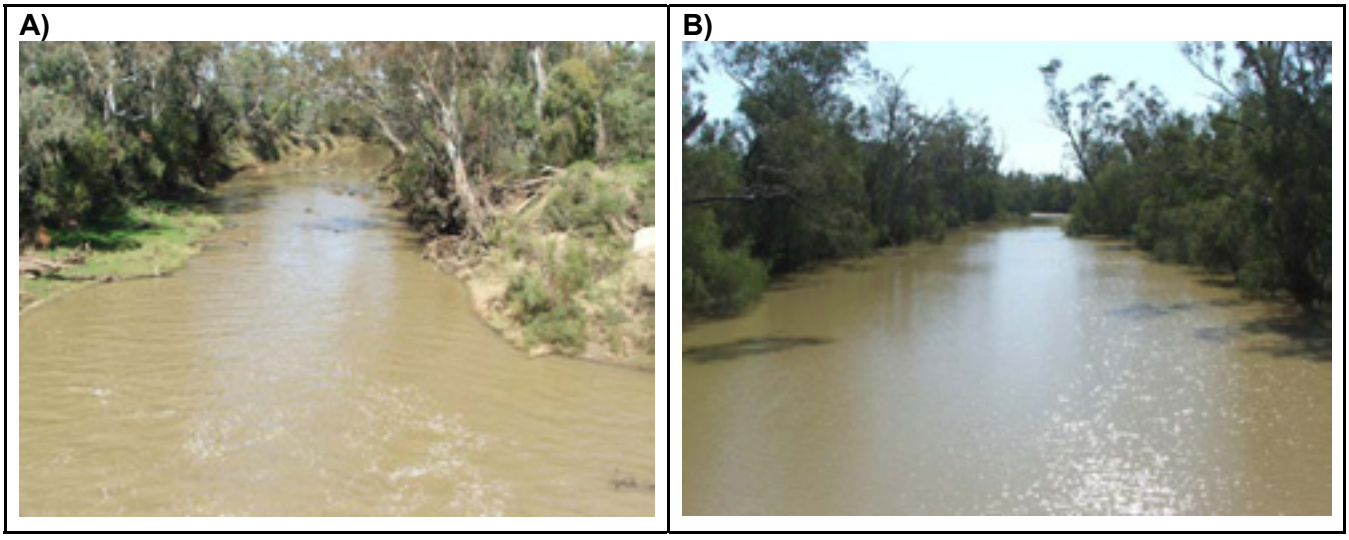

Figure 3: Namoi River A) downstream and B) upstream of Gunidgera Weir (08.09.2005, 365ML/day).

Proposed Remediation Actions

As the weir is a total barrier to fish passage at all times other than when the gates are lifted free of the water, it is recommended that fish passage options be further investigated at this site and the management of the vertical lift gates be re-assessed to facilitate fish movement past the structure.

- **Option 1 –** Fishlock (Deelder or similar)

A fishlock operates in a similar manner to a boat lock. The fishway works by attracting fish through an entrance similar to that of a pool type fishway, but instead of swimming up a channel the fish accumulate in a holding area at the base of the lock (Thorncraft and Harris 2000). The holding area where the fish accumulate is sealed and water is directed into the chamber until water levels are equal to the upstream weir pool. Fish are encouraged to swim through the lock using a series of attraction flows and crowding screens. The only lock fishway built in NSW to date is at Yarrawonga Weir on the River Murray. This fishlock has been shown to be effective in transporting fish over the 12 metre high weir, although several operating and exit arrangements require modification (Thorncraft and Harris 2000).

For smaller structures (less than 5 metres), the Deelder fishlock is considered a cost effective option for fish passage and up until 2002, had not been applied to Australian rivers. The Deelder fishlock was trialled in Australia at Balranald Weir on the Murrumbidgee River and has proven to be effective in passing a range of fish species and size classes including Australian smelt, juvenile bony bream, crimson spotted rainbowfish, golden perch, and the threatened silver perch. The outcome of the subsequent monitoring at this site has proved that “the Deelder fishlock was extremely effective at providing passage for Australian native fish under low flow conditions” (Baumgartner 2003). Monitoring of fish passage at this site continues and will observe fish passage under various flow conditions to determine whether this design is applicable for other sites across NSW.

Further trials of Deelder fishlocks have been recommended by Thorncraft and Harris (2000) at other sites along the Murrumbidgee River including Berembed, and Yanco Weirs, which currently have ineffective submerged orifice fishways.

As with Balranald Weir, a fishlock could be incorporated into the existing fishway located on the right hand side of Gunidgera Weir at a relatively low cost.

The results of the Balranald fishlock study will provide some useful concepts that could be applied to this site. Although it is still in an experimental stage, the Deelder fishlock has already proven to be effective at passing a wide range of native fish species and size classes during low flow periods.

- **Option 2 –** Retrofit existing fishway with a Denil insert

At present Gunidgera Weir represents a total barrier to fish passage alienating fish from the Upper Namoi River. During several site inspections by NSW DPI, fish were observed congregating below the weir, unable to negotiate the highly turbulent conditions, with high velocities experienced at the entrance to the fishway. Currently the fishway consists of an enclosed concrete channel with an estimated gradient of 1:6. There are many cells within this channel, which are created by wooden baffles with a single submerged orifice. The fishway is fully enclosed which has created a behavioural barrier to many fish as a result of poor lighting. There is some scope for improvements to the existing fishway that may allow it to function more effectively, such as through the installation of a Denil insert.

A Denil fishway is a channel incorporating U-shaped baffles that reduce velocity and turbulence so that fish can ascend without undue stress. Denil fishways are cheaper than vertical slot fishways because they can be constructed on steeper slopes thereby requiring less materials for their construction (Baumgartner 2005). The required gradient to allow native fish passage through Denil fishways is currently estimated as 1:12 or less (a more conservative slope).

The modifications that would be required to increase fish passage would include the following:

- Retrofitting the existing fishway channel with U-shaped baffles that reduce velocity and turbulence so that fish can ascend without undue stress; and
- Establishing natural lighting along the concrete channel. This may be achieved by opening the channel roof, replacing the concrete with steel mesh grates, or by installing skylight holes along the length of the fishway channel. Alternatively lighting could be provided artificially, depending on the structural composition of the material overlying the fishway and the ease of removal/modification.

There are limitations in the use of Denil inserts, however, with Larinier (1990) identifying Denil fishways as only being effective in passing fish greater than 200mm in length. Mallen-Cooper (2000) recommends Denil fishways be constructed on slope no greater than 1:12 as slopes greater than this (less conservative slopes) limit the movement of smaller fish. Experimental work carried out in NSW indicated that bony herring could ascend Denil fishways with a slope of 1:12, although their movement was greatly restricted on steeper slopes. Mallen-Cooper (2000) further recommended that Denil fishway designs should not be used where adult Murray cod are present, as it has not yet been established whether this species will use the Denil design.

The NSW Fish and Rivers in Stress survey (Harris and Gehrke 1997) identified a high abundance of both bony herring and Murray cod in the Namoi River.

The Denil fishway as described above is not conducive for the fish passage requirements of these species, however it would improve fish passage for some species, and is likely to be the most cost effective remediation option for this site.

- **Option 3 –** Replacement of the existing fishway with a vertical slot fishway

The removal of the old fishway and replacement with a vertical slot fishway design is another remediation option for Gunidgera Weir. With varying head loss, the vertical slot fishway would be more effective in passing a greater range of fish size classes. Vertical slot fishways are considered one of the most effective fishway designs and are the preferred option where threatened species are present (this site is within the expected distribution of silver perch, purple spotted gudgeon, and olive perchlet).

The concrete construction of the weir makes it an ideal anchor for securing the vertical slot fishway and its associated infrastructure, with the preferred location being on the right hand bank. Adequate attraction flow would need to be created by increasing flows through the fishway during low flow periods.

The cost of the vertical slot fishway is based on a broad estimate of $150,000 per vertical metre, although this amount is dependant on site location and access, along with various structural and hydrological constraints. The construction of a vertical slot fishway at Gunidgera Weir is therefore the most expensive option. It should be noted that vertical slot fishways are as yet untried on weirs greater than 4.5 metres in Australia. This is largely been related to cost as lock and lift-style fishways become more viable as structure height increases. In addition, the major structural modifications potentially required to allow for the construction of vertical slot fishway may be unrealistic, and may outweigh the benefits to fish passage. Further detailed cost analysis should be undertaken to determine the viability of this option.

Projected Remediation Costs

Projected cost	< $50K	$50K - $150K	$150K - $250K	$250K - $500K	$500K - $1M	> $1M
Option 1					✔	
Option 2			✔			
Option 3						✔

Recommendation

It is recommended that the installation of a fishlock (Deelder or similar) into the existing submerged orifice fishway be further investigated along with an appropriate lighting source (Option 1). In addition, appropriate management of the vertical lift gates to minimise their effect on fish larvae is also a priority for this site.

During low diversion periods (during the winter months), the vertical lift gates should be raised clear of the water to reinstate a natural flow regime and effective fish passage. Where possible, investigations should be undertaken to determine if this management option is available during fish migration periods (spring/summer).

Benefits Associated with Remediation

The Namoi River contains important fish habitat that should be protected, and the reinstatement of fish passage along the entire system would generate substantial benefits to the ecology of the catchment.

The Lower Namoi River has been classified as having a High Conservation Value (HCV) by the Department of Environment and Conservation (DEC) and NSW DPI due to its high species diversity and presence of one or more threatened species. Harris (2004) identifies areas downstream of Narrabri (lowland river reaches) as 'core habitats', which are crucial for fish recruitment and migration. The reinstatement of fish passage at Gunidgera Weir on the Lower Namoi River would provide unimpeded access to approximately 60km of potential core habitat, benefiting particular species such as the golden perch and Murray cod.

WEETA WEIR, NAMOI RIVER

Figure 1. Weeta Weir, Namoi River (08.09.2005, 576ML/day).

Figure 2. Submerged orifice fishway, Weeta Weir, Namoi River (21.03.2005, 53ML/day).

Description and Setting

Weeta Weir (Figure 1) is located 40km south west of Wee Waa on the Namoi River in the lower end of the catchment. Access to the weir is possible via Pilliga Road. The weir is approximately 2 metres high and is approximately 45 metres across the length of the crest. Weeta Weir is a regulating structure with four bays, comprising three leaf gates and one vertical lift gate. The weir also possesses an ineffective submerged orifice fishway (Figure 2). The weir therefore acts as a barrier to fish passage at flows of less than approximately 3,600ML/day when the structure is drowned out. At flows below 3,600ML/day, fish passage is restricted due to excessive head loss, increased turbulence, and increased water velocities experienced across the face of the structure.

Weeta Weir is ranked as a high remediation priority within the Namoi CMA region due to the following factors:

- Class 1 fish habitat - major permanently flowing waterway and presence of threatened fish species (this site is within the expected distribution of silver perch (*Bidyanus bidyanus),* olive perchlet (*Ambassis agassizii)*, purple spotted gudgeon (*Mogurnda adspersa*) and the endangered river snail (*Notopala sublineata*));
- Located within the Aquatic Endangered Ecological Community of the Lowland Catchment of the Darling River;
- Location within the catchment (fish habitat that is located in the mid – lower end of the catchment generally has a higher conservation need due to the higher prevalence of spawning grounds as 'core habitats');
- Diverse range of native fish (High Conservation Value);
- Improved stream connectivity: the next upstream barrier to fish is Gunidgera Weir located on the Namoi River approximately 20km away by river (owned and operated by State Water). The next weir downstream is the Walgett Shire Council Weir on the Namoi River at Walgett approximately 150km away (owned and managed by the Walgett Shire Council); and
- Low frequency of drown out (flow at which fish passage is possible, where headloss and velocity are minimal).

Hydrology

Flows in the Namoi catchment are controlled by Keepit, Split Rock, Chaffey, and Dungowan Dams. Split Rock Dam, located at the headwaters of the Manilla River, was built to augment the supply to Keepit Dam and also supplies stock, domestic, and irrigation waters to diverters along the Manilla River. These two dams collectively regulate flows within the mid-lower end of the catchment. Chaffey and Dungowan Dams are primarily used for town water supply, some riparian use, and irrigation within the Peel Valley.

The closest DNR river gauge is on the Namoi River downstream of Weeta Weir (station 419068). Information referred to in this report regarding flows within the Namoi River downstream of Weeta Weir were sourced from the DNR website and staff, with data acquired between 01.01.1978 – 31.08.2005. There are three other barriers to fish passage located upstream of this weir on the Namoi River: Gunidgera Weir, Mollee Weir, and Keepit Dam - all of which are owned and operated by State Water.

It has been estimated that Weeta Weir would drown out with flows in excess of 3,600ML/day. The time weighted flow duration curve for the Namoi River at this location shows that flows would exceed 3,600ML/day approximately 7% of the time.

Operational Details

Weeta Weir is owned and operated by State Water. The structure and its non-functioning fishway were built in 1977 to store water for stock and irrigation when required.

All environmental and irrigation flows are released through the vertical lift gate adjacent the submerged orifice fishway on the left hand side of the structure, with the hinged leaf gates remaining closed. The use of the vertical lift gates causes concern with regard to the mortality rates of juvenile fish species that pass under the vertical lift gate (see *Ecological Considerations*).

This fishway was constructed based on the European designs built to pass salmonoid fish species. These designs have since been recognised as ineffective in passing Australian native fish species in Australia due to their comparatively poorer swimming abilities. In the event that Weeta Weir is upgraded, a new fishway would be required at this site to allow for fish passage.

Ecological Considerations

Fish passage may be possible approximately 7% of the time due to structure drown out, however the timing of these flows may not necessarily coincide with spawning migrations of all or any of the resident fish species within the Namoi River system. Harris (2004) identifies the Weeta Weir on the Namoi River as one of several "important artificial barriers to (fish) migration" within the Namoi catchment.

The weir consists of three leaf gates and a vertical lift gate (undershot weir). Undershot weirs are known to have a negative impact on fish larvae (up to 40% mortality of larvae passing through an undershot weir, compared to only 16% in an overshot weir) (Marttin and Graaf 2002, Baumgartner 2005). It is therefore important that we understand the effect of weirs on fish communities so that they can be better managed to assist in the protection of native fish and their habitats in the entire Namoi catchment.

Anecdotal evidence from local anglers, landholders and NSW DPI Fisheries officers indicates that fish species including freshwater catfish, golden and silver perch, and Murray cod occur in the area and have recently been caught. The High Conservation Value (HCV) database (NSW DPI accessed 10.08.05) indicates that the following native species are expected to occur within the Lower Namoi River: freshwater catfish, golden perch, Murray cod, spangled perch, bony herring, Australian smelt, Darling River hardyhead, fly specked hardyhead, crimson spotted rainbow fish, carp gudgeon, with the threatened silver perch, olive perchlet, and purple spotted gudgeon also expected. Introduced species including common carp, goldfish, and eastern gambusia are also present in the Lower Namoi River.

The Namoi River contains important fish habitat components including instream large woody debris, which provides valuable shelter for fish from strong water currents and larger avian and aquatic predators.
In addition, woody debris also provides an important substrate for fish to lay eggs and the growth of algae (thereby creating a food source for macroinvertebrates).

The weir site has moderately vegetated banks both upstream and downstream of the site (Figure 3). The riparian vegetation is dominated by eucalypts, and at the time of the inspection possessed a well established grassy understorey. On the right hand bank the riparian buffer zone is 100 metres or more, however on the left hand bank agricultural development encroaches on the riparian zone directly adjacent to the weir. There was no obvious access to the river by stock at the time of the inspection.

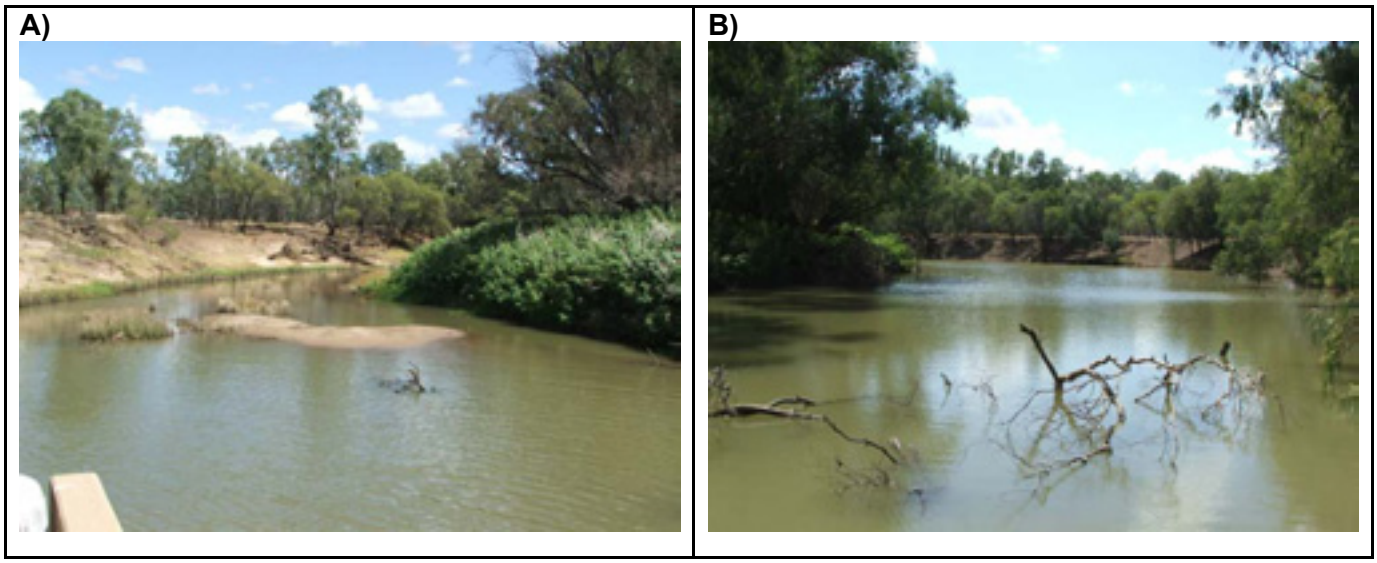

Figure 3. Namoi River A) downstream and B) upstream of Weeta Weir (30.11.2004, 95ML/day).

Proposed Remediation Actions

As the weir does not drown out regularly, it is recommended that fish passage options be further investigated at this site, with the management of the vertical lift gate re-assessed to minimise its effect of fish larvae.

- **Option 1 –** Deelder fishlock

A Deelder fishlock is a low level lock fishway that operates in a similar manner to a boat lock and consists of two chambers divided by an internal weir. The fishway works by attracting fish through an entrance similar to that of a pool type fishway, but instead of swimming up a channel the fish accumulate in a holding area at the base of the lock (Thorncraft and Harris 2000). The holding area where the fish accumulate is sealed and water is directed into the chamber until water levels are equal to the upstream weir pool. Fish are encouraged to swim through the lock using a series of attraction flows and crowding screens.

The Deelder fishlock design is considered a cost effective option for fish passage and up until 2002, had not been applied to Australian rivers. The Deelder fishlock was trialled in Australia at Balranald Weir on the Murrumbidgee River and has proven to be effective in passing a range of fish species and size classes including Australian smelt, juvenile bony bream, crimson spotted rainbowfish, golden perch, and the threatened silver perch. The outcome of the subsequent monitoring at this site has proved that “the Deelder fishlock was extremely effective at providing passage for Australian native fish under low flow conditions” (Baumgartner 2003). Monitoring of fish passage at this site continues and will observe fish passage under various flow conditions to determine whether this design is applicable for other sites across NSW.

Further investigations for Deelder fishlocks have been recommended by Thorncraft and Harris (2000) at other sites along the Murrumbidgee River including Berembed and Yanco Weirs, which currently have ineffective submerged orifice fishways. As with Balranald Weir the Deelder fishlock could be incorporated into the existing fishway located on the left hand side of Weeta Weir at a relatively low cost.

It is possible that the Deelder fishlock design could be applied to Weeta Weir. The results of the Balranald fishlock study will provide some useful concepts that could be applied to this site. Although it is still in an experimental stage the Deelder fishlock has already proven to be effective at passing a wide range of native fish species and size classes during low flow periods.

- **Option 2 –** Replacement of the existing fishway with a vertical slot fishway

With varying headloss the vertical slot fishway would be more effective in passing a greater range of fish size classes than other fishway designs. Vertical slot fishways are considered one of the most effective fishway designs and are the preferred option where threatened species are present (this site is within the expected range of silver perch, olive perchlet, and purple spotted gudgeon).

The concrete construction of the weir makes it an ideal anchor for securing the vertical slot fishway and its associated infrastructure, with incorporation of an attraction flow at the entrance to the fishway also important. The construction of a vertical slot fishway on the left hand bank is the preferred option for fish passage remediation at Weeta Weir. The cost of the vertical slot fishway is based on a broad estimate of $150,000 per vertical metre, although this estimate is dependant on site location, access and various structural and hydrological conditions. It is believed that a vertical slot fishway would provide a cost effective solution to fish passage at this site.

- **Option 3 –** Retrofit existing fishway with a Denil insert

There is some scope for improvements to the existing fishway that may allow it to function more effectively. At present Weeta Weir represents a total barrier to fish passage, alienating fish within the Lower Namoi catchment. By retrofitting the existing fishway with a Denil insert it would be possible to achieve an increase in fish passage. The Denil fishway is a channel incorporating U-shaped baffles that reduce velocity and turbulence so that fish can ascend without undue stress. Denil fishways are cheaper than vertical slot fishways because they can be constructed on steeper slopes thereby requiring less materials for their construction (Baumgartner 2005).

There are limitations in the use of Denil inserts, however. Larinier (1990) identifies Denil fishways as only being effective in passing fish greater than 200mm. Mallen-Cooper (2000) recommends Denil fishways be constructed on slope no greater than 1:12 as slopes greater than this (less conservative slopes) limit the movement of smaller fish. Experimental work carried out in NSW indicated that bony herring could ascend Denil fishways with a slope of 1:12, although their movement was greatly restricted on steeper slopes. Mallen-Cooper (2000) further recommended that Denil fishway designs should not be used where adult Murray cod are present, as it has not yet been established whether this species will use the Denil design.

The NSW Fish and Rivers in Stress survey (Harris and Gehrke 1997) identified a high abundance of both bony herring and Murray cod in the Namoi River.

The Denil fishway as described above is not conducive to the fish passage requirements of Murray cod and bony herring, although it would improve fish passage for some species. This option is therefore not recommended for this site.

Projected Remediation Costs

Projected cost	< $50K	$50K - $150K	$150K - $250K	$250K - $500K	$500K - $1M	> $1M
Option 1					✔	
Option 2				✔		
Option 3		✔				

Recommendation

The recommendation for fish passage remediation at this site is to install a vertical slot fishway (Option 2). Previously NSW DPI has recommended that a vertical slot fishway be installed at this site in the planned upgrade process of the weir. Although this is a more costly option, it is likely to provide the greatest environmental benefit.

In addition, appropriate management of the vertical lift gate to minimise its affect on fish larvae is also a priority for this site. During low diversion periods (during the winter months), the vertical lift gate should be raised clear of the water to reinstate a natural flow regime and effective fish passage. Where possible, investigations should be undertaken to determine if this management option is available during fish migration periods (spring/summer).

Benefits Associated with Remediation

The Namoi River contains important fish habitat that should be protected, and the reinstatement of fish passage along the entire system would generate substantial benefits to the ecology of the catchment.

The Lower Namoi River has been classified as having a High Conservation Value (HCV) by the Department of Environment and Conservation (DEC) and NSW DPI due to its high species diversity and presence of one or more threatened species.

Harris (2004) identifies areas downstream of Narrabri (lowland river reaches) as ‘core habitats’, which are crucial for fish recruitment and migration. The reinstatement of fish passage at Weeta Weir on the Lower Namoi River would provide unimpeded access to approximately 160km of potential core habitat, benefiting particular species such as the golden perch and Murray cod.

WALGETT SHIRE COUNCIL WEIR, NAMOI RIVER

Figure 1. Walgett Shire Council Weir, Namoi River (08.09.2005, 50ML/day).

Description and Setting

The Walgett Shire Council Weir (Figure 1) is located just within the town limits of Walgett on the Namoi River approximately 300 metres upstream of the 'Namoi Bridge' in the Lower Namoi catchment. The weir is 4km upstream of the junction of the Namoi and Barwon Rivers and is easily accessible via a public reserve on the right hand bank. The Walgett Shire Council Weir stands approximately 1.8 metres high and is approximately 30 metres across the length of the crest. The weir is a fixed crest structure with no regulating infrastructure associated with it and acts as a barrier to fish passage at flows less than approximately 1,500ML/day. At flows below 1,500ML/day fish passage is restricted due to excessive head loss, increased turbulence, and increased water velocities experienced across the face of the structure.

The Walgett Shire Council Weir is ranked as a high remediation priority within the Namoi CMA region due to the following factors:

- Class 1 fish habitat - major permanently flowing waterway and presence of one or more threatened fish species (this site is within the expected distribution of silver perch (*Bidyanus bidyanus*), olive perchlet (*Ambassis agassizii*), and purple spotted gudgeon (*Mogurnda adspersa*));
- Location within the catchment (fish habitat that is located in the lower end of the catchment generally have a higher conservation need due to the higher prevalence of spawning grounds as 'core habitats');
- Diverse range of native fish (High Conservation Value);
- Improved stream connectivity: the next upstream weir is Weeta Weir located on the Namoi River approximately 150km away, the next barrier downstream is Weir 11A, located on the Barwon River approximately 4km away. Weir 11A

falls within the Western CMA, and has been identified as a high priority structure for fish passage in that area. Both Weeta and 11A weirs are owned and operated by State Water; and

- Low frequency of drown out (flow at which fish passage is possible, where headloss and velocity are minimal).

Hydrology

Flows in the Namoi catchment are controlled by Keepit, Split Rock, Chaffey, and Dungowan Dams. Split Rock Dam, located at the headwaters of the Manilla River was built to augment the supply to Keepit Dam and also supplies stock, domestic, and irrigation water to users along the Manilla River. These two dams collectively regulate flows within the mid-lower end of the catchment. Chaffey and Dungowan Dams are primarily used for town water supply, some riparian use, and irrigation within the Peel Valley.

The flow data used in the hydrological assessment of this site was taken from upstream DNR river gauges on the Namoi River at Goangra (station 419026) and upstream of Walgett (station 419091). Information regarding flows in the Namoi River at these two gauging sites were sourced from the DNR website and staff, using data acquired between 01.08.1954 – 01.09.2005.

It has been estimated that Walgett Shire Council Weir would drown out with flows in excess of 1,500ML/day. The time weighted flow duration curve for the Namoi River at this location shows that flows would exceed 1,500ML/day approximately 21% of the time.

There are four other barriers to fish passage located upstream from Walgett Shire Council Weir on the Namoi River, including Weeta Weir, Gunidgera Weir, Mollee Weir, and Keepit Dam, all of which are owned and operated by State Water.

There are currently several licensed water extractors who utilise the water in the upstream weir pool including Walgett Shire Council, who are licensed to extract water to supply the town of Walgett.

Operational Details

Walgett Shire Council Weir was built prior to 1991 and was originally licensed as a temporary structure. The weir is owned and managed by Walgett Shire Council who draw water from the upstream weir pool - securing a back up supply of town water from the Namoi River when the river is low. The rock fill and sheet metal piling weir has no fishway.

Discussions have previously taken place with regard to increasing the height of the State Water owned 11A Weir located approximately 5km downstream on the Barwon River so that the weir pool from this structure would extend further upstream closer to Walgett township. Further hydrological assessment would be required to determine whether water security could be achieved from the modifications as discussed.
The Walgett Shire Council Weir has been repaired many times, the last of which occurred in 2003 without consultation with NSW DPI. The *NSW Fisheries Management Act 1994* states “the Minister may require a person who constructs, alters or modifies a dam or weir to provide fish passage”.

Discussions are currently ongoing with regard to the future management options for this weir, with all modifications or repairs requiring approval from NSW DPI.

Ecological Considerations

Fish passage may be possible at 21% of the time when the structure is drowned out, however the timing of these flows may not necessarily coincide with spawning migrations of all or any of the resident fish species within the Namoi River system.

Harris (2004) identified the Walgett Shire Council Weir on the Namoi River as one of several "important artificial barriers to (fish) migration" along the main stem of the Namoi River. The next barrier downstream is Weir 11A on the Barwon River approximately 5km away, which is a complete barrier to fish passage during flows of less than 4,500ML/day. Reference is also made by Harris (2004) to the significant effect that Weir 11A is having on fish communities within the Namoi River due to "the interconnected functioning of inland fish communities".

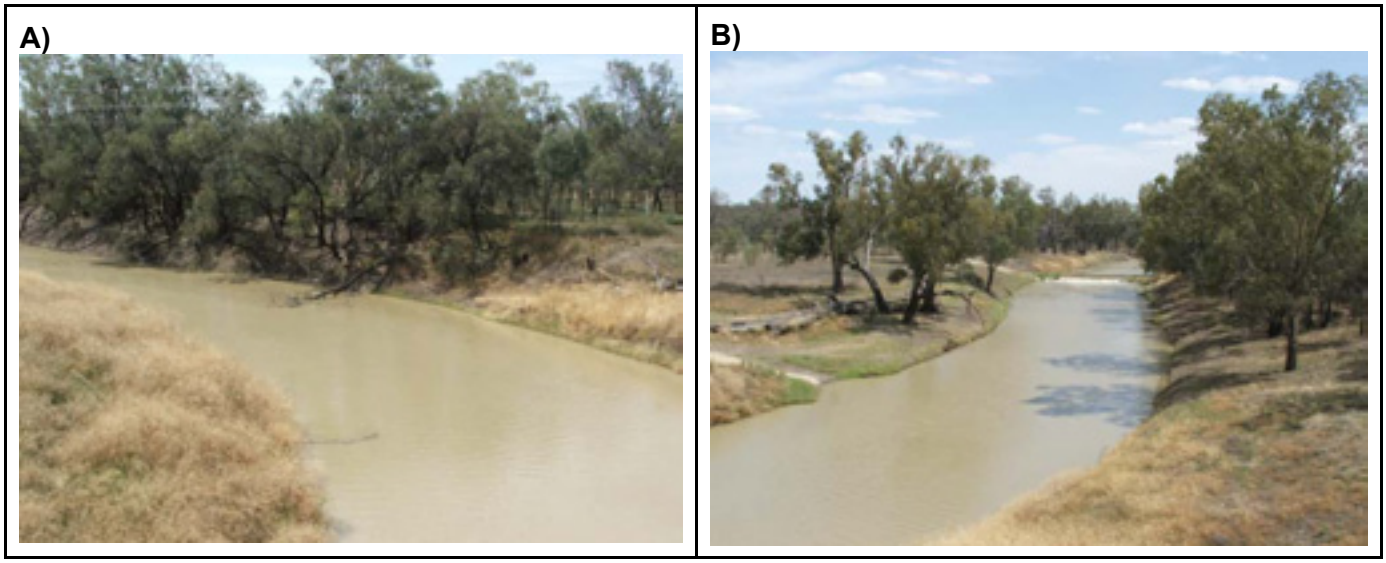

Figure 2. Namoi River A) looking downstream from and B) upstream to Walgett Shire Council Weir (30.11.2004, 95ML/day).

Anecdotal evidence from local anglers, landholders and NSW DPI Fisheries officers indicates that fish species including freshwater catfish, golden and silver perch, and Murray cod occur in the area and have recently been caught. The High Conservation Value (HCV) database (NSW DPI accessed 10.08.05) states that the following species native species are expected to occur within the Lower Namoi River: freshwater catfish, golden perch, Murray cod, spangled perch, bony herring, Australian smelt, Darling River hardyhead, fly specked hardyhead, crimson spotted rainbow fish, and carp gudgeon, with the threatened silver perch and olive perchlet also expected to be present. Introduced species including common carp, goldfish, and eastern gambusia are also present in the Lower Namoi River.

The Namoi River at Walgett downstream of the weir possesses some important fish habitat including instream large woody debris. Large woody debris provides valuable shelter for fish from strong water currents and larger avian and aquatic predators. Woody debris also provides an important substrate for fish to lay eggs, as well as for the growth of algae (thereby providing a food source for macroinvertebrates).

The weir site has moderately vegetated banks both upstream and downstream of the site (Figure 2).

The riparian vegetation is dominated by eucalypts and at the time of the inspection emergent grass species were present. On the right hand bank the riparian vegetation was sparse and resembled open woodland with little or no understorey, whilst on the left hand bank understorey shrubs were more prevalent. Stock access was possible on both banks as no fencing was in place. Noticeable rubbish debris was observed within the waterway and adjacent riparian zone.

Proposed Remediation Actions

As the weir does not drown out regularly, it is recommended that fish passage options be further investigated at this site. Licensing issues with regard to this weir are ongoing. Walgett Shire Council modified the weir without approval from NSW DPI and has since been asked to install a fishway on the structure if the weir was not going to be removed. Future consultation between Walgett Shire Council, DNR, and NSW DPI will need to take place regarding this issue. By creating fish passage past this weir it will enable fish to move upstream from the Barwon and lower end of the Namoi River and downstream from the Namoi into the Barwon River system.

- **Option 1 –** Full width rock ramp fishway

Fish passage past Walgett Shire Council Weir is not possible for the majority of the time, with the weir drowning out at less than 21% of the time. The construction of a full width rock ramp fishway, designed to pass fish prior to the drown out of the structure would make a significant contribution to improving native fish passage and provide a significant benefit to the Namoi River system. The modifications would involve extending the existing spillway so that a gradient of 1:20 was created and strategically placing several transverse rock ridges to create resting pools that are connected by short "riffles". The full width rock ramp could be constructed perpendicular with the weir, with a low flow path enabling fish passage at flows prior to drown out. Construction of a full width rock ramp fishway would provide passage at this site to a greater range of fish species and size classes during a greater range of flows.

- **Option 2 –** Complete removal

It is possible that the weir may be removed without any negative impact on the ability of Council to draw water from the Namoi River for town water supply. The weir pool created by the State Water owned Weir 11A on the Barwon River backs up nearly to the site of Walgett Shire Council Weir – this could be confirmed through a hydrological survey. Intentions to raise Weir 11A were first suggested to NSW DPI in 2000. Weir 11A is also a high priority for fish passage in the Western CMA. State Water and NSW DPI will investigate options for reinstating fish passage past Weir 11A.
The removal of the Walgett Shire Council Weir on the Namoi River is considered the most cost effective solution for this site, with the greatest environmental benefits for the aquatic biota of the Namoi River. This is the preferred remediation option for the site.

Projected Remediation Costs

Projected cost	< $50K	$50K - $150K	$150K - $250K	$250K - $500K	> $1M
Option 1			✔		
Option 2	✔				

Recommendation

The complete removal of Walgett Shire Council Weir (Option 2) is the preferred option for improving fish passage at this site. If consultation with Walgett Shire Council, DNR, and NSW DPI determines that the weir is still required to augment town water supply, it is recommended that a full width rock ramp fishway (Option 1) be constructed at this site.

Benefits Associated with Remediation

The Namoi River contains important fish habitat that should be protected. Reinstatement of fish passage along the entire system would generate substantial benefits for the ecology of the catchment.

Harris (2004) identifies areas downstream of Narrabri (lowland river reaches) as 'core habitats', which are crucial for fish recruitment and migration. In addition, due to its high species diversity, and the presence of one or more threatened species, the Lower Namoi River has been classified as having a High Conservation Value (HCV) by Department Environment and Conservation (DEC) and NSW DPI.

The reinstatement of fish passage at Walgett Shire Council Weir on the Lower Namoi River would provide access to approximately 145km of potential core habitat, benefiting particular species such as the golden perch and Murray cod.

JEWRY STREET CROSSING, PEEL RIVER

Figure 1. Jewry Street Crossing, Peel River (08.09.2005, 667ML/day).

Figure 2. Jewry Street Crossing, Peel River (17.03.2005, 50ML/day).

Description and Setting

The Jewry Street Crossing (Figures 1 and 2) is located within the town limits of Tamworth on the Peel River approximately 100 metres downstream of the Jewry Street Bridge and is located in the Mid-Upper Namoi catchment. The disused road crossing is located 50km upstream of the junction of the Namoi and Peel Rivers and is accessible via the public reserve on the left hand bank. Jewry Street Crossing is approximately 1.5 metres in height and is approximately 60 metres across the length of the crest. The crossing is a fixed crest structure with no associated regulating infrastructure. The crossing acts as a barrier to fish passage during flows of less than approximately 1200ML/day, during which the weir restricts fish passage due to excessive head loss, increased turbulence, and increased velocity across the face of the structure.

The Jewry Street Crossing is ranked as a high remediation priority within the Namoi CMA region due to the following factors:

- Class 1 fish habitat - major permanently flowing waterway and presence of one or more threatened fish species (this site is within the expected distribution of silver perch (*Bidyanus bidyanus*), olive perchlet (*Ambassis agassizii*), and purple spotted gudgeon (*Mogurnda adspersa*));
- Located within the Aquatic Endangered Ecological Community of the Lowland Catchment of the Darling River;
- Diverse range of native fish (High Conservation Value);
- Improved stream connectivity: the next upstream barrier to fish passage is a concrete capped water supply pipe located approximately 4km away, situated directly below Paradise Bridge on King Georges Avenue (this structure is owned and operated by Tamworth Regional Council). The next major barrier to fish downstream of Jewry Street Crossing is Mollee Weir, approximately 230km away on the Namoi River (this structure is owned and operated by State Water); and
- Low frequency of drown out (flow at which fish passage is possible, where headloss and velocity are minimal).

Hydrology

Flows in the Namoi catchment are controlled by Keepit, Split Rock, Chaffey, and Dungowan Dams. Split Rock Dam, located at the headwaters of the Manilla River was built to augment the supply to Keepit Dam and also supplies stock, domestic and irrigation waters to diverters along the Manilla River. These two dams collectively regulate flows within the mid-lower end of the catchment. Chaffey and Dungowan Dams are primarily used for town water supply and some riparian use, as well as irrigation within the Peel Valley.

There are three barriers known to exist upstream of Jewry Street Crossing on the Peel River, and include the Tamworth Water Supply Pipe at Paradise Bridge (Figure 3), the State Water owned instream gauging station at Calala (7km upstream), and Chaffey Dam (47km upstream), which is also owned and operated by State Water and is located in the upper reaches of the Peel River Valley.

The closest DNR river gauge is on the Peel River upstream of this site (station 419009). Information referred to in this report regarding flows in the Peel River was sourced from the DNR website and staff, using data acquired between 01.01.1925 – 31.08.2005.

It has been estimated that the crossing would drown out with flows in excess of 1200ML/day. The time weighted flow duration curve for the Peel River at this site shows that flows would exceed 1200ML/day approximately 8% of the time.

Figure 3. Council owned water supply pipe, Peel River (08.09.2005, 776ML/day).

Operational Details

The Jewry Street Crossing is no longer utilised by Tamworth Regional Council for access across the Peel River as a two lane overhead bridge has superseded it. Currently the crossing is in a state of disrepair and presents itself as a public liability. Discussions have been held between NSW DPI and Tamworth Regional Council since 2002 with regard to the future management of this crossing. It was suggested that the removal of the crossing may be a feasible option, however Council were concerned about the social impacts this may have on the community and whether the footings of the upstream bridge would be compromised. A riverbed survey was subsequently carried out by DNR in 2004 to ascertain the likely hydrological and geomorphologic impacts of removing the crossing, although this information was not released by DNR or made available to NSW DPI or Council. If this information continues to remain unavailable, further surveys may be required.

NSW DPI would not support the reinstatement of the crossing, as it now serves no practical function. The *NSW Fisheries Management Act 1994* states “the Minister may require a person who constructs, alters or modifies a dam or weir to provide fish passage”.
The *NSW Weirs Policy 1997* aims to halt and, where possible, reduce and remediate the environmental impact of weirs. The policy contains three main components that: limits approvals for new or expanded weirs; requires a review of all existing weirs; and provides for consideration of the need for fishways at each structure. Hence approval for reinstatement of the weir would not be give from NSW DPI.

Ecological Considerations

As a result of overtopping of the structure, fish passage may be possible at 8% of the time, although the timing of these flows may not necessarily coincide with spawning migrations of all or any of the resident fish species within the Peel River.

Harris (2004) identified the Jewry Street Crossing on the Peel River as one of several "important artificial barriers to (fish) migration" in the Namoi catchment. The next barrier to fish passage upstream of this crossing on the Peel River is the Council owned Tamworth Water Supply Pipe Line, which intersects the Peel River directly below Paradise Bridge on King Georges Avenue (see Figure 3). This pipeline is a barrier to fish due to excessive head loss, increased turbulence and velocity over the structure. The barrier is not expected to drown out during flows less of than 1000ML/day, which according to the time weighted flow duration curve for the Peel River upstream of the old Paradise Weir (station 419024), occurs only 10% of the time.

Anecdotal evidence from local anglers, landholders, and NSW DPI Fisheries officers indicates that fish species including freshwater catfish, golden and silver perch and Murray cod occur in the area and have recently been caught. The High Conservation Value (HCV) database (NSW DPI accessed 10.08.05) indicates that the following native species are expected to occur within the Peel River: freshwater catfish, golden perch, Murray cod, bony herring, Australian smelt, carp gudgeon, Darling River hardyhead, fly specked hardyhead, crimson spotted rainbow fish, with the threatened silver perch and olive perchlet also expected to be present. Introduced species including common carp, goldfish, and eastern gambusia are also present in the Peel River.

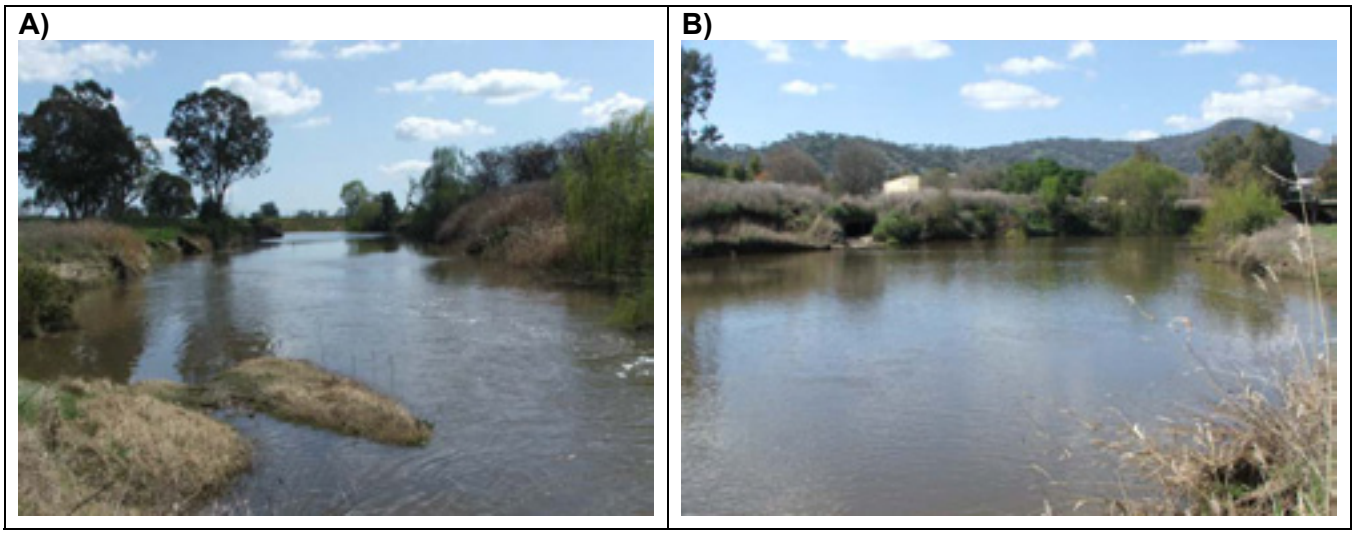

Figure 3. Peel River habitat A) downstream and B) upstream of Jewry Street Crossing (08.09.2005, 667ML/day).

The area surrounding Jewry Street Weir is highly urbanised, with a football field and storm water outlet on the right bank, and a public reserve on the left bank. At the time of inspection, there was limited riparian vegetation, with the grass understorey mown to within 2 metres of the riverbank. Downstream of the crossing the banks are highly eroded with steep vertical banks in need of stabilisation.

The remediation of the crossing could be incorporated into a demonstration reach, where Tamworth Regional Council and other stakeholders could undertake major bank stabilisation and erosion protection works, in addition to revegetation and fencing of the riparian zone.

Proposed Remediation Actions

As the crossing does not drown out regularly, it is recommended that fish passage options be further investigated at this site.

- **Option 1 –** Complete removal of redundant crossing

The crossing only drowns out 8% of the time, meaning that fish passage is not possible for the majority of time. In its current state the crossing is acting as a barrier to fish moving from the Namoi and Lower Peel Rivers into the upper catchment and its tributaries. The complete removal of the structure would provide the greatest benefit to the health of the Peel River and provide significant improvements in the amount of aquatic and riparian habitat made available to fish and other aquatic organisms. The crossing is no longer required and the removal of this structure has a much greater economic benefit than trying to reinstate the structure and construct a full width rock ramp fishway or vertical slot fishway.

- **Option 2 –** Full or partial width rock ramp fishway

The founding principles of fishway construction are to provide a series of small steps leading to the structure that have an overall slope of 1:20. Attraction flows are created to help fish locate the fishway entrance, whilst low flows are directed down the fishway channel to enable fish passage prior to structure drown out. Currently the structure is undermined and a substantial amount of flow moves under the concrete slab. Before a fishway could be installed on this structure the crossing would need to be stabilised and sealed to ensure that the flow was directed through the fishway. These modifications would be at great expense, and may still prevent the movement of some species and size classes of fish. The construction of a full width rock ramp fishway would therefore not provide the same benefits as removing the entire structure. This option is not recommended.

- **Option 3 –** Modification of upstream water supply pipe

The head loss currently created by this pipe is estimated to be in excess of 800mm. Fish passage is generally not possible with a head loss greater than 100mm, depending on the depth and velocity of water moving over the structure.

Fish passage works being undertaken at the Jewry Street Crossing would be complemented by the modification of the water supply pipe located upstream of the site (Figure 3). A partial width rock ramp fishway could be incorporated into the existing concrete cased pipe structure.
Although drown out of the structure may occur several times a year (see *Operational Details*), there remain significant periods of time where the passage of all fish will be affected.

Alteration of the existing structure to include a partial width rock ramp fishway designed to pass fish prior to drown out would make a significant contribution to improving the passage of native fish for a relatively small investment.

The modifications could include creating a ramp on the left hand bank with a gradient of 1:20, and strategically placing several rock ridges to create resting pools connected by small “riffles”. These modifications would result in the upstream and downstream passage to a greater range of fish species and size classes during adequate flow periods. This option is considered the most cost effective solution for this site, and is the preferred remediation option for this location.

Projected Remediation Costs

Projected cost	< $50K	$50K - $150K	$150K - $250K	$250K - $500K	$500K - $1M	> $1M
Option 1	✔					
Option 2				✔		
Option 3	✔					

Recommendation

The complete removal of the Jewry Street Crossing and the construction of a partial width rock ramp fishway at the upstream concrete water pipe (Option 1 and 3) is the most cost effective option and is therefore the preferred response for fish passage remediation within this reach.

Benefits Associated with Remediation

The Peel River contains important fish habitat that should be protected, and the reinstatement of fish passage along the entire system would bring about substantial benefits to the ecology of the catchment. In addition to reinstating fish passage throughout the system there are many opportunities to incorporate other habitat rehabilitation works. In particular, bank stabilisation and riparian revegetation could be undertaken in conjunction with fish passage initiatives to form a demonstration reach.

The reinstatement of fish passage at the Jewry Street Crossing and the upstream water supply pipe on the Peel River would allow access to approximately 234km of potential fish habitat upstream of the site.

BARRABA WEIR, MANILLA RIVER

Figure 1. Barraba Weir, Manilla River (10.03.2004, 4ML/day).

Figure 2. Barraba Weir, Manilla River, showing ineffective vertical slot fishway (10.03.2004, 4ML/day).

Description and Setting

The Barraba Weir (Figure 1) is located just within the town limits of Barraba on the Manilla River approximately 100 metres upstream of the Manilla River Bridge in the Upper Namoi catchment. The weir is 43km upstream of Split Rock Dam and is accessible via the public reserve on the right hand bank. The weir is approximately 1.5 metres in height and approximately 25 metres across the length of the crest. The weir is a fixed crest structure with no regulating infrastructure associated with it. Barraba Weir currently has an ineffective vertical slot fishway (Figure 2). The weir is acting as a barrier to fish passage during flows less than approximately 500ML/day. When flows are less than this, fish passage is restricted due to excessive head loss and increased velocity and turbulence across the structure face.

The Barraba Weir is ranked as a high remediation priority within the Namoi CMA region due to the following factors:

- Class 1 fish habitat - major permanently flowing waterway and presence of one or more threatened fish species (this site is within the expected distribution of silver perch (*Bidyanus bidyanus*), olive perchlet (*Ambassis agassizii*), and purple spotted gudgeon (*Mogurnda adspersa*));
- Diverse range of native fish (High Conservation Value);
- Improved stream connectivity: the next upstream barrier to fish is a privately owned crossing, which is approximately 24km away, with a council owned crossing (Figure 3) located 5km upstream of this structure on the Manilla River. The next major barrier to fish located downstream is Split Rock Dam, which is owned and operated by State Water, approximately 40km downstream. There are also three bed level crossings between the Barraba Weir and Split Rock Dam, which have been inspected but are not considered major barriers to fish passage; and
- Low frequency of drown out (flow at which fish passage is possible, where headloss and velocity are minimal).

Hydrology

Flows in the Namoi catchment are controlled by Keepit, Split Rock, Chaffey, and Dungowan Dams. Split Rock Dam, located at the headwaters of the Manilla River, was built to augment the supply to Keepit Dam and supplies stock, domestic and irrigation waters to diverters along the Manilla River. These two dams collectively regulate flows within the mid-lower end of the catchment. Chaffey and Dungowan Dams are primarily used for town water supply and some riparian use, as well as irrigation within the Peel Valley.

The closest DNR river gauge is located approximately 10km downstream from this site at Black Springs (station 419053). Information referred to in this report regarding flows in the Manilla River were sourced from the DNR website and staff members, using data acquired between 01.01.1972 – 31.08.2005.

It has been suggested that the weir would drown out with flows in excess of 500ML/day. The time weighted flow duration curve for the Manilla River at Black Springs river gauge shows that flows would exceed 500ML/day approximately 3% of the time.

Operational Details

The Barraba Weir is utilised by Tamworth Regional Council for aesthetics and some riparian basic rights. Council has never used the weir for town water supply, with the weir being constructed solely as part of a beautification scheme. Currently the weir is not licensed, however there are ongoing discussions between DNR and Tamworth Regional Council regarding their licensing requirements. NSW DPI has advised both parties that fish passage is a priority at this site.

The weir currently has a non-functioning vertical slot fishway (Figure 2). Site inspections carried out by NSW DPI on several occasions have determined that the fishway is ineffective. As stated in section 218 of the *Fisheries Management Act 1994, "*the Minister may require a person responsible for the management or control of a dam, weir or reservoir to carry out repairs to a fishway", indicating that ownership of the structure carries with it responsibilities for maintenance and improvement where necessary to facilitate fish passage.

Ecological Considerations

Fish passage may be possible at 3% of the time, however the timing of these flows may not necessarily coincide with spawning migrations of all or any of the resident fish species within the Upper Manilla River.

There are two other barriers to fish passage known to exist upstream from this weir on the Manilla River, one of which is the Tamworth Regional Council owned crossing (Figures 3 and 4). This crossing is a barrier to fish passage primarily because of the excessive head loss over the concrete base slab, as well as the high water velocity within the round pipe, inadequate flow depth and inadequate lighting within the structure. Fish behave differently in light and dark environments and some species are less likely to move through a dark cell, especially if they normally migrate during daylight hours or vice versa. Drown out of the crossing's base slab is estimated to be in excess of 150ML/day, therefore, based on the time weighted flow duration curve for the Manilla River at Black Springs (station 419053), it can be assumed that fish passage would be possible less than 6% of the time at this site.

Anecdotal evidence from local anglers, landholders and NSW DPI Fisheries officers indicate that fish species including freshwater catfish, golden and silver perch and Murray cod occur in the area and have recently been caught. The High Conservation Value (HCV) database (NSW DPI accessed 10.08.05) shows that the following native species are expected to occur within the Upper Manilla River: freshwater catfish, golden perch, Murray cod, mountain galaxias, bony herring, Australian smelt, carp gudgeon, with the threatened silver perch and olive perchlet species also expected to be present. Introduced species including brown trout, rainbow trout, common carp, goldfish, and eastern gambusia are also likely to be present in the Upper Manilla River.

The section of Manilla River adjacent to the weir is moderately vegetated. On the right hand bank there is a public reserve, which is mowed in close proximity to the riverbank. On the left hand side the land is privately owned and at the time of the inspection the banks were well vegetated (Figure 1). The riverbed is very stable at this location with bedrock acting as a natural control point resulting in no active erosion upstream or downstream from this site.
Willows are present in high numbers both upstream and downstream from this site (Figures 1 and 2) and their management should be a priority in conjunction with any fish passage remediation works at this site.

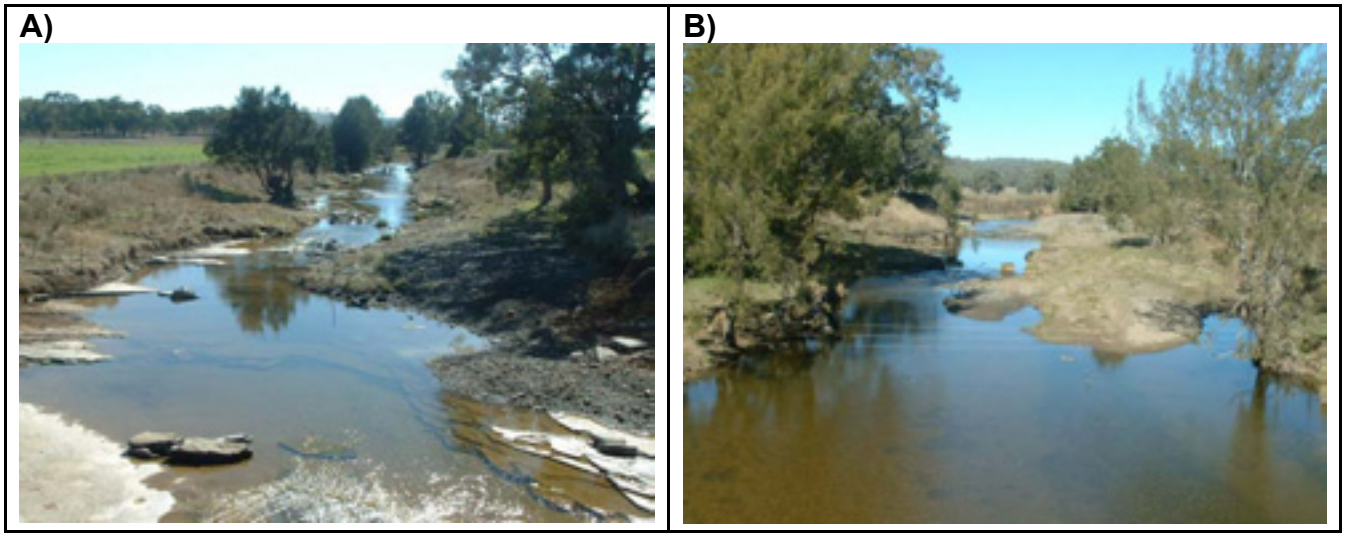

Figure 3. Manilla River habitat A) downstream and B) upstream of Mayvale Road crossing, 29km upstream of Barraba Weir (21.07.2005, 27ML/day).

Figure 4. Tamworth Regional Council owned road crossing (Mayvale Road) located 29km upstream of Barraba Weir, Manilla River (21.07.2005, 27ML/day).

Proposed Remediation Actions

As a result of the minimal drown out frequency of this weir, it is recommended that fish passage options be further investigated at this site. Licensing issues with regard to this weir are ongoing. Correspondence with Tamworth Regional Council in previous years has recommended that the fishway be modified to allow fish passage at this site, with the specifications to carry out the works provided.

Negotiations are currently taking place with Tamworth Regional Council and NSW DPI to address these issues.

- **Option 1 –** Retrofit existing vertical slot fishway

Barraba Council Weir only drowns out 3% of the time, resulting in the obstruction of fish passage for the majority of the time, although there is some scope for improvements to the existing fishway that may allow it to function more effectively. At present it represents a total barrier to fish passage alienating the Upper Manilla River, with reports of substantial accumulations of fish below the weir during a fresh. During a site inspection by NSW DPI, hundreds of bony herring were observed congregating below the weir, unable to negotiate the highly turbulent conditions and excessive headloss. The modifications that would be required to allow the passage of a greater number of fish over a greater range of flows would include the following:

- The addition of extra vertical slot baffles, particularly in the first and last baffles (to assist the pooling of water in the fishway);
- Reduction in the slot width of existing baffles to assist pooling within the fishway (potentially reducing widths from the current estimated width of 250mm to 200mm or 150mm). This could be achieved with existing slots by bolting on metal pieces of appropriate size;
- The addition of a very small detention basin where the tailwater exits the fishway, so as to pool up water and reduce tailwater velocities exiting the fishway (water level would need to be above the existing spillway below the nearby metal hinge on the weir);
- Associated with the small detention basin would be the construction of a small rock ramp at a slope of approximately 1:20 leading up to the detention basin from the downstream side; and
- Cutting a V-notch into the top wall of fishway so as to concentrate flows and increase depth at the top of the fishway.

- **Option 2 –** Replace entire vertical slot fishway

The removal of the existing vertical slot fishway and the construction of a new fishway is also an option. The fishway could be redesigned to comply with NSW DPI fishway standards and re-built. The concrete wall of the weir would provide a suitable anchor for the vertical slot fishway and its associated infrastructure. The cost of the vertical slot fishway is based on a broad estimate of $150,000 per vertical metre, which is dependant on site location/access and various structural and hydrological constraints. This option would therefore be the more costly than retrofitting the existing fishway.

- **Option 3 –** Modification of upstream crossing (Mayvale Road)

The modification of the crossing located upstream (Figure 4) would complement fish passage works to the Barraba Weir. The head loss created by this crossing is estimated to be in excess of 500mm. For some native species, fish passage is generally not possible with a head loss greater than 100mm, depending on the depth and velocity of water moving through or over the structure. The central pipe culvert could be removed, and the central box culvert inverts lowered to form low flow channels and provide fish passage past this structure. Negotiations between NSW DPI and Tamworth Regional Council are currently underway to remediate this crossing as part of the Namoi Fish Passage Project.

- **Option 4 –** Removal of weir

The weir only drowns out 3% of the time, therefore restricting fish passage for most of the time. The complete removal of the structure would provide the greatest benefit to the health of the Manilla River and provide significant improvements in the availability of aquatic habitat and water quality. In addition, complete removal would negate the need for council to maintain both the weir structure and the fishway with regards to trash/debris accumulation.

Projected Remediation Costs

Projected cost	< $50K	$50K - $150K	$150K - $250K	$250K - $500K	$500K - $1M	> $1M
Option 1	✔					
Option 2			✔			
Option 3		✔				
Option 4	✔					

Recommendation

Removal of the weir and re-establishing fish passage at Mayvale road crossing (Options 3 and 4) is the preferred response for fish passage remediation along this 29km reach and is the most cost effective option. However, community consultation would be required in order to determine if it is feasible to remove the weir and may see Options 1 (retrofitting the existing vertical slot fishway) and Option 3 as the most viable alternatives.

Benefits Associated with Remediation

The Manilla River contains important fish habitat that should be protected, and the reinstatement of fish passage along the entire system would bring about substantial benefits to the ecology of the catchment.

The reinstatement of fish passage at the Barraba Weir on the Manilla River would open up access to approximately 65km of potential fish habitat. This could be further increased if fish passage is addressed at the road crossing located approximately 29km upstream.

CALALA GAUGING STATION, PEEL RIVER

Figure 1. Calala Gauging Weir, Peel River (12.09.2005, 99ML/day).

Figure 2. Calala Gauging Weir looking downstream, Peel River (12.09.2005, 99ML/day).

Description and Setting

The Calala Gauging Weir (Figures 1 and 2) is located between the suburb of Calala and Farrer Agricultural High School, near Tamworth on the Peel River in the Mid – Upper Namoi catchment. The weir is located approximately 5km upstream of the Paradise Bridge, and is situated 200 metres upstream of the Tamworth Water Treatment Station. Calala Gauging Weir is approximately 1.2 metres in height and is approximately 10 metres across the length of the crest. The weir is a fixed crest gauging weir with a vertical flume "San Dimas Weir". The weir acts as a barrier to fish passage during flows less than approximately 350ML/day, during such flows fish passage is restricted due to excessive head loss, velocity and increased turbulence through the vertical flume.

The Calala Gauging Weir is ranked as a high remediation priority within the Namoi CMA region due to the following factors:

- Class 1 fish habitat - major permanently flowing waterway and presence of one or more threatened fish species (this site is within the expected distribution of silver perch (*Bidyanus bidyanus*), olive perchlet (*Ambassis agassizii*), and purple spotted gudgeon (*Mogurnda adspersa*));
- Diverse range of native fish (High Conservation Value);
- Improved stream connectivity: the next downstream barriers to fish are a concrete capped water supply pipe located approximately 5km away (directly below Paradise Bridge on King Georges Avenue) and Jewry Street Weir, approximately 7km downstream on the Namoi River. The next major barrier to fish passage upstream is Chaffey Dam, approximately 40km away; and
- Low frequency of drown out (flow at which fish passage is possible, where headloss and velocity are minimal).

Hydrology

The flows within the Namoi catchment are controlled by Keepit, Split Rock, Chaffey, and Dungowan Dams. Chaffey and Dungowan Dams are primarily used for town water supply and some riparian use as well as irrigation within the Peel Valley.

This flume gauging weir serves as an in stream gauging structure (station 41907) and is utilised by State Water, DNR, and Tamworth Regional Council, for the purposes of determining water allocations from Chaffey Dam. The ownership of the gauging weir is at present unclear. Information referred to in this report regarding flows in the Peel River was sourced from the DNR website and staff, using data acquired between 01.01.1980 – 31.08.2005.

It has been estimated that the weir would drown out with flows in excess of 350ML/day. The time weighted flow duration curve for the Peel River at this site shows that flows would exceed 350ML/day approximately 10% of the time.

An assessment of all crossings on the Peel River upstream of this site was conducted and it was found that none presented themselves as fish passage barriers. There are also no licensed weirs known to exist upstream between this site and Chaffey Dam, in the upper reaches of the Peel River Valley.
Two hundred metres downstream, however, there is a temporary sandbag weir that is managed by Tamworth Regional Council (Figure 3), and aims to secure town water during low flow periods. This sand bag weir is estimated to drown out during flows in excess of 110ML/day.

Figure 3. Temporary sandbag weir, Peel River (12.09.2005, 99ML/day).

Operational Details

The Calala Gauging Weir (Figure 1) is utilised by Tamworth Regional Council, State Water and DNR to determine flows within the Peel River at this location. Flows have been monitored at this site since 1980.

When the temporary sand bag weir (Figure 3) is in place the flume gauging weir becomes inoperable and a gauge located approximately 150 metres upstream on a natural control point is used. A permit to install the sandbag weir has been issued by NSW DPI, and has been instigated each year since 2002 for as many as six months at a time to pool water up for the Tamworth Water Treatment Works. This upstream control point has proven to be effective in monitoring flows within the Peel River and has employed for this purpose since early 2004. The fact that flows can still be accurately measured without utilising the flume weir highlights the need to identify whether this structure is required at all. While the weir remains in place it continues to pose a barrier to the natural migration of fish within the Peel River.

At other locations across the state, discharge and river heights can be measured in the absence of instream structures where natural control points are present.
There are as many as 11 other instream works that are managed by DNR in the Namoi CMA region that have been identified by NSW DPI as being potential barriers to the natural migration of fish. A state wide assessment of these structures needs to be undertaken in consultation with DNR, State Water and NSW DPI to mitigate their impacts on native fish populations. Where structures are no longer being utilised or alternative gauging technology can be used, these structures should be removed.

Ecological Considerations

Structure drown out occurs approximately 10% of the time, therefore fish passage may also be possible approximately 10% of the time across this structure. The timing of these flows, however, may not necessarily coincide with spawning migrations of all or any of the resident fish species within the Peel River.

The temporary sandbag weir located downstream drowns out during flows in excess of 110ML/day, which occurs approximately 23% of the time. Ideally, the permit conditions for this temporary weir would require that during key migration periods (generally throughout late spring and summer months), the structure would be removed to allow the upstream and downstream movement of migratory species within the Peel River.

Anecdotal evidence from local anglers, landholders and NSW DPI Fisheries officers indicates that fish species including freshwater catfish, golden and silver perch, Murray cod and introduced trout species occur in the area and have been caught recently. The High Conservation Value (HCV) database (NSW DPI accessed 10.08.05) states that the following native species are expected to occur within the Peel River: freshwater catfish, golden perch, Murray cod, bony herring, Australian smelt, carp gudgeon, Darling River hardyhead, fly specked hardyhead, crimson spotted rainbow fish, with the threatened species silver perch, and olive perchlet also expected to be present. Introduced species including common carp, goldfish, eastern gambusia, brown trout, and rainbow trout are also likely to be present in the Peel River.

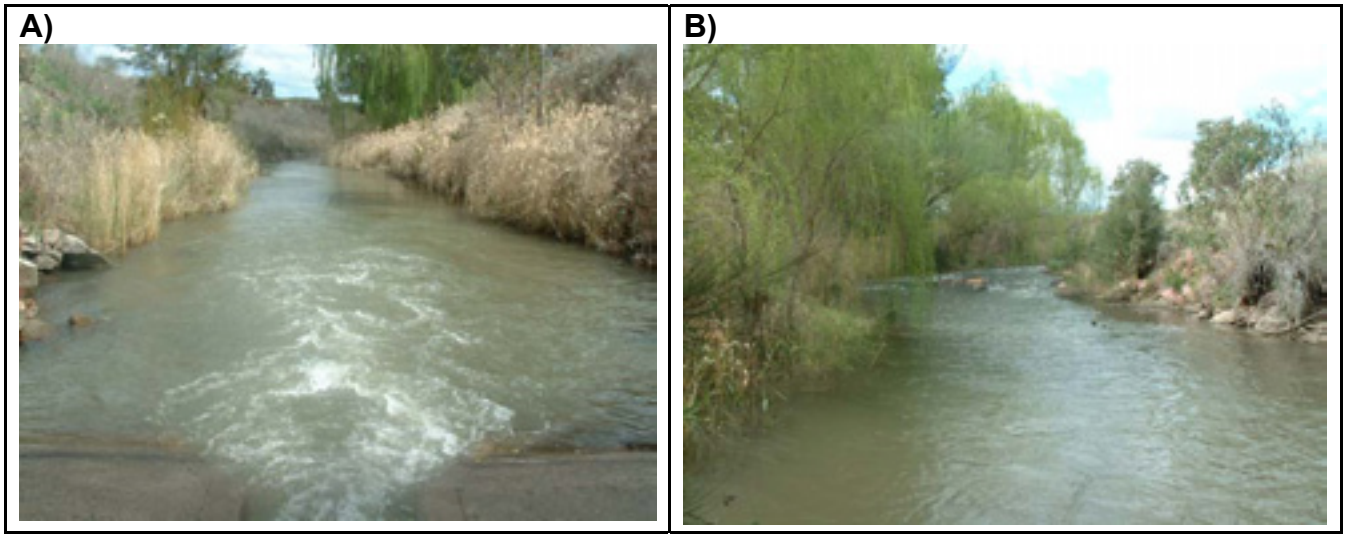

Figure 4. Peel River habitat A) downstream and B) upstream of Calala Gauging Station (12.09.2005, 99ML/day).

The river banks adjacent and either side of the structure are well vegetated (Figure 4). Erosion control structures have been put in place downstream to reduce the likelihood that the banks will be undercut as a result of the regulated flows. There is little or no instream woody debris surrounding the site - it is likely that this was previously removed so that it did not interfere with the gauging weir. Willows are also present upstream and downstream and should be eradicated in conjunction with any fish passage works at this site.

Proposed Remediation Actions

As the Calala gauging weir does not drown out frequently, it is recommended that fish passage options be further investigated at this site.

- **Option 1 –** Complete removal of instream gauging weir

The weir only drowns out 10% of the time, meaning that fish passage is not possible for the majority of the time. In its current state the weir is acting as a barrier to fish moving from the Namoi and Lower Peel Rivers up into the upper catchment and its tributaries for approximately 90% of flows within the Peel River. The complete removal of the structure would provide the greatest benefit to the health of the Peel River and provide significant improvements in the availability of aquatic and riparian habitat for fish and other aquatic organisms.

Due to the management of the downstream sandbag weir (constructed each year since 2002 at up to six months at a time), and the fact that the gauging station is not operable during this time, other methods of improved flow data collection should be investigated for this site, with a view to removing the gauging structure in the future. Discussions between Tamworth Regional Council, DNR, State Water and NSW DPI should occur to determine if this option is valid.

A state wide review of all in instream gauging structures needs to take place as mentioned in the *Operational Details* section, with consultation between DNR, State Water and NSW DPI being a high priority. It may be feasible to remove disused structures or redundant structures, where alternative gauging technology can be used.

- **Option 2 –** Fishway options study

The construction of a vertical slot fishway at this site may be feasible if the gauging components of the existing weir could be incorporated into the fishway. A detailed study would need to be undertaken to develop an engineering solution to fish passage at this site. However it should be noted that the construction of a fishway would still not provide the same benefits as removal of the entire structure (some species and size classes of fish may still be prevented from moving). In addition the modifications would be very expensive due to the requirements of the weir as a gauging instrument needing to be taken into account as part of the fishway design.

Projected Remediation Costs

Projected cost	< $50K	$50K - $150K	$150K - $250K	$250K - $500K	$500K - $1M	> $1M
Option 1	✔					
Option 2				✔		

Recommendation

The complete removal of the weir (Option 1) is the preferred response for fish passage remediation and is the most cost effective option for this site. If the weir cannot be removed, and alternative stream gauging innovations cannot be pursued, the weir will remain in place and fishway options will need to be further investigated (Option 2).

Benefits Associated with Remediation

The Peel River contains important fish habitat that should be protected, and the reinstatement of fish passage along the entire system would bring about substantial benefits to the ecology of the catchment.

The reinstatement of fish passage at the Calala Gauging Station Weir on the Peel River would provide access to approximately 145km of potential fish habitat. In addition to reinstating fish passage throughout the system there are many opportunities to incorporate other habitat rehabilitation works, such as bank stabilisation, willow removal and riparian revegetation. Habitat rehabilitation works could be undertaken in conjunction with fish passage initiatives to establish a demonstration reach in the Peel River.

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7. APPENDICES

Appendix A: Detailed Weir Assessment Proforma

Please note: It is important to complete as much of this form as possible in the office to avoid unnecessary delays in the field.

PRELIMINARY QUESTIONS Fish Passage

1. Is the structure a barrier to fish passage (a drop of 10cm can create a barrier, as can high velocities through round piped culverts) YES/ NO.

(i) Please describe (eg. Drop >10cm, Slope >1:20, Increased velocity, Increased turbulence, Debris, Minimum Flow depth (<200mm)…….

(ii) Significance of the structure as a barrier to fish passage: headloss (height of fall from headwater to tailwater)……..cm

(iii) Description of water flow over structure
Vertical fall/ steep cascade/ moderate cascade/ gentle incline/ high velocity through pipe/ Moderate velocity through pipe/ other……..

Date of review:

Name of Reviewer:

Contact phone No:

SECTION 1 OWNERSHIP AND LICENCE INFORMATION

1a ***Barrier/ Structure location information:***

Name of weir:

General directions, landmarks etc:

Name of nearest town:

Grid Reference:

Name of Watercourse:

Catchment Management Area:

Local Government Area:

(it is essential that a topographic map be attached for the location of each weir)

1b ***Structure Ownership details:***

Type (eg. private, local Govt., state Govt):
Owner Name: .....

1c ***Land Ownership details:***

Owner of land on which structure is built

DIPNR/ State Water/ Crown Land/ Private / Other……..

Is access to the structure via Easement / Public road / Other……

Property Boundaries on which structure is located Lot…….Dp……

Plan Number…….

1d ***Contact person for weir assessment details:***

Position Title: Owner name:

Office Address:

Phone: Mobile:

1e ***Weir Licence details (if applicable):***

Licence No: .....

Date of issue: ..... Date of expiry: .....

Licensing Office: .....

License Type (stock/domestic/irrigation/other):……..

SECTION 2 STRUCTURAL AND OPERATIONAL DETAILS

2a (i) ***Type of Structure*** **(Please describe):**

(ii) ***Barrier Construction material:***

Concrete ☐

Earth & rock ☐

Sheet piling ☐ with rock fill ☐ or other ……

Cribwork or gabion modules ☐ with rock fill ☐ or other ……

(cribwork type/material eg. steel or timber)……

2b ***Structure dimensions:***

…….. (m) crest length (length in metres at the weir crest)

…….. (m) vertical height (from the downstream toe to weir crest)

2c (i) ***Barrier type (eg. fixed or adjustable release structure):***

Fixed Crest Structure ☐ Adjustable release structure ☐

(ii) ***Release operations (if gated or regulated):***

…….. mechanism (eg. Gates, valves, removable boards, spillway etc.)

..... release frequency

..... duration

..... season of opening

(iii) ***Additional features of structure*** *(eg. Bottom release valve, skimmer box or siphon outlet configuration – for surface release, existing fishway, navigation lock, spillway, automated operation etc.):*

2d (i) ***Is the structure critical to the operations of the property or land use adjacent?***

Yes / No

Please provide brief details:

.....

2d (ii) ***Could the current operation of the structure be modified to improve environmental conditions?***

.....

2e (i) ***What is the current condition of the structure?***

working ☐ unserviceable ☐ decommissioned ☐

(ii) ***In terms of structural stability, does the structure require any of the following?*** Yes / No

immediate maintenance ☐ modification ☐ replacement ☐

Please provide details:

SECTION 3 WEIR/BARRIER USE

3a (i) **Date of construction:**

(ii) **Original use or purpose/s (if known):**

3b (i) **Current purpose/s of the structure** (eg. Irrigation, flood control, town water supply, re regulation, domestic, stock, industrial, drought water storage, recreation, river crossing, access). Please comment.

(ii) **Additional uses** (eg. Recreation, aesthetic, road crossing, environment, boundary fence). Please comment.

3c (i) **Number of direct weir pool users (eg. Pumping licences upstream & downstream licenses served)**

List Users;

1 …….. 2 ……

3 …….. 4 ……

4 …….. 6 ……

(For more users please use separate sheet)

(ii) **Number of licensed customers using weir pool**
(Please fill out attached sheet – Appendix 1 to provide details of these customers)

(iii) **Number of Riparian Stock and Domestic pumps using weir pool**

(iv) **Additional beneficiaries of structures (eg. Local community water supply, fishing groups)**

3d (i) **List any recognised Heritage or cultural values associated with the structure. (Check heritage list)** See Austral & ERM (2003) for details and also check the heritage resister at http://www.heritage.nsw.gov.au.
…….

(ii) **List any areas of Aboriginal Heritage significance associated with the structure.** (Contact should be made with local Aboriginal Lands Council & Department Environment & Conservation office to discuss aboriginal issues).

…….

3e **What types of land use operates in the riparian and floodplain zones adjacent to the weir pool?**

…….

…….

SECTION 4 WEIR SETTING

4a (i) ***What is the stream classification of the watercourse at the weir location?*** *(please refer to appendix 2)*

(ii) ***How wide is the watercourse upstream of the weir pool*** *(beyond the influence of the weir)**?***

(m)

(iii) ***Is the watercourse a tributary, anabranch, or floodrunner?***

4b (i) ***What is the total catchment area upstream of the weir?***
……. (sq. km)

(ii) ***What is the proportion of the catchment controlled by the weir*** *(upstream to the next river bed obstruction include natural and artificial).*
……. %

4c (i) ***What is the distance upstream of the weir to the next major river bed obstruction*** *(eg. Weir or other barrier)? Please name structure.*

(km) Structure name and/or type

(ii) ***What is the distance downstream of the barrier to the next major river bed obstruction*** *(including natural)?*

(km) Structure name and/or type

(iii) ***Is the barrier a Coastal River?*** Yes / No

If Yes is the barrier a tidal barrage or located in the tidal zone or immediately upstream of the estuary?

Please provide details:
……..

(iv) ***Do upstream water users pump freshwater from weir pool? If yes how may they be affected by removal of the structure?****(Obtain advise as necessary eg hydrologist)*
……

4d ***What section of the catchment is the structure located (circle one)?***

Upper *Middle* *Lower*

SECTION 5 HYDROLOGY INFORMATION

5a (i) ***What is the average depth of water in the pool immediately upstream of the barrier?***

…..... (m)

5a (ii) ***What is the height of the stream banks above the crest of the structure?***

……(m)

5b ***Is there a defined weir pool? If yes, how long is it?***

Yes / No (m)

5c (i) ***Is there a continuous flow across the crest of the barrier? Or through a pipe, gate or other regulator?***

Yes / No Yes / No

(ii) ***Is the stream regulated or unregulated*** Regulated / Unregulated

(iii) ***How does the flow vary?*** (eg daily, seasonally, flood, rainfall)

Comments:
…..

5d ***How frequently does drownout occur?***

….. (per year) OR don't know

5e (i) ***Is there information on the water quality in the weir pool or releases?*** *Yes / No*

If yes where is the information held or located?
…..

(ii) ***Is there evidence of salinity, acid sulphate soils, scalding, or other soil problems in the vicinity of the weir pool?***

Yes / No / don't know

Please describe:
…..

(iii) ***Has there been any changes to groundwater levels in the vicinity of the weir pool?***
Yes / No / don't know

SECTION 6 GEOMORPHIC INFORMATION

6a ***Are there any signs of bed erosion downstream of the barrier?***

Yes / No / don't know

Comments:

6b (i) ***What is the condition of the stream banks adjacent to the barrier?***

Intact ☐ minor erosion ☐ extensive erosion ☐

Please describe:

(ii) ***What is the condition of the stream banks upstream of the barrier?***

Intact ☐ minor erosion ☐ extensive erosion ☐

Please describe:

6b (iii) ***What is the condition of the stream banks downstream of the barrier?***

Intact ☐ minor erosion ☐ extensive erosion ☐

Please describe:

6c (i) ***Is there any evidence of siltation in the weir pool?***

Yes / No / don't know

Please describe:…….

(ii) ***If yes, what is the difference in bed level on the upstream and downstream side of the barrier wall?***

…..... (m)

(iii) ***Has any mining or other associated activities taken place in the catchment upstream of the structure?***

Is there any chance of contaminated sediment behind structure ie. Heavy metals etc?

(Please provide details……..

6d (i) ***Is there an accumulation of debris around the structure? (eg LWD, sediment, gross pollutants etc)***

Yes / No Please describe

(ii) ***If yes, is it causing problems to the structure or operation of gates, spillways or fish ladders associated with the weir?***

Yes / No

Please describe:
……

6e (iii) ***Is desnagging carried out upstream of the structure?***

Yes / No / don't know

SECTION 7 ECOLOGICAL CONSIDERATIONS

7a (i) ***Does the structure have a fishladder, rock ramp, or some other allowance for fish passage?***

Yes / No structure type: …..

(ii) ***If yes, has there been fish monitoring and/or an inspection to support fish passage?***

Yes / No / don't know

Comments:

(iv) ***What native fish species are present or are expected to occur at this site (ie. Refer to guidelines + local knowledge if available).***

……
……

(v) ***What introduced fish species are present or are expected to occur at this site (ie. Refer to guidelines + local knowledge).***

……
……

7b (i) ***Has there been any outbreak of nuisance aquatic/riparian weeds within the weir pool area eg. lippia, water hyacinth, willows ?***

Yes / No

Comments:
……

(ii) ***Have there been any outbreaks of blue-green algae?***

Yes / No/ don't know

If yes, what time of year and how frequently do outbreaks occur?

……. season ……. (frequency)

7c (i) ***How extensive is the vegetation cover on the banks of the river? (<50m from water line).***

Well vegetated ☐ moderately vegetated ☐ poorly vegetated ☐

Dominant species present (including native and introduced):

……

Please comment on native riparian vegetation and introduced plant species:

……

(ii) ***Is there any evidence of dieback occurring near the weir pool?***

Yes / No

Comments:

……

……

7d ***What percent of the weir pool area is colonised by aquatic vegetation eg. Phragmites, cumbungi?***

<5% ☐ 5-10% ☐ 10-30% ☐ <30% ☐

Dominant species present (including native and introduced):

……

7e ***Are there any rare and threatened flora and fauna species, populations or communities known to occur in the area?***

Yes / No / Don't know

Comments
……

……

7f (i) ***Is the river bank along the weir pool fenced?***

Yes / No / partial one side / both sides

Comments:
……

(ii) **Do stock have access to the river?**

Yes / **No /** **partial** **one side /** **both sides**

Comments:

….....

SECTION 8 RECOMMENDATIONS

8a ***Removal Option*** *YES / NA (please circle)*

(i) **Is the structure required by the adjacent Landholders?** Yes / No.

Comments:

….....

(ii) **Is the structure required by the Community, fishing club, access, aesthetics?** Yes / No.

Comments:

….....

(iii) **Is the structure acting as a bed control structure? (Seek advice from DIPNR if unsure)**

……

If the Answer to Question 8 (i)-(iii) is No

Is demolition of the structure supported by owner? Yes / No

Comments:

……

Would any person or group object to the weir being demolished?

Please describe:

….....

….....

(vi) **Is the weir remote/difficult to access?** Yes / No
If Yes, please describe access/location (Is there all weather access?)

……

……

(VI) **ESTIMATED COST OF REMOVAL/PARTIAL (USE COST MATRIX- APPENDIX 3) OR CONTRACTOR QUOTE?**

8b **Fishway options** *YES/NA (please circle)*

(i) **Does the structure lend itself to the addition of a fishway?** YES/NO

(ii) **Fishway type best suited to the structure** (Please take into account habitat, fish species, hydrology of watercourse)? Vertical slot / Full Width Rock Ramp / Partial Width Rock Ramp / Denil Insert/ Lock/ Other

(III) **ESTIMATED COST OF FISHWAY BASED ON APPROX. $150 000 PER VERTICAL METER?**

=

Comments (Include supporting literature and any correspondence with fishway experts):

……

……

……

8c **Modification of Structure to allow for fish passage**

(i) **Please describe proposed works (eg. Box culverts etc)?**

……

……

(II) ESTIMATED COST OF PROPOSED WORKS

8d Suggested management action (eg removal of drop boards, gated weir opening, removal of debris)

Comments (Include supporting literature and correspondence)

……

……

……

……

8e No action recommended

Comments (Include supporting literature and correspondence)

……

……

……

……

SECTION 9 ADDITIONAL INFORMATION

For further information:

- Austral Archaeology Pty Ltd & ERM Australia Pty Ltd, (2003), Heritage Assessment of 206 River Structures, Coastal and Central Regions, NSW, (Final Report and Appendix A: Group Two, Volume One).
- NSW DPI (Fisheries) Aquatic Habitat Rehabilitation database
- Pethebridge, Lugg and Harris (1998) Obstructions to fish passage in New South Wales south coast streams. NSW Fisheries final report series No 4 ISSN 1440-3544
- Williams RJ, Watford FA (1996) An inventory of impediments to tidal flow in NSW estuarine fish habitats *Wetlands (Australia)* 15, 44-54.

Appendix B: Weir Prioritisation Scheme for NSW Coastal CMAs

INITIAL PRIORITISATION						
A) STREAM HABITAT VALUE						**SCORE**
Primary aquatic habitat rating						
Habitat Class	1	2	3	4		
Location in the system	Tidal	Lower	Middle	Upper		
Downstream obstructions	0	1-2	3 - 5	> 5		
Habitat opened if remediated	> 100 km	50 – 100 km	20 - 50 km	10 - 20 km	< 10 km	
B) STRUCTURE IMPACT CRITERIA						
Environmental effect rating						
Physical barrier: Headloss	> 2000 mm	1000 - 2000 mm	500 – 1000 mm	100 - 500 mm		
Drown out frequency per annum	> 4	2 - 4	1			
SECONDARY PRIORITISATION						
C) ENVIRONMENTAL CRITERIA						
Secondary aquatic habitat rating						
Instream habitat condition	Good	Fair	Poor			
Riparian condition	Good	Fair	Poor			
Siltation	None	Minor	Major			
Threatened species	Habitat Class 1-2	Habitat Class 3	None			
D) MODIFICATION CRITERIA						
Structure use and remediation cost						
Maintenance Required	Yes	No				
Redundant Weir	Yes	No				
Ease of Remediation	Removal	Modification	Fishway installation			
Ancillary uses	Flood mitigation	Bed Control	Recreation			
					TOTAL	

Appendix C: Weir Prioritisation Scheme for NSW Inland CMAs

INITIAL PRIORITISATION						
A) STREAM HABITAT VALUE						**SCORE**
Primary aquatic habitat rating						
Habitat Class	1	2	3	4		
Location in the system	Lower	Middle	Upper			
Downstream obstructions	0	1-5	5-10	>10		
Habitat opened if remediated	>150 km	100 – 150 km	50 - 100 km	20 - 50 km	<20 km	
B) STRUCTURE IMPACT CRITERIA						
Environmental effect rating						
Physical barrier: Headloss	>3000 mm	2000 - 3000 mm	1000 – 2000 mm	200 - 1000 mm		
Drown out frequency per annum	>5%	1-5%	0%			
Undershot Structure	Yes	No				
SECONDARY PRIORITISATION						
C) ENVIRONMENTAL CRITERIA						
Secondary aquatic habitat rating						
Instream habitat condition	Good	Fair	Poor			
Riparian condition	Good	Fair	Poor			
Threatened species	Habitat Class 1-2	Habitat Class 3	None			
D) MODIFICATION CRITERIA						
Structure use and remediation cost						
Redundant Weir	Yes	No				
Ease of Remediation	Removal	Modification	Fishway installation			
					TOTAL	


aquatic habitat rehabilitation
making more fish
...naturally