

# REDUCING THE IMPACT OF WEIRS ON AQUATIC HABITAT

## NSW DETAILED WEIR REVIEW



REPORT TO THE NEW SOUTH WALES ENVIRONMENTAL TRUST

BORDER RIVERS/GWYDIR CMA REGION



NSW DEPARTMENT OF  
PRIMARY INDUSTRIES



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## 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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## 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<sup>1</sup> and the Department of Land and Water Conservation<sup>2</sup> 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.

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<sup>1</sup> Now NSW Department of Primary Industries

<sup>2</sup> 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 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<sup>3</sup> 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.

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<sup>3</sup> **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).

<b>Classification</b>	<b>Characteristics of Waterway Type</b>
<b>CLASS 1 Major fish habitat</b>	Major permanently or intermittently flowing waterway (e.g. river or major creek), habitat of a threatened fish species.
<b>CLASS 2 Moderate fish habitat</b>	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.
<b>CLASS 3 Minimal fish habitat</b>	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.
<b>CLASS 4 Unlikely fish habitat</b>	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. Border Rivers/Gwydir CMA - Detailed Weir Review Sites



**Legend**

- Towns
- Weirs
- Rivers
- Border Rivers/Gwydir CMA
- Main Road



**Border Rivers / Gwydir 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	Cunningham Weir	-28.441255	150.574168	Fixed Crest (timber)	Dumaresq River	Border Rivers Commission	No	Removal	500K - 1M	>1 M	69.9
2	Moree Weir	-29.468343	149.844500	Fixed Crest (concrete and sheet piling)	Mehi River	Council	No	Removal	50 - 150K	150 - 250K	50
3a	Boomi Weir	-28.624041	149.671420	Fixed Crest (concrete and sheet piling)	Macintyre River	Border Rivers Commission	No	Vertical-slot	250 - 500K	250 - 500K	263
3b	Boggabilla Weir	-28.591543	150.361436	Adjustable Crest (vertical lift gates)	Macintyre River	Border Rivers Commission	No (ineffective vertical-slot fishway present)	Modify fishway	250 - 500K	150 - 250K	215
5	Tareelaro Regulator	-29.450125	150.036480	Adjustable Crest (vertical lift gates)	Mehi River	State Water	No (ineffective submerged orifice fishway present)	Vertical-slot	250 - 500K	150 - 250K	275
6	Bonshaw Weir	-28.591093	151.163802	Fixed Crest (sheet piling)	Dumaresq River	Border Rivers Commission	No	Vertical-slot	250 - 500K	250 - 500K	124
7	Booloroo Weir	-29.414488	149.885902	Adjustable Crest (vertical lift gates)	Gwydir River	State Water	No	Vertical-slot	250 - 500K	250 - 500K	45
8	Glenarbon Weir	-28.689890	150.892287	Fixed Crest (sheet piling)	Dumaresq River	Border Rivers Commission	No (ineffective pool-type fishway present)	Vertical-slot	250 - 500K	150 - 250K	81

## **CUNNINGHAM WEIR, DUMARESQ RIVER**



**Figure 1.** Cunningham Weir, Dumaresq River view from the left bank (0 ML/day).

### ***Description and Setting***

Cunningham Weir (Figure 1) is situated approximately 32km northwest of Texas near the locality of Beebo, and is accessible via a public road and easement from the left bank. The weir is approximately 59km downstream of Bonshaw Weir on the mainstem Dumaresq River located in the Middle Macintyre catchment. The weir is a fixed crest, stepped timber crib constructed with a variety of materials including timber and metal sheeting. Measuring 48 metres along its crest and standing approximately 4.4 metres high, Cunningham Weir has a full storage capacity of 520ML and pools water over 6km upstream at depths of approximately 2.5 – 3 metres. The weir restricts fish passage due to an excessive headloss (300cm) and increased turbulence, prior to structure drown out, (which occurs when the water level exceeds 253.0 metres EL).

Prioritisation of weirs in the Border Rivers Gwydir CMA region has highlighted Cunningham Weir as a high remediation priority within the Border Rivers Gwydir CMA due to the following factors:

- The Dumaresq River is a Class 1 fish habitat, supporting a diverse range of habitat types and native fish species including vulnerable silver perch (*Bidyanus bidyanus*), threatened Murray cod (*Maccullochella peelii peelii*), and endangered populations of olive perchlet (*Ambassis agassizii*) and purple spotted gudgeon (*Mogurnda adspersa*);
- The Dumaresq River is included in the Endangered Aquatic Ecological Community of the Lowland Darling River catchment (Section 4 of the *Fisheries Management Act 1994*)

- Instream habitat along the Dumaresq River is considered in medium to good condition;
- Approximately 59km of unimpeded fish habitat is available upstream of the structure;
- The low number of significant barriers to fish passage on the Dumaresq River; and
- The weir is no longer used for water retention and distribution purposes and is in severe disrepair.

### ***Hydrology***

The flows within the Macintyre catchment are controlled by Glenlyon Dam. With a capacity of 253,000ML it provides regulated flows for irrigation, stock, town and industrial purposes to users as far as Mungindi Weir. Cunningham Weir is located within the Camp Creek subcatchment of the Macintyre catchment, a major tributary of the Darling – Barwon River system. The total catchment area upstream of the weir is 8754km<sup>2</sup>, approximately 18% of the total Border Rivers catchment area. Upstream of the weir pool, the Dumaresq River ranges from 10-18 metres wide, with depths varying between 0.5-1.5 metres until it meets Bonshaw Weir (59km upstream).

There is no river gauge associated with Cunningham Weir. The closest DNR river gauge is at Glenarbon Weir approximately 11km downstream from this site (#416040). Flow levels referred to in this report were sourced from staff members of SunWater and the Border Rivers Commission and from the DNR website. Flows within the Dumaresq River are dictated to by rainfall levels in the upper reaches of the catchment and water release from Glenlyon Dam. During periods of regulated flow the structure is overtopped, occurring when water levels exceed full supply level at EL 253.0 metres.

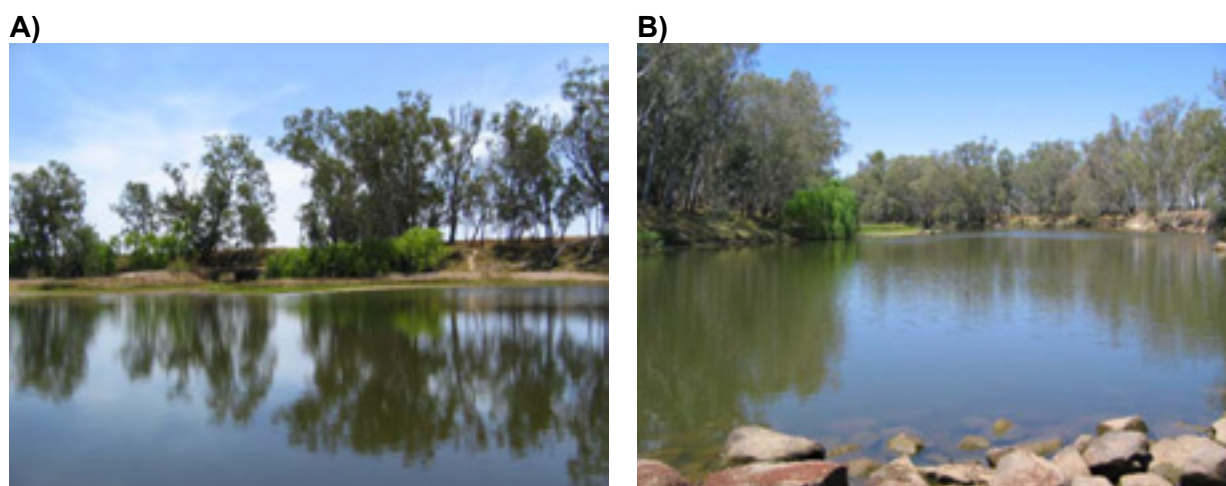
### ***Operational Details***

Cunningham Weir was constructed in 1954 and named in honour of Andrew Cunningham's first crossing into Queensland (in 1827). The weir was constructed primarily for conserving and regulating flows of the Dumaresq River for irrigation purposes. However, following the construction of Glenlyon Dam the weir was no longer required and in 1987 was formally decommissioned. Since then, maintenance of the structure has been withheld allowing the state of the weir to deteriorate. At present, the structure is in severe disrepair and poses a safety hazard to the general public who use the surrounding area for recreational purposes, picnicking and camping. Fishing is not allowed within waters 14 metres upstream and downstream of Bonshaw Weir, according to the NSW DPI Regulations. Two of the properties that adjoin the weir pool have water extraction licences totalling 4750ML per annum of surface water allocation drawn from a total of 16 pumps for stock, irrigation of crops, and domestic purposes. The pool has also been used to restrict stock movement across the river.

## **Ecological Considerations**

Cunningham Weir at AMTD 67.9km is one of three weirs located on the mainstem Dumaresq River below Glenlyon Dam. Bonshaw Weir (AMTD 126km) and Glenarvon Weir (AMTD 57km) are both barriers to fish passage and have been assessed as part of this review. Bonshaw Weir, although a working structure, has been mentioned for review with respect to its works in the future. Glenarvon Weir is a working structure, which has a fishway installed. Unfortunately, the fishway is currently blocked with debris and fish passage is inhibited during the majority of flow conditions. Remediation of this fishway, or the construction of a more effective fishway are options being considered at this site to allow fish passage. The remediation of fish passage at these structures and Cunningham Weir could potentially open up approximately 200km (not including tributaries) of unimpeded habitat for native fish species.

The riparian areas adjacent to the weir are moderately vegetated with blue gums (*Eucalyptus tereticornis*), river she-oak (*Casuarina cunninghamiana*), and weeping bottlebrush (*Callistemon viminalis*). Bankside vegetation, in association with the rock, clay and sandstone composition of the soil proffers stabilisation to the banks adjacent to, upstream and downstream of the structure, aiding in erosion prevention. The introduced weeping willow (*Salix babylonica*), Mexican poppy (*Argemone ochroleuca*) and Noogoora burr (*Xanthium pungens*) are also present at this site. At the time of survey the weir pool was largely clear of aquatic weed; however, aquatic weeds which may be obstructive to water flow have been observed within the weir pool including; ferny azolla (*Azolla pinnata*), ribbonweed (*Vallisneria gigantea*) and *Myriophyllum* sp. The riparian area of the weir pool is unfenced, allowing stock access to the river (Figure 2). This can have severe ecological impacts on the riparian area, the aquatic habitat, and aquatic biota. The river bed downstream of the structure is stable. However, a large volume of silt has accumulated immediately behind the weir to within approximately one metre of the weir crest (estimated to between 50,000 and 120,000 cubic metres). In consequence, a change of bed level from EL 249.2 to EL 252, approximately 2.8 metres is present from the downstream to upstream side of the structure.



**Figure 2.** Dumaresq River A) upstream and B) downstream of Cunningham Weir.

## ***Proposed Remediation Actions***

The structure is frequently “topped over” by regulated flow releases from Glenlyon Dam and during flood events; however, the water levels are not sufficient for fish passage requirements. It is recommended fish passage options be further investigated at this site.

- **Option 1 – Removal of Cunningham Weir**

The complete removal of the structure would provide the greatest benefit to the health of the Dumaresq River by providing unrestricted fish passage and reintroducing natural sediment fluxes. Additionally, the Border Rivers Commission would no longer be liable for the site. Although under severe disrepair and decommissioned, this weir is still used for irrigation purposes by neighbouring properties, thus the effect of removing this weir, its associated weir pool, and the effect on ground water (if any) would need further assessment. The readjustment of water pumping infrastructure and the identification of an alternative water source are possible avenues that may warrant investigation. The historical value bestowed on the weir by the local community and its use as a recreational area would also need to be taken into consideration. However, the use of the weir pool as a barrier to cattle movement across the river does not justify maintaining the weir. Removal of the weir would need to incorporate fencing on both sides of the river. The build up of silt behind the structure would also need to be addressed, care would be needed to ensure the silt was not released into the downstream environment, where it could potentially smother aquatic habitat.

- **Option 2 – Refurbishment and partial removal of Cunningham Weir**

The weir in its present condition has a limited life span and could potentially fail and wash away in a large flood event. Therefore, partial removal of the structure would also require complete refurbishment of the weir to a working capacity. This option would involve removal of the upper step of the timber crib, thus reducing the full supply level to approximately EL 252.2 metres. A smaller weir pool than at present would result, thus water pumps associated to the weir pool would require modification. The large volumes of silt behind the structure would also need to be addressed to ensure silt was not released into the downstream environment, with partial or total removal of the silt an option. Refurbishment and partial removal option would also need to incorporate a fishway (see Option 4 below).

- **Option 3 – Vertical-slot fishway**

A vertical-slot fishway is the most effective design for barriers up to 6 metres high, passing large numbers of fish of all species and sizes, and would therefore be the most suitable type for this site. Refurbishment of the structure would be required, due to the limited life-span of the weir in its current condition. The left hand side of the structure is the preferred location for the fishway. The crest of the weir on this side would need to be slightly lowered to produce an attractant flow to the entrance of the fishway. This slight lowering would have marginal effects on the water level within the weir pool. Additionally, the entrance to the fishway would be located near the base of the weir (reverse leg) to attract migrating fish. Cell dimensions of 3 metres long by 2 metres wide, with slot width of 300mm are recommended for vertical-slot fishways in the Murray-Darling Basin and associated inland rivers. Maintenance of the fishway would need to be incorporated into maintenance works (e.g. debris removal) of the weir. The design would need to comply with NSW DPI policy and guidelines to ensure fish passage occurred during 95% of flows.

- **Option 4 – Full width rock-ramp fishway**

Rock-ramp fishways can be used to allow fish passage at weirs that are generally less than 4 metres in height. At its current height a rock-ramp fishway would not be suitable on this structure. However, partial removal and refurbishment of the structure would reduce the maximum height of the structure to approximately 3 metres, in this situation a rock-ramp fishway would be appropriate. Further investigation into hydrology would be required at this site to determine if a rock-ramp would be adequate for fish passage and what slope would be required.

### ***Projected Remediation Costs***

Projected cost	< \$250 K	\$250K - \$500K	\$500K - \$750K	\$750K - \$1000K	> \$1000K
Option 1				✓	
Option 2				✓	
Option 3					✓
Option 4					✓

### ***Recommendation***

Complete removal of the structure is the preferred option for fish passage remediation along this 69.7km reach. However, when structure removal, silt removal, site rehabilitation, and pump compensation or modification are factored into the equation, it is the most expensive option. A management plan has been drawn up for Cunningham Weir by the Border Rivers Commission (BRC) (effective as of the July 1, 2005). This plan includes:

1. the removal of the top timber piles to minimise public risk;
2. a program to closely monitor the structure of the weir;
3. a siltation survey of the weir pool to approximately 2.5km upstream;
4. an assessment into the possible impact of removing the weir on groundwater levels in the vicinity;
5. an investigation into necessary approvals and assessments required for removal of the weir; and
6. reconsideration of the future of Cunningham Weir.

DPI (Fisheries Management) supports any action, which would address the needs for native fish passage at this site however, full removal is the preferred option.

### ***Benefits Associated with Remediation***

The Dumaresq River provides 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 Cunningham Weir on the Dumaresq River would open up access to approximately 59km of potential fish habitat. This could be further increased if fish passage is addressed at Bonshaw Weir and Glenarbo Weir.

## **MOREE WEIR, MEHI RIVER**



**Figure 1.** Moree Weir, Mehi River view from left bank.

### ***Description and Setting***

Moree Weir (Figure 1) is located within crown land reserved for public recreation. The weir, which is accessed through Kirkby or Jellicoe Park's in Moree, sits on the mainstem Mehi River, located in the Moree subcatchment (which encompasses 4.74% of the Gwydir system) in the Lower Barwon catchment area. The weir is a fixed crest sheet piling structure that measures 3.9 metres high by 28 metres long. A centrally placed, vertical slide gate for low flow conditions is installed (however, there is no record of this being used). Large quantities of concrete are present on the downstream, right bank side of the structure, seemingly placed by Council in an attempt to stabilise the structure and the rock filled mattresses (gabions), most of which have been degraded and washed away by flood events. Moree Weir pools water over approximately 2km, at depths varying from 1 to 2 metres, and has a capacity of approximately 350ML. Fish passage only occurs at this structure when drown-out takes place during large flood events (1-3 times a year). For the majority of the time the weir represents a barrier to fish passage due to a stepped “*waterfall effect*” over the crest of the structure, producing a large headloss of approximately 150cm.

Prioritisation of weirs in the Border Rivers Gwydir CMA region has highlighted Moree Weir as a high remediation priority within the Border Rivers Gwydir CMA due to the following factors:

- The Mehi River is a Class 1 fish habitat, supporting a diverse range of habitat types and native fish species including the vulnerable silver perch (*Bidyanus bidyanus*), threatened Murray cod (*Maccullochella peelii peelii*), and

endangered populations of olive perchlet (*Ambassis agassizii*) and purple spotted gudgeon (*Mogurnda adspersa*);

- The Mehi River is included in the Endangered Aquatic Ecological Community of the Lowland Darling River catchment (Section 4 of the *Fisheries Management Act 1994*);
- Over 30km of unimpeded habitat is available upstream of the weir for fish passage.

### **Hydrology**

The flows within the Mehi River are primarily controlled by Copeton Dam. Located on the Gwydir River and draining an area of 5.360km<sup>2</sup>, Copeton Dam holds a capacity of 1,364,000ML and regulates 55% of the total catchment flows. The dam provides water for irrigation, stock and domestic supplies to the Gwydir and Mehi Rivers, Carole and Moomin Creeks, and associated wetlands. In closer proximity to Moree Weir is the Tareelaro Regulator (20-30km upstream), regulating flow control at the Mehi River off-take. Upstream of the weir pool, the Mehi River ranges from 10-15 metres wide, with depths varying between 1 to 2.5 metres.

Hydrological flows for the Mehi River referred to in this report were determined from DNR river gauge #418002, and sourced from the DNR website and staff members of State Water. There is a regular flow across the crest of Moree Weir, which varies with rainfall in the middle and upper catchment, release of flows from the Tareelaro Regulator, and seasonal events. Structural drown-out historically occurs three to four times a year during large flood events. State Water releases excess flows from structures upstream to ensure Moree Weir pool is at full capacity and can be topped-over easily, guaranteeing flow levels meet supply demand further downstream.

### **Operational Details**

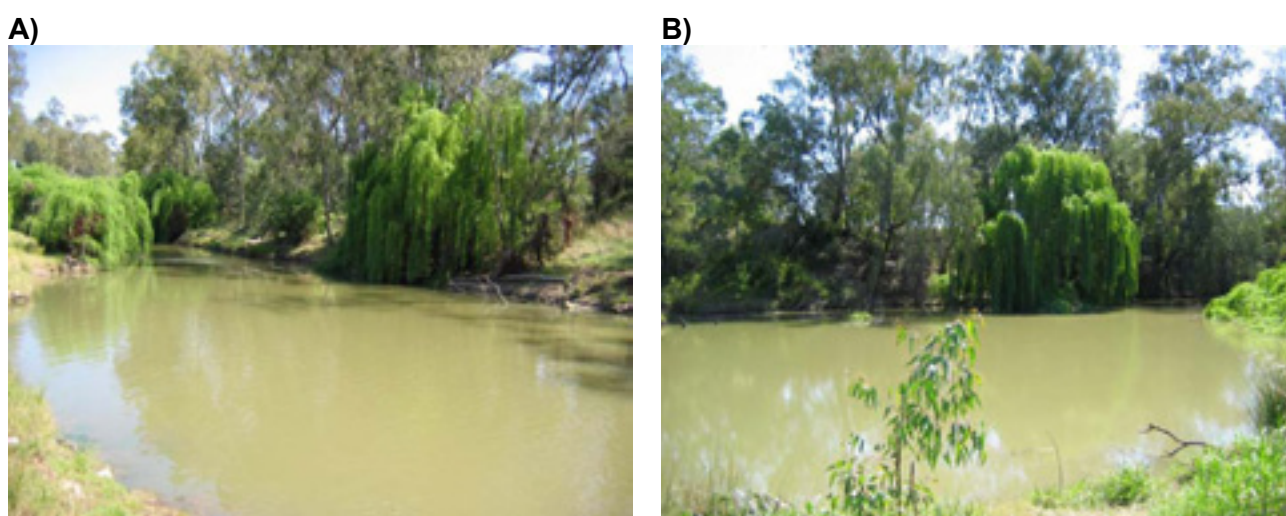
Moree Weir was constructed in 1985 as an APEX club, community involved project with the sole purpose of creating a pool for recreational activities in parkland surroundings. Today, ownership of the weir is unclear. However, it is maintained by Moree Plains Shire Council and the weir pool is still used exclusively for recreational purposes. The weir has also been known to be used (on occasion), as a foot-crossing by the local Aboriginal community. However, the Council considers this action to be unwise and potentially dangerous, with Council possibly liable for any accidents that may occur. In addition concerns have been raised relating to the stability of the structure.

### **Ecological Considerations**

Moree Weir is one of three weirs located on the mainstem Mehi River, a major effluent stream of the Gwydir River. The Tareelaro Regulator is a large, reinforced concrete, earth and rock fill structure, located immediately downstream of the Mehi River and the Gwydir River confluence, approximately 20-30km upstream of Moree Weir. The regulator has a submerged-orifice fishway. However, the poor design of this type of fishway has resulted in heavy silting and inadequate passage of native fish. Gundare Regulator is a large adjustable crest structure, approximately 50km downstream of Moree Weir. There is no provision for fish passage at this weir, and consequently the movement of native fish is impeded. Likewise, Combanello Weir located on Moomin Creek immediately downstream of the junction of Moomin Creek with the Mehi River, presents as a barrier to fish passage except during flood events.

The remediation of fish passage for native species at these structures and the re-establishment of fish passage at Moree Weir could potentially open up over 300km of unimpeded habitat for native fish species.

The park-land area surrounding the weir is grassed and mowed on a regular basis. The riparian areas upstream to the weir are moderately well vegetated with a combination of eucalypt species including river gums, and the introduced pest species weeping willow (*Salix babylonica*). Downstream of the weir, the vegetation cover is less extensive, with weeping willows the predominant species (Figure 2A and B). Immediately adjacent to the structure the banks are steep and extensive erosion is evident. The concrete (largely on the right hand side bank) below the weir is causing a diversion of flows and consequently, serious undercutting of the left bank. A relatively large accumulation of silt is present immediately behind the structure, resulting in a change in bed level from the upstream to downstream side of approximately one metre.



**Figure 2.** Mehi River A) upstream and B) downstream of Moree Weir.

### ***Proposed Remediation Actions***

Fish are only able to pass this weir during large flood events, when the structure completely drowns out. It is recommended fish passage options be further investigated at this site and that any remediation project also incorporates:

- the removal of the concrete placed downstream of the structure;
  - willow eradication;
  - rehabilitation of the riparian zone with native species;
  - bank stabilisation; and
  - a carp (*Cyprinus carpio*) control project possibly involving the local community, fishing and rivercare groups.
- **Option 1 – Removal of Moree Weir**

The complete removal of the structure would provide the greatest benefit to the health of the Mehi River by providing unrestricted fish passage and reintroducing natural sediment fluxes. Additionally, Moree Shire Plains Council would no longer be liable for the site, and the potential public safety risk.

Furthermore, the excess volumes of water State Water release in order to top over the structure would not be required. Flows within the Gwydir River system would be more efficient. The build up of silt behind the structure would also need to be addressed. Care would be needed to ensure the silt was not released into the downstream environment, where it could potentially smother aquatic habitat. The aesthetic and recreational use of the weir pool would be lost.

- **Option 2 – Partial removal and refurbishment of Moree Weir**

This option would involve a reduction in the height of the weir to approximately 2 metres. Partial removal of the structure in conjunction with removal of the downstream concrete would require investigation into the stability of the structure. If unstable, the weir could potentially fail and wash away in a large flood event. A smaller weir pool than at present would result; however some water would be retained for aesthetic purposes and recreational use by the community. The large volumes of silt behind the structure would also need to be addressed, to ensure the silt was not released into the downstream environment, with partial or total removal of the silt an option (with total removal being the preferred option). To ensure fish passage at this site, this option would incorporate the installation of a full width or partial width rock-ramp fishway. A full width rock-ramp fishway would be the most ideal type; however, construction costs would be high. Therefore, a partial width, reverse leg rock-ramp located to one side of the structure, ensuring the entrance to the fishway was located near the face of the weir to attract migrating fish is also an option.

- **Option 3 – Removal of slide gate**

The weir could be easily and inexpensively breached by removing the centrally placed gate, allowing regular flow through the structure. This option would remediate the “waterfall effect” and allow fish passage at this site. However, water velocity and turbulence through the gap, created as a result of removing the gate could potentially be too high for the majority of native fish species to swim against. The height of the gate would require investigation, if it does not span the full height of the weir a fish way (partial width rock-ramp) would need to be installed. To ensure fish passage was efficient, the entrance to the fishway would need to be located at the base of the weir (reverse leg rock-ramp), since fish migrating up the side of the waterway channel could potentially miss the entrance and find themselves at the foot of a barrier. Guiding walls from the river banks to the entrance of the fishway could also be incorporated into the design. The stability of the structure following removal of the gate would also need to be investigated. If removing the central gate causes destabilisation of the weir, potentially the structure could fail and wash away in a large flood event. . In addition, the silt behind the structure would need to be addressed, to ensure the silt was not released into the downstream environment. This option would result in the loss of the weir pool for recreational and aesthetic purposes and would expose the steel sheet piling.

***Projected Remediation Costs***

Projected cost	< \$50 K	\$50K - \$150K	\$150K - \$250K	\$250K - \$500K	> \$500K
Option 1		✓			
Option 2			✓		
Option 3		✓			

### ***Recommendation***

Option 1, the total removal of Moree Weir is the preferred option for remediation of fish passage to this reach in the Gwydir River system. However, the social implications of this option are fully understood. Although there are no economic benefits directly associated with the weir, it is still of great value to the local community; providing a pool for recreational and aesthetic purposes. Taking the needs of the local community into consideration in conjunction with the aim to improve fish passage at this site, Option 2 is therefore recommended. Further investigation and consultation with fishway experts and engineers would be required to ensure designs were technically sound.

### ***Benefits Associated with Remediation***

The Mehi River provides 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 Moree Weir on the Mehi River would open up access to over 30km of potential fish habitat. This could be further increased if fish passage is addressed at the Tareelaroï Regulator, Gundare Regulator and Combadello Weir and other weirs located in the Gwydir catchment.

## **BOOMI WEIR, MACINTYRE RIVER**



**Figure 1.** Boomi Weir, Macintyre River view from left bank (61.424ML/day)

### ***Description and Setting***

Boomi Weir (Figure 1) is situated on a reserve within the locality of Batavia, located approximately 20km north of Boomi Township, and accessed via a gazetted road that runs along levee banks within black soil cotton fields. The weir is on the mainstem Macintyre River located in the Lower Barwon catchment, approximately 147km from where the Macintyre and Weir Rivers meet, forming the Barwon River. The weir is a fixed crest, sheet piling structure, concreted with an earth and rock fill. Measuring 25 metres along its crest and 4 metres high, Boomi Weir pools water over approximately 12km, at depths varying from 1 to 3 metres. The total submerged area of Boomi Weir pool is 19ha, resulting in a Full Supply Level of 150ML. The weir also has an inlet box and manually operated valve that are no longer working and are believed to be blocked with silt. Fish passage only occurs at this structure when severe drown-out takes place during large flood events (once or twice every two years). During the majority of flow events the weir represents a barrier to fish passage due to a “waterfall effect” over the crest of the structure, producing a large headloss of approximately 300cm.

Prioritisation of weirs in the Border Rivers Gwydir CMA region has highlighted Boomi Weir as a high remediation priority within the Border Rivers Gwydir CMA due to the following factors:

- The Macintyre River is a Class 1 fish habitat, supporting a diverse range of habitat types and native fish species including vulnerable silver perch (*Bidyanus bidyanus*), threatened Murray cod (*Maccullochella peelii peelii*),

and endangered populations of olive perchlet (*Ambassis agassizii*) and purple spotted gudgeon (*Mogurnda adspersa*);

- The Macintyre River is included in the Endangered Aquatic Ecological Community of the Lowland Darling River catchment (Section 4 of the *Fisheries Management Act 1994*);
- Over 120 km of unimpeded habitat is available upstream of the weir for fish passage in the Macintyre River up to Goondiwindi Weir; and
- The weir has been identified as the fourth highest priority structure requiring a fishway within the Murray-Darling Basin (Native Fish Strategy for the Murray-Darling Basin 2003-2013).

### **Hydrology**

The flows within the Macintyre River are controlled by Glenlyon Dam, located on Pike Creek in QLD and Pindari Dam, located on the Severn River in NSW. The combined capacity of these dams is 565,000ML, collectively regulating flows for irrigation, stock, town and industrial purposes to users as far as Mungindi Weir. Upstream of the weir pool, the Macintyre River ranges from 10-15 metres wide, with depths varying between 1 - 3 metres.

Hydrological flows for the Macintyre River referred to in this report were determined from DNR river gauge #416043, and sourced from the DNR website and staff members of SunWater. Flows within this section of the Macintyre River are dictated to by rainfall levels in the middle and upper reaches of the catchment, regulated water release from Glenlyon and Pindari Dams and re-regulated flows from Boomi Regulator. Boomi Regulator is located on the Boomi River, in close proximity to Boomi Weir, 200 metres downstream of the confluence between the Macintyre and Boomi Rivers (Figure 2).



**Figure 2.** Boomi Regulator, Boomi River.

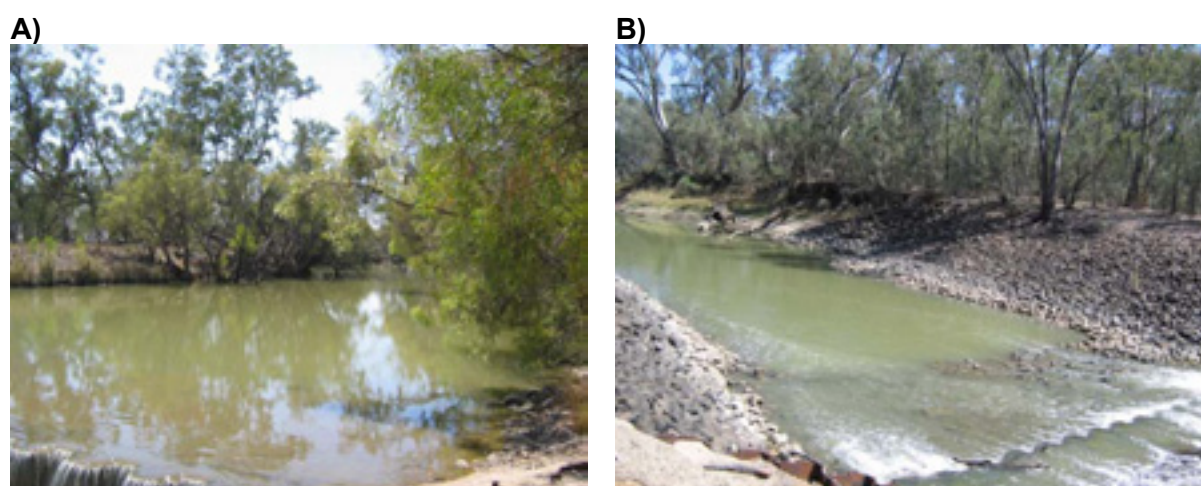
The physical environment surrounding the weir, namely, a narrow river channel and steep sided banks, result in quick structural down-out of the weir. Drown-out occurs in times of seasonal flood events (can take place on average of 1-3 times a year), when flows exceed 2000ML/day. Over-topping of the structure occurs when levels exceed EL 184.29 metres.

### ***Operational Details***

Boomi Weir was constructed in 1960 for irrigational, industrial, urban, stock and domestic water supply purposes. Today, the weir is still used for its original supply purposes. Boomi Weir is under the control of the Border Rivers Commission, with operational maintenance carried out by SunWater. Maintenance includes the clearing of large woody debris that accumulates around the structure and structural repairs (e.g. recent concrete and rock protection installed to the left hand side of the structure). Flows across the crest are generally considered constant, averaging around 50ML/day. Local fishing groups also use the weir pool.

### ***Ecological Considerations***

Boomi Weir (AMTD 147.0km) is one of three weirs located on the mainstem Macintyre River, which drains the Waterloo Range. Goondiwindi Weir (AMTD 268.8km) is a privately owned, crib-work and concrete structure that incorporates a centrally placed rock-ramp fishway. Many native fish generally prefer to swim up the sides of the waterway channel, in areas of reduced flow and decreased turbulence. The central location of the fishway at Goondiwindi Weir suggested that fish moving upstream during anything but low flows, could potentially miss the entrance and find themselves obstructed by the weir. Guiding walls, to the entrance of the fishway were recently constructed with the aim to remediate this issue, and further investigations are required to determine if their addition was successful in enhancing fish passage. Boggabilla Weir (AMTD 283.5km) is a large reinforced concrete earth filled structure with a vertical-slot fishway, which allows fish passage for some species over a narrow flow range. The remediation of fish passage to all native species at these structures and the re-establishment of fish passage at Boomi Weir could potentially open up over 200km (not including tributaries) of unimpeded habitat for native fish species.



**Figure 3.** Macintyre River A) upstream and B) downstream of Boomi Weir.

The riparian areas adjacent to the weir are moderately well vegetated with a variety of pasture grasses, a mix of eucalypt species, including blue gums (*Eucalyptus tereticornis*), and ti tree bark (*Melaleuca sp.*) and casuarinas. Also present in close proximity to the weir is the parasitic mistletoe (*Amyema sp.*), upon which the ubiquitous mistletoe bird (*Dicaeum hirundinaceum*) can be observed feeding.

The riparian vegetation present extends some stabilising properties to the banks adjacent to, upstream, and downstream of the structure, thereby aiding in erosion prevention (Figure 3). However, although fencing is present in the immediate vicinity of the weir pool on the NSW side, it is lacking on the QLD side and further up and downstream on both sides. This lack of fencing allows stock regular access to the river and weir pool, (pugging was observed at the time of study to the banks below the weir), and can potentially result in destabilisation and erosion of the riparian zone. Large volumes of silt have accumulated immediately behind the structure. Siltation, is the probable cause for the outlet valves no longer working, and has resulted in a change in bed level from the upstream to downstream side of approximately 1.5 metres.

### **Proposed Remediation Actions**

Boomi Weir is regularly “over topped”, while large flood events historically “drown-out” the weir once or twice every year. However, water levels for the majority of the year are insufficient for fish passage needs. It is recommended fish passage options be further investigated at this site.

- **Option 1 – Vertical-slot fishway**

The height of Boomi Weir (4 metres) implies a vertical-slot fishway would be the most effective at this site. This type of fishway is the most successful for barriers up to 6 metres high, passing large numbers of fish of all species and sizes. The left bank is the most easily accessible and is the preferred location for this structure. The crest of the weir on this side would need to be slightly lowered to produce an attractant flow to the entrance of the fishway. This slight lowering would have marginal effects on the water level within the weir pool. Additionally, the entrance to the fishway would be located near the base of the weir (reverse leg) to attract migrating fish. Cell dimensions of 3 metres long by 2 metres wide, with slot width of 300mm are recommended for vertical-slot fishways in the Murray-Darling Basin and associated inland rivers. Maintenance of the fishway would need to be incorporated into maintenance works of the weir. The design would need to comply with NSW DPI policy and guidelines to ensure fish passage occurred during 95% of flows.

- **Option 2 – Partial removal**

Option 2 would involve a reduction in the height of the weir to approximately 2 metres. Structural stability assessments would be required to determine if the weir could survive large flooding events in a reduced height state. A smaller capacity weir pool would result, the effect of this on water supply to upstream irrigation licenses would require investigation, and pump adjustments or relocation of pumps may be required. The silt build-up would also need to be addressed, due to the potential consequences of its release into the downstream aquatic habitat. Partial or total removal of the silt is an option, with complete removal being the preferred option. To allow for fish passage at this site, this option would incorporate the installation of a full width or partial width rock-ramp fishway.

A full width rock-ramp fishway would be the most ideal type; however, construction costs would be high. Therefore, a partial width, reverse leg rock-ramp located to one side of the structure, with the entrance located near the face of the weir to attract migrating fish could also be considered.

**Projected Remediation Costs**

Projected cost	< \$50 K	\$50K - \$150K	\$150K - \$250K	\$250K - \$500K	> \$500K
Option 1				✓	
Option 2				✓	

**Recommendation**

The construction of a vertical-slot fishway is the preferred and most cost effective option for remediation of fish passage to this 266km reach. Further investigation and consultation with fishway experts and engineers would be required to ensure designs were technically sound.

**Benefits Associated with Remediation**

The Macintyre River provides 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 Boomi Weir on the Macintyre River would open up over 120km of potential fish habitat. This could be further increased if fish passage is addressed at Goondiwindi Weir, Boggabilla Weir and other weirs located in the Barwon catchment.

## **BOGGABILLA WEIR, MACINTYRE RIVER**



**Figure 1.** Boggabilla Weir, Macintyre River view from upstream side on the left bank (369.317ML/day).

### ***Description and Setting***

Boggabilla Weir (Figure 1) is situated 12km south of Goondiwindi via the Newell Highway, approximately 4km upstream of Boggabilla Township. The weir is on the mainstem Macintyre River located in the Lower Barwon catchment, within the northern lowlands of the Murray-Darling River system, approximately 283.5km north east from where the Macintyre and Weir Rivers meet, to form the Barwon River. The weir is a large adjustable release structure with five, vertical lift, fixed wheel, steel gates. Measuring 77 metres along its crest and standing a total of 21 metres high, with a 73 metre wide concrete spillway, Boggabilla Weir pools water over an extensive 21km upstream at depths of approximately 4.5 - 6 metres, resulting in a total storage capacity of 5,850ML.

The weir has a vertical-slot fishway positioned on the left abutment downstream of the weir (Figure 2A). However, inaccurate estimates of tailwater levels at high headwater levels during the design phase, have led to increased turbulence within the fishway when the weir pool is at full capacity, resulting in inefficient fish passage (QLD DPI&F, *in prep*). In an attempt to reduce the turbulent conditions, the weir pool level is maintained 2 metres below full supply level (EL 214 metres) during spring and summer (peak irrigation periods). Nonetheless, QLD DPI & F established that even with improving the turbulent flow conditions, the fishway is still providing inadequate fish passage for the majority of native species present in the system. In addition, the weir is an undershot weir, which is known to have negative impacts on fish larvae (passage through an undershot weir resulted in the death of 95 +/- 1%

golden perch larvae and 52 +/- 13% Murray cod larvae, by comparison mortality was significantly lower in an overshot weir) (Baumgartner *et al.* 2006). It is therefore important that we understand the effect of weirs on fish communities and the migratory patterns of species native to the area, so that we can better manage them to assist in the protection of native fish in the entire Barwon catchment.

Prioritisation of weirs in the Border Rivers Gwydir CMA region has highlighted Boggabilla Weir as a high remediation priority within the Border Rivers Gwydir CMA due to the following factors:

- The Macintyre River is a Class 1 fish habitat, supporting a diverse range of habitat types and native fish species including vulnerable silver perch (*Bidyanus bidyanus*), threatened Murray cod (*Maccullochella peelii peelii*), and endangered populations of olive perchlet (*Ambassis agassizii*) and purple spotted gudgeon (*Mogurnda adspersa*);
- The Macintyre River is included in the Endangered Aquatic Ecological Community of the Lowland Darling River Catchment (Section 4 of the *Fisheries Management Act 1994*);
- The stretch of the Macintyre River from Goondiwindi Town to Boggabilla Weir has been flagged as a potential “demonstration reach” as part of the Living Murray Project. Works could include riparian zone revegetation, fencing and exotic weed eradication.
- Over 200km of unimpeded habitat is available upstream of the weir for fish passage throughout the Macintyre River, Dumaresq River, Severn River and Macintyre Brook; and
- The current vertical-slot fishway was identified by Fishway Consulting Services as a high remediation priority (Mallen-Cooper 2000).

## **Hydrology**

The flows within the Macintyre River are controlled by Glenlyon Dam, located on Pike Creek in QLD and Pindari Dam, located on the Severn River in NSW. The combined capacity of these dams is 565,000ML, collectively regulating flows for irrigation, stock, town and industrial purposes to users as far as Mungindi Weir. The total catchment area upstream of Boggabilla Weir is 23,050km<sup>2</sup>, nearly half (47%) of the total Border Rivers Catchment area. Upstream of the weir pool, the Macintyre River ranges from 10-18 metres wide, with depths generally between 0.5-1.5 metres.

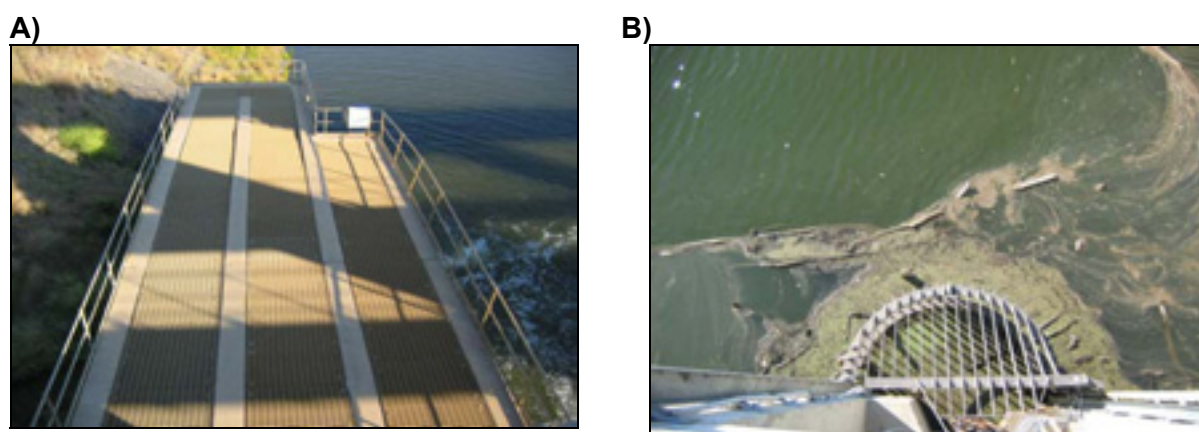
Hydrological flows for the Macintyre River referred to in this report were determined from DNR river gauge #416065 (located at the weir site) and #416002 (at Boggabilla Township), and sourced from the DNR website and staff members of SunWater. Flows within the Macintyre River are dictated by rainfall levels in the middle and upper reaches of the catchment and regulated water release from Glenlyon and Pindari Dams. Flow is maintained over the structure and is increased in response to demand primarily during the drier seasons when increased supply is required for cotton crops. The automated gates allow flow levels to be regulated on a daily scale. In the event of a flood, the gates automatically rise if water levels exceed 216 metres EL.

Operators are currently limited to a maximum draw-down rate of 0.5 metres per day to minimize the impact of the weir operations on bank slumping upstream of the weir (BRC Annual Report 2003-2004).

Concerns have been raised over changes in groundwater levels in the vicinity in the weir, as a result of an expected seepage problem on the left hand side of the structure. Monitoring bores set up with data loggers and telemetry have been established adjacent to the structure and surrounding paddocks to ascertain the degree of seepage.

### ***Operational Details***

Construction of Boggabilla Weir finished in 1991 at a total cost of \$13.5 million. The weir is under the control of the Border Rivers Commission and operational maintenance is carried out by SunWater. Boggabilla Weir was erected to increase water supply to irrigators in the Border Rivers system at a reasonable cost, and improve the efficiency of the water supply system. Monthly safety and surveillance maintenance is carried out, including the removal of large woody debris that accumulates around the structure (Figure 2B). Flow across the crest is fairly continuous and fully automated. The weir is currently used for re-regulation of supply from Glenlyon Dam to Mungindi Weir; irrigation of surrounding farmland (primarily cotton crops as well as lucerne, cereals, pastures and horticulture); urban supply to the towns of Texas, Yelarbon, Boggabilla, Goondiwindi and Mungindi; and domestic supply and stock water. Additionally, the weir pool is used by the local community for recreational purposes, swimming, boating, fishing and canoeing.

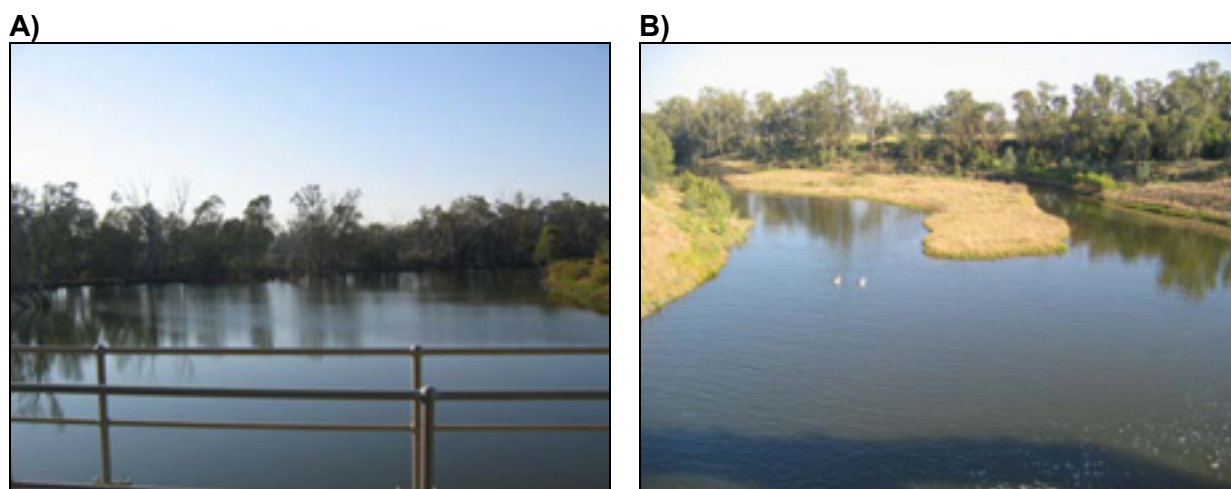


**Figure 2.** A) Vertical-slot fishway and B) debris accumulated at exit of fishway.

### ***Ecological Considerations***

Boggabilla Weir at AMTD 283.5km, is one of three weirs located on the mainstem Macintyre River that drains the Waterloo Range. Goondiwindi Weir (AMTD 268.8km) is a privately owned, crib-work and concrete structure that incorporates a centrally placed rock-ramp fishway. Fish are more likely to swim up the sides of the waterway channel, in areas of reduced flow and decreased turbulence. The central location of the fishway at Goondiwindi Weir suggested that fish moving upstream during anything but low flows, could potentially miss the entrance and find themselves obstructed by the weir. Guiding walls, to the entrance of the fishway were recently constructed with the aim to remediate this issue, and investigations are required to determine the success of this modification. Boomi Weir (AMTD 147.0km) is a fixed crest, sheet piling structure that also inhibits fish passage. Boomi Weir has been assessed as part of this study.

The remediation of fish passage at these structures and the improvement of fish passage at Boggabilla Weir could potentially open up over 200km (not including tributaries) of unimpeded habitat for native fish species.



**Figure 3.** Macintyre River A) upstream and B) downstream of Boggabilla Weir.

The river banks adjacent to the weir are moderately vegetated with a variety of pasture grasses, blue gums (*Eucalyptus tereticornis*), common reeds (*Phragmites australis*) and ti trees (*Melaleuca sp.*). This vegetation cover is not as extensive as it was prior to construction of the weir. Increased bank slumping, steeper banks and decrease in vegetation cover have led to destabilisation of the riparian zone. This is particularly evident downstream of the weir (on the right bank), where the bank is severely eroded. This action is possibly the consequence of the formation of a sand island in the centre of the main channel (Figure 3B) that has resulted from changes in hydrology following weir construction. In addition, dieback of melaleucas and river gums is taking place along the back fringing edge of the weir pool, due to their prolonged inundation since the weirs' construction.

The river banks in close proximity to the weir are fenced, however, further up and downstream stock can access the river, potentially resulting in further destabilisation and erosion of the riparian zone. The river bed downstream of the structure is stable, and the constant flows over the crest ensure build up of silt remains minimal.

Small amounts of nuisance aquatic weeds (e.g. duck weed) are a recurring issue within the weir pool, and an extensive bloom of cyanobacteria (blue-green algae) occurred in November 2004. At this time, the average algal count sharply increased from an average of 800 cells/ML to 45,906 cells/ML. The potentially toxic *Anabaena sp.* was identified as the predominant species (DNR data). Warning signs and water restrictions were quickly put in place till levels returned to normal and deemed safe to the public. Water quality, flows and thermal stratification have since been closely monitored.

### ***Proposed Remediation Actions***

Boggabilla Weir is important to the economy of the local community, surrounding towns and agriculture. Removal or partial removal of this structure is not an option. Therefore, modification of the existing fishway to restore fish passage at this site is the only reasonable option and will satisfy the needs of all interested parties.

- **Option 1 – Modify existing fishway**

The existing vertical-slot fishway was constructed at great expense. Unfortunately, inaccurate estimates of headwater and tailwater levels have led to turbulent conditions at full capacity, and inefficient fish passage. The current manipulation of weir pool levels has marginally improved fish passage. However, the fishway is inadequate at passing the majority of fish located in the vicinity of the weir (especially smaller species). To improve fish passage, extra cells could be added to extend the channel downstream. Additionally, a narrower slot width and reduced head loss between the cells is required to reduce velocity and turbulence.

- **Option 2 –Denil insert**

Fish passage could alternatively be improved through retrofitting the existing fishway with a Denil insert, thus allowing a greater proportion of different size and species of native fish to migrate upstream. However, a number of criteria need to be met to determine if the site is suitable, including:

- a 1:12 slope
- sufficient stream flow of at least 44ML/day; and
- low variation in headwater.

To ensure these criteria were met, this option may also need to incorporate some structural modifications to the existing fishway.

***Projected Remediation Cost***

Projected cost	< \$50 K	\$50K - \$150K	\$150K - \$250K	\$250K - \$500K	> \$500K
Option 1			✓		
Option 2				✓	

***Recommendation***

Although previous concerns have been raised regarding the criteria necessary for Denil-inserts, this modification of the existing fishway is the preferred option and will result in increased fish passage to an extensive amount of upstream habitat. Further engineering designs would need to be developed to confirm that the suggested insert was technically sound and met required fishway guidelines.

***Benefits Associated with Remediation***

The Macintyre River provides 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 restoration of fish passage at Boggabilla Weir on the Macintyre River would open up access to over 200km of potential fish habitat. This could be further increased if fish passage is addressed at Boomi Weir and other fish passage barriers located in the Barwon catchment.

## TAREELAROI REGULATOR, MEHI RIVER



**Figure 1.** Tareelaro Regulator, Mehi River view of weir from left bank (29.751ML/day).

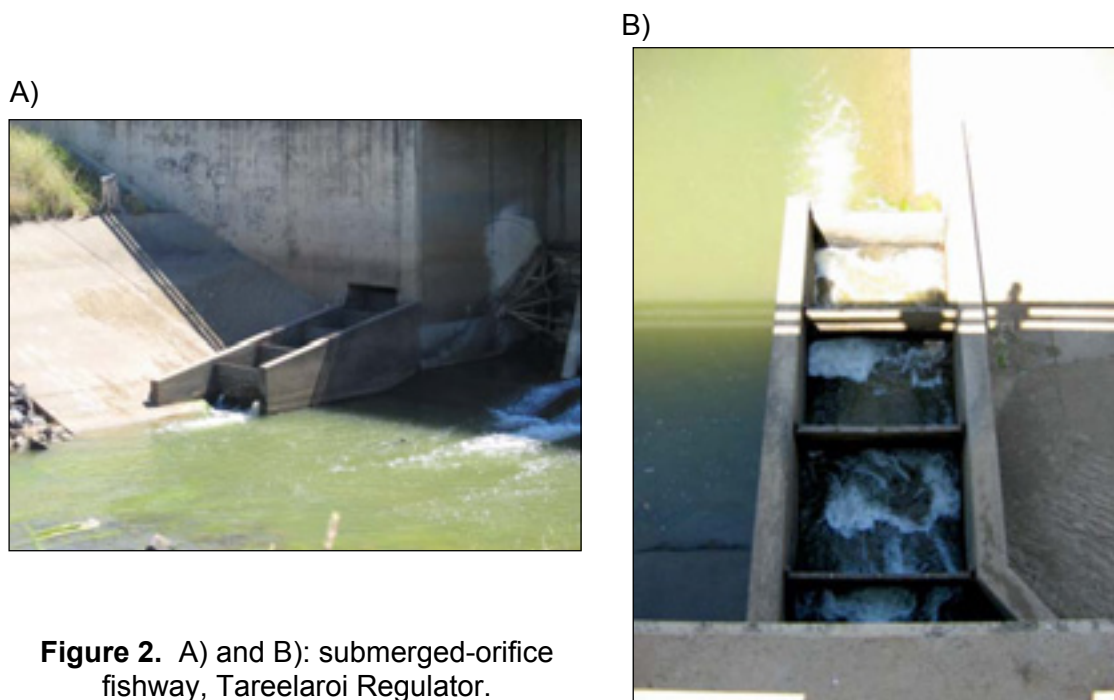
### **Description and Setting**

Tareelaro Regulator (Figure 1) is situated 20km east of Moree via the Gwydir Highway, near the township of Pallamallawa within the Parish of Mia Mia. The weir is located on the mainstem Mehi River, in the Middle Gwydir catchment, within the northern lowlands of the Murray-Darling River system, located a few hundred metres downstream of the confluence of the Mehi and Gwydir rivers. The weir is a large adjustable release structure with 4 steel radial gates. Measuring 18 metres along its crest and standing a total of 4 metres high, the Tareelaro Regulator pools water over approximately 500 metres until it meets the pool created by the Tareelaro Weir. Water depths of approximately 3-3.5 metres occur within the weir pool resulting in a full capacity of 2400ML (FSL 219.18 metres).

The weir has a submerged-orifice fishway positioned on the right bank, downstream of the weir (Figure. 2A and B). However, poor design and increased siltation have resulted in inadequate fish passage through this fishway. Therefore, the weir presents a physical barrier to migrating fish except during large flood events when the gates are open and the steep cascade off spillway is overcome (“drowned out”). In addition, the weir is an undershot weir, which is known to have negative impacts on fish larvae (passage through an undershot weir resulted in the death of 95 +/- 1% golden perch larvae and 52 +/- 13% Murray cod larvae, by comparison mortality was significantly lower in an overshot weir) (Baumgartner *et al.* 2006). It is therefore important that we understand the effect of weirs on fish communities and the migratory patterns of species native to the area, so that we can better manage them to assist in the protection of native fish in the whole Gwydir catchment.

Prioritisation of weirs in the Border Rivers Gwydir CMA region has highlighted the Tareelaroi Regulator as a high remediation priority within the Border Rivers Gwydir CMA due to the following factors:

- The Mehi River is a Class 1 fish habitat, supporting a diverse range of habitat types and native fish species including vulnerable silver perch (*Bidyanus bidyanus*), threatened Murray cod (*Maccullochella peelii peelii*), and endangered populations of olive perchlet (*Ambassis agassizii*) and purple spotted gudgeon (*Mogurnda adspersa*);
- The Mehi River is included in the Endangered Aquatic Ecological Community of the Lowland Darling River catchment (Section 4 of the *Fisheries Management Act 1994*);
- Over 250km of unimpeded habitat is available upstream of the weir for fish passage throughout the Gwydir River and its tributaries; and
- The low number of barriers to fish passage upstream of the structure.



### **Hydrology**

The flows within the Mehi River are controlled by the Tareelaroi Regulator and on a larger scale Copeton Dam. Located on the Gwydir River, Copeton Dam drains an area of 5.360km<sup>2</sup>, holds a capacity of 1,364,000ML and regulates 55% of the total inflow to the Gwydir River. The dam provides water for irrigation, stock and domestic supplies to the Gwydir and Mehi Rivers, their tributaries including Carole and Moomin Creeks, and associated wetlands. Upstream of the weir pool, the Gwydir River ranges from 18-25 metres wide, with depths varying between 1-4 metres.

Hydrological flows for the Mehi River referred to in this report were determined from DNR river gauge #418044 (located downstream of the weir site), and sourced from the DNR website and staff members of State Water.

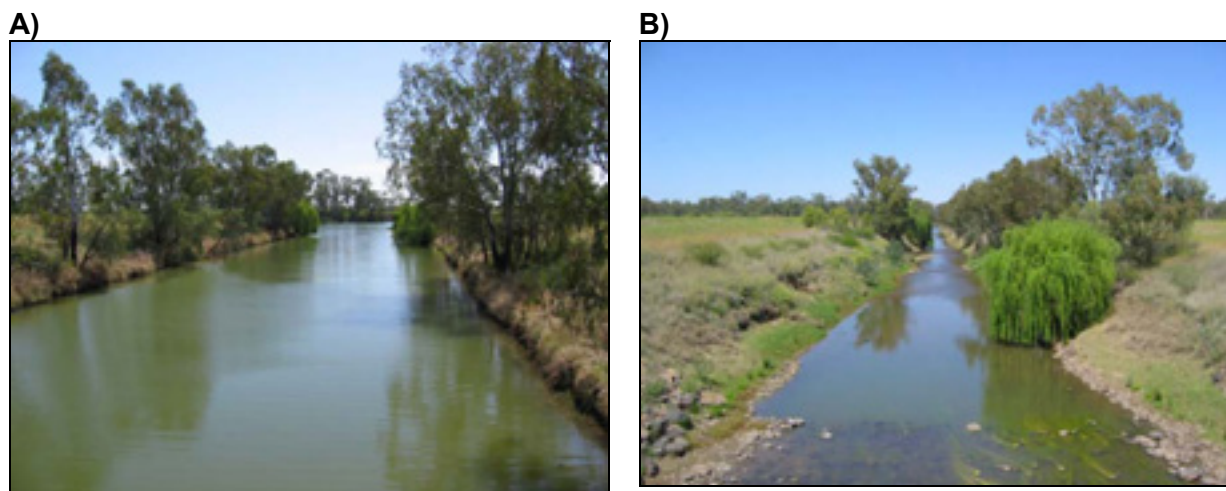
Flows within the Mehi River are dictated by rainfall levels in the middle and upper reaches of the catchment, water release from Copeton Dam, and re-regulated water release from the Tareelaroi Regulator. A base flow is maintained across the crest of the structure and is increased in response to demand, especially during the drier seasons when increased supply is required for irrigation. The automated gates allow flow levels to be regulated daily if required. In the event of a flood, if the water level exceeds 219.3 metres EL (occurs approximately 1% of the time) the flood program is initiated and gates automatically start to rise, if the level continues increasing the gates are opened to their full extent in preparation for the peak of the flood waters.

### ***Operational Details***

The Tareelaroi Regulator was constructed in 1974 to regulate the flow control at the Mehi River off-take, as well as to provide water for irrigation, stock and domestic supply. The regulator is owned and maintained by State Water. Regular safety and surveillance maintenance is performed including the removal of large woody debris that accumulates around the structure. There is a continuous base flow across the crest through the gates which is computer automated. The regulator is currently used for its original purpose. There is one water extraction licence “linked” to the works of the Tareelaroi Regulator, with a capacity of 70ML/day, however, this has not been used for a number of years. In addition, the weir is used as a road crossing, and the weir pool is used by local fishing groups for recreational purposes.

### ***Ecological Considerations***

The Tareelaroi Regulator is located approximately 250km downstream of Copeton Dam, and is one of three weirs on the main-stem Mehi River, a major effluent stream of the Gwydir River. Moree Weir (approximately 20-30km further downstream) and Gundare Regulator (approximately 50km downstream of Moree Weir) additionally act as barriers to fish passage for the majority of flow events. Moree Weir has been assessed as part of this study.



**Figure 3.** Mehi River A) upstream and B) downstream of the Tareelaroi Regulator.

The remediation of fish passage at these structures and the improvement of fish passage at the Tareelaroi Regulator could potentially open up over 300km (not including tributaries) of unimpeded habitat for native fish species.

The river banks immediately adjacent to the structure are poorly vegetated with a sparse covering of pasture grasses. Further downstream, the left hand banks are also poorly vegetated, while the right hand banks are moderately vegetated with a variety of pasture grasses, eucalypt species (river gums) and weeping willows (*Salix babylonica*) (Figure 3). Minor erosion is evident on both banks within the vicinity of the weir. However, further upstream along the banks of the Gwydir River, extensive erosion has occurred since the regulators construction, with complaints from local landholders being documented. The river banks in close proximity to the weir are fenced, however, further up and downstream stock can access the river, potentially resulting in further destabilisation and erosion of the riparian zone. The river bed downstream of the structure is stable, and the constant base flow ensures silt build up is minimal.

### ***Proposed Remediation Actions***

The Tareelaro Regulator is an economically important structure to the local community, surrounding towns and agriculture. Removal or partial removal of this structure is not an option. However, due to the inadequacy of the existing fishway, fish are only able to pass this weir during large flood events, when the gates are open to their maximum extent, and the “waterfall effect” is overcome. It is recommended fish passage options be further investigated at this site

- **Option 1 – Refurbish existing fishway**

The existing submerged-orifice fishway is presently silted. In addition, the design of this type of fishway did not take into consideration the behaviour and swimming ability of native fish. Fish passage for the majority of native fish species is therefore limited, due to increased turbulence, excessive head loss and high flow velocities. In order to improve fish passage a Denil-insert could be retrofitted within the existing fishway channel and trash racks installed to ensure floating debris did not accumulate within the fishway. However, there are certain criteria which would need to be met to determine if this site was suitable for a Denil-insert, including:

- a minimum flow of 44ML/day for a 1:12 slope;
- further assessment into the capabilities of passing larger species such as adult Murray cod; and
- a relatively low capacity of migrating fish at any one time.

- **Option 2 – Vertical-slot fishway**

The height of the Tareelaro Regulator to the crest of the spillway promotes a vertical-slot fishway as the most effective design for the site. This type of fishway is the most successful design for barriers up to 6 metres high, passing large numbers of fish of all species and sizes. This option would involve the removal of the existing fishway on the left hand bank and the construction of a new fishway in its place. A constant base flow would be required, preferably through the gate closest to the fishway to produce an attractant flow to the entrance of the fishway. The entrance would be at the base of the weir. Cell dimensions of 3 metres long by 2 metres wide, with slot width of 300mm are recommended for vertical-slot fishways in the Murray-Darling Basin and associated inland rivers. Maintenance of the fishway would need to be incorporated into maintenance works (e.g. debris removal) of the weir however, if an efficient trash rack covering the channel was incorporated into the design, maintenance required would be minimal.

**Projected Remediation Costs**

Projected cost	< \$50 K	\$50K - \$150K	\$150K - \$250K	\$250K - \$500K	> \$500K
Option1			✓		
Option 2				✓	

**Recommendation**

Option 1 is the most economical option for remediation of fish passage at this site. However, due to previous concerns raised regarding the selection criteria for efficient fish passage through Denil-inserts, the preferred option for remediation of fish passage at this 280km reach is the construction of a new vertical-slot fishway (Option 2). This would ensure the provision of unimpeded passage for a greater number, size and species of native fish. Further investigation and consultation with fishway experts and engineers would be required to ensure designs were technically sound.

**Benefits Associated with Remediation**

The Mehi River provides 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 Tarelaroi Regulator on the Mehi River would open up access to over 250km of potential fish habitat. This could be further increased if fish passage is addressed at Moree Weir, Gundare Regulator and other weirs located in the Gwydir catchment.

## **BONSHAW WEIR, DUMARESQ RIVER**



**Figure 1.** Bonshaw Weir, Dumaresq River. View of the weir is from the right bank (120.788ML/day).

### ***Description and Setting***

Bonshaw Weir (Figure 1) is located approximately 8km north of Bonshaw locality and is accessible via a public road from the right bank. The weir is sited on the mainstem Dumaresq River, in the Middle Macintyre catchment, approximately 66km downstream of Glenlyon Dam. The weir is a fixed crest, steel sheet piling structure that is back-filled with concrete. Measuring 65 metres along its crest and standing approximately 4 metres high, Bonshaw Weir pools water over 5km upstream, at depths of approximately 2.5-3 metres (total storage capacity 617ML). Water cascades over the crest of the weir, resulting in excessive headloss (250cm) and increased turbulence, restricting fish passage prior to structure dross out, (which occurs when the water level exceeds 293.92 metres EL).

Prioritisation of weirs in the Border Rivers Gwydir CMA region has highlighted Bonshaw Weir as a high remediation priority within the Border Rivers Gwydir CMA due to the following factors:

- The Dumaresq River is a Class 1 fish habitat, supporting a diverse range of habitat types and native fish species including vulnerable silver perch (*Bidyanus bidyanus*), threatened Murray cod (*Maccullochella peelii peelii*), and endangered populations of olive perchlet (*Ambassis agassizii*) and purple spotted gudgeon (*Mogurnda adspersa*);
- The Dumaresq River is included in the Endangered Aquatic Ecological Community of the Lowland Darling River Catchment (Section 4 of the *Fisheries Management Act 1994*);

- Approximately 66km of potential fish habitat is available upstream of the weir along the Dumaresq River;
- Instream habitat along the Dumaresq River is considered in good condition; and
- There are few significant barriers to fish passage on the Dumaresq River.

### ***Hydrology***

The flows within the Macintyre Catchment are controlled by Glenlyon Dam. With a capacity of 253,000ML it provides regulated flows for irrigation, stock, town and industrial purposes to users as far as Mungindi Weir. Bonshaw Weir is located within the Bonshaw sub-catchment of the Macintyre River, a major tributary of the Darling – Barwon River system. The total catchment area upstream of the weir is 7252km<sup>2</sup>, approximately 15% of the total Border Rivers catchment area. Upstream of the weir pool, the Dumaresq River ranges from 12-20 metres wide, with depths generally between 1-2.5 metres.

Hydrological flows for the Dumaresq River referred to in this report were determined from DNR river gauge #416007 located immediately downstream of the structure, sourced from the DNR website and staff members of DNR and SunWater, and uses data acquired between 01/01/73 and 19/10/05. Flows within the Dumaresq River are dictated to by rainfall levels in the upper reaches of the catchment and regulated water release from Glenlyon Dam. Bonshaw weir's full supply level (EL 293.92 metres) is regularly exceeded resulting in a fairly continuous base flow across the crest.

### ***Operational Details***

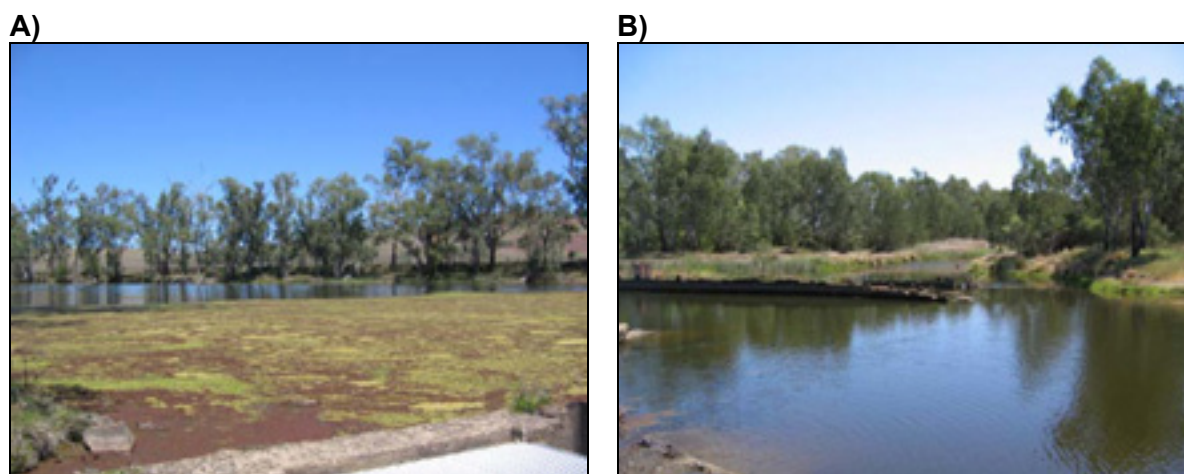
Bonshaw Weir was constructed in 1958 for irrigation water supply. However, the initial weir at this location was built in 1953. A timber crib-work structure, the original weir was washed away in a major flooding event in 1956. The remnants of this first structure still remain downstream of the current weir, as shown in Figure 2B. Now owned by the Border Rivers Commission and operated and maintained by SunWater, Bonshaw Weir is still used for its original irrigational purpose. Although the siphon outlets on the weir are no longer working, the weir is considered to be in working condition with satisfactory structural stability. The weir pool is also used for recreational purposes, specifically by local fishing groups. However, fishing is not permitted within waters 14 metres upstream and downstream of Bonshaw Weir according to NSW DPI regulations.

### ***Ecological Considerations***

Bonshaw Weir at AMTD (Adopted Middle Thread Distance) 126km, is one of three weirs located on the mainstem Dumaresq River below Glenlyon Dam. Cunningham Weir (AMTD 67.9km) and Glenarvon Weir (AMTD 57km) are both barriers to fish passage and have been assessed as part of this review. Cunningham Weir is no longer used for water distribution purposes. Currently in severe disrepair, the weir is under review for possible removal due to concerns over public safety and remediation options with regards to fish passage. Glenarvon Weir is a working structure that incorporates a fishway. Unfortunately, the fishway is currently blocked with debris and fish passage is inhibited during the majority of flow conditions. Remediation of this fishway, or the construction of a more effective fishway are options being considered at this site to allow fish passage.

The remediation of fish passage at these structures and Bonshaw Weir could potentially open up approximately 200km (not including tributaries) of unimpeded habitat for native fish species.

The riparian areas adjacent to the weir are moderately vegetated with a variety of pasture grasses, blue gums (*Eucalyptus tereticornis*), common reeds (*Phragmites australis*) and casuarinas. This vegetation proffers stabilisation to the banks adjacent to, upstream and downstream of the structure, aiding in erosion prevention. The introduced weeping willow (*Salix babylonica*) is also present in high numbers along with the introduced pest species *Opuntia sp* (Figure 2). Within the close proximity of the weir the river banks are fenced, thus restricting stock access and preventing further erosion. However, stock have partial access to the river further upstream. Nuisance aquatic weeds are often present within in the weir pool, with a large mass of ferny azolla (*Azolla pinnata*) thriving immediately upstream up the structure at the time of the study (as shown in Figure 2A). The river bed downstream of the structure is stable. In addition, there has been a gradual accrual of silt upstream of the weir. This build-up has caused a change in bed level between the upstream and the downstream side of approximately 0.5 -1metres.



**Figure 2.** Dumaesq River A) upstream and B) downstream of Bonshaw Weir.

### ***Proposed Remediation Actions***

Although Bonshaw Weir is regularly “over-topped”, the water levels are not sufficient for fish passage. Therefore, the following recommendation for fish passage should be investigated at the weir.

- **Option 1 – Removal of Bonshaw Weir**

The complete removal of the structure would provide the greatest benefit to the health of the Dumaesq River through the provision of unrestricted fish passage and reintroducing natural sediment fluxes. However, this weir is still used for irrigation purposes and has a gauging station in close proximity, thus the effect of removing this weir and its associated weir pool would need further assessment. The identification of an alternative water source and infrastructure readjustment for affected landholders may be required. The build up of silt behind the structure would also need to be addressed, if removal was the preferred option.

Care would be needed to ensure the silt was not released into the downstream environment, where it could potentially smother aquatic habitat. This option would be the most expensive.

- **Option 2 – Partial width rock-ramp fishway**

A partial width rock-ramp fishway could be constructed to the right hand side of the structure. This is the most cost effective option and favours most fish species and sizes. The crest of the weir would need to be slightly lowered on the right hand side to produce an attractant flow for the rock-ramp fishway. This slight lowering would have marginal affects on the water level within the weir pool. Additionally, the entrance to the fishway would be located near the base of the weir (reverse leg) to attract migrating fish and the point at the weir crest from which fish would exit the fishway would require lowering, to ensure it was submerged. Maintenance of the structure would need to be incorporated into maintenance works (e.g. debris removal). Remnants of the initial weir structure downstream of the current weir causes water to be diverted in several directions and restricts the possible construction of a more effective full width rock-ramp fishway. The removal of this remnant structure may possibly allow for the construction of a full width rock-ramp fishway.

- **Option 3 – Vertical – slot fishway**

A vertical-slot fishway is the most effective design for barriers up to 6 metres high, passing large numbers of fish of all species and sizes, and would therefore be the most suitable type for this site. The right hand side of the structure is the preferred location for the fishway. The crest of the weir on this side would need to be slightly lowered to produce an attractant flow to the entrance of the fishway. This slight lowering would have marginal affects on the water level within the weir pool. Additionally, the entrance to the fishway would be located near the base of the weir (reverse leg) to attract migrating fish. Cell dimensions of 3 metres long by 2 metres wide, with slot width of 300mm are recommended for vertical-slot fishways in the Murray-Darling Basin and associated inland rivers. A suitable trash rack would need to be installed and/or maintenance of the fishway incorporated into maintenance works (e.g. debris removal) of the weir. The design would need to comply with NSW DPI policy and guidelines to ensure fish passage occurred during 95% of flows.

***Projected Remediation Costs***

Projected cost	< \$50 K	\$50K - \$150K	\$150K - \$250K	\$250K - \$500K	> \$500K
Option 1				✓	
Option 2				✓	
Option 3				✓	

***Recommendation***

With regards to fish passage, complete removal of this structure is the preferred option. However, in conjunction with silt removal it could potentially be the most expensive and the future of the structure has yet to be decided upon by the weir owner, the Border Rivers Commission. Prior to this decision being made, for ease of reporting it is conjectured that the structure is to remain in place, and therefore constructing a vertical-slot fishway is the favoured option to restore fish passage to this 125km reach.

### ***Benefits Associated with Remediation***

The Dumaresq River provides 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 Bonshaw Weir on the Dumaresq River would open up access to approximately 67km of potential fish habitat. This could be further increased if fish passage is addressed at Cunningham Weir and Glenarbon Weir.

## **BOOLOOROO WEIR, MEHI RIVER**



**Figure 1.** Boolooroo Weir, Mehi River view of weir is from the left bank (12.10.05, 66.593ML/day diverted into Carole Creek).

### ***Description and Setting***

Boolooroo Weir (Figure 1) is situated 8km northeast of Moree via the Newell Highway, within the Parish of Boolooroo. The weir is sited on the mainstem Gwydir River within the northern lowlands of the Murray-Darling River system, and is located a few hundred metres downstream of the junction of Carole Creek with the Gwydir River. The weir is a large adjustable release structure with four steel vertical gates. Rock filled gabions are present for upstream and downstream protection. Measuring 54 metres across and standing a total of 3.3 metres high, Boolooroo Weir pools water over a few kilometres at depths ranging between 1.5-3.5 metres resulting in a full capacity of approximately 400ML.

Water cascades across the crest of the weir through the gates, with no additional structure being present to address fish passage. As a result, migrating fish are restricted due to this excessive headloss (150cm) except during major flood events that drown out the crest of the weir. In addition, the weir is an undershot weir, which is known to have negative impacts on fish larvae ((passage through an undershot weir resulted in the death of 95 +/- 1% golden perch larvae and 52 +/- 13% Murray cod larvae, by comparison mortality was significantly lower in an overshot weir) (Baumgartner *et al.* 2006). It is therefore important that we understand the effect of weirs on fish communities and the migratory patterns of species native to the area, so that we can better manage them to assist in the protection of native fish in the entire Murray-Darling River system.

Prioritisation of weirs in the Border Rivers Gwydir CMA region has highlighted Boolooroo Weir as a high remediation priority due to the following factors:

- The Gwydir River is a Class 1 fish habitat, supporting a diverse range of habitat types and native fish species including the vulnerable silver perch (*Bidyanus bidyanus*), threatened Murray cod (*Maccullochella peelii peelii*), and endangered populations of olive perchlet (*Ambassis agassizii*) and purple spotted gudgeon (*Mogurnda adspersa*);
- The Gwydir River is included in the Endangered Aquatic Ecological Community of the Lowland Darling River catchment (Section 4 of the *Fisheries Management Act 1994*);
- Over 30km of unimpeded habitat is available upstream of the weir for fish passage throughout the Gwydir River and its tributaries; and
- The Gwydir River flows into the Gwydir wetland. One of the largest wetland areas in NSW (823ha), it is recognised as internationally important under the Ramsar Convention.

### **Hydrology**

The flows within the Gwydir River are largely controlled by Copeton Dam. Located on the Gwydir River, Copeton Dam drains an area of 5.360km<sup>2</sup>, holds a capacity of 1,364,000ML, and regulates 55% of the total inflow to the Gwydir River. The dam provides water for irrigation, stock and domestic supplies to the Gwydir and Mehi Rivers, Carole and Moomin Creeks; and associated wetlands. Since the construction of Copeton Dam and other large water storage structures in the upper catchment, flooding regimes within the Gwydir wetlands have been severely impacted and have resulted in significant changes to the wetlands and rivers from their natural state.

As of the 1<sup>st</sup> of July 2004 the “*Water Sharing Plan for the Gwydir Regulated River Water Source*” commenced (building on previous plans laid out by the Gwydir River Management Committee). The plan aims to produce a sustainable healthy river system whilst providing reliable water flows for the community, environment, agriculture and industry. Within the plan, minimum environmental flow levels to pass into the Gwydir wetlands have been set at whichever is the lesser between:

- a) the sum of the flows in the Horton River, Myall Creek, and Halls Creek tributaries, plus any water spill or pre-release for flood mitigation purposes from Copeton Dam (described as “the 3 T’s plus C” by State Water staff); or
- b) 500ML/day.

Environmental flows released from Boolooroo Weir average 200ML/day, varying according to rainfall levels in the upper catchment and releases from Copeton Dam.

Hydrological flows for the Gwydir River referred to in this report were determined from DNR river gauge #418051 (located at the weir site) and #418036 (downstream of the weir in Carole Creek), and sourced from the DNR website and staff members of State Water. The automated gates on Boolooroo Weir allow flow levels to be adjusted daily if required. In the event of a flood, the gates automatically start to rise if the water level exceeds 206.7 metres EL (occurs approximately 3% of the time). If the water level continues to increase the gates are opened to their full extent in preparation for the flood waters.

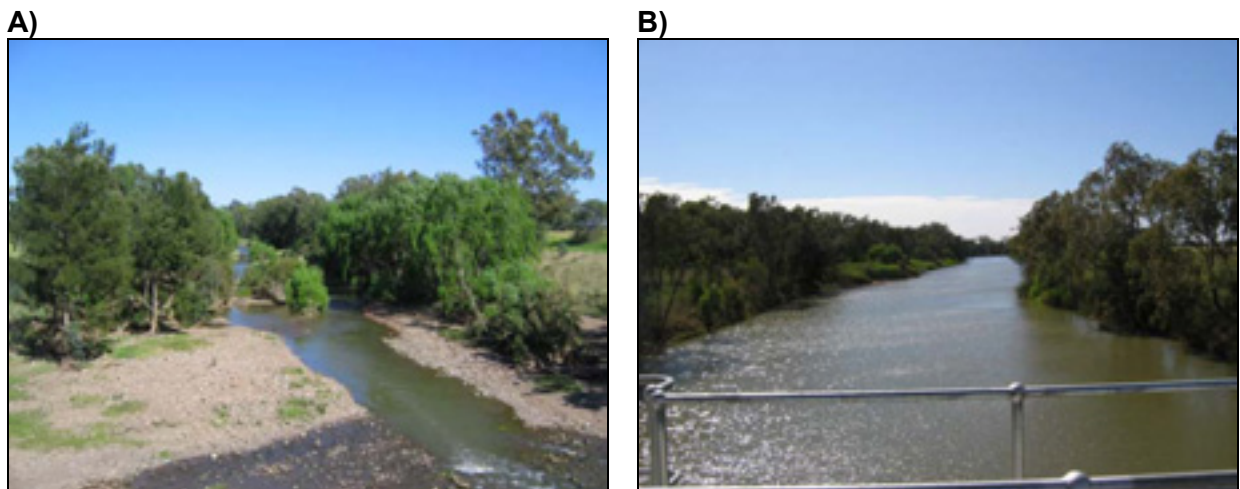
### **Operational Details**

Booloroo Weir was constructed in 1978 as a re-regulating storage structure for the purpose of regulating the downstream flow of the Gwydir River, allowing excess water to be stored for future use, and for the diversion of water into Carole Creek for the irrigation of approximately 19600ha of economically important cotton crops. The weir, which is still used for its original purpose today, is owned and maintained by State Water. A budget of \$60,000 per year is set aside for regular safety and surveillance maintenance of the structure, including the removal of large woody debris that accumulates around the structure.

There is a continuous base flow across the crest through the gates, control of which is computer automated. Two water extraction licences are currently linked to the works on the weir pool, with extraction capacities of 180ML/day and 40ML/day. State Water revenue from these water extraction licenses total approximately \$400,000 per annum. In addition, the weir pool is used by neighbouring communities for recreational purposes: swimming, boating and fishing. In times of full flood flow, local children have also been known to attach a rope and tyre to the downstream side of the structure and “surf” the turbulent wake created.

### **Ecological Considerations**

Booloroo Weir located approximately 300km downstream of Copeton Dam, is one of four weirs within close proximity of each other on the Gwydir River system. Tarelaroi Weir (approximately 30km upstream) on the Gwydir River, the Tyreel Regulator (approximately 15km downstream) on the Lower Gwydir River and Tyreel Weir on Gingham Watercourse (approximately 15km downstream) act as barriers to fish passage for the majority of flow events, except during periods of large floods. The remediation of fish passage at these structures and the improvement of fish passage at Booloroo Weir could potentially open up over 350km (not including tributaries) of unimpeded habitat for native fish species.



**Figure 2.** Mehi River A) upstream and B) downstream of Booloroo Weir.

The river banks, up and downstream of the weir are well vegetated with a combination of pasture grasses, casuarinas and eucalypts (Figure 2). This vegetation coverage provides vital stabilising qualities to the riparian zone, aiding in erosion prevention. However, weeping willows (*Salix babylonica*) are also present, and the weir pool and downstream channel are unfenced.

This lack of fencing allows stock access to the river (a number were present at the time of study), which can potentially result in destabilisation and erosion of the riparian zone. There is a build-up of approximately one metre of silt behind the structure however; constant base flows ensure silt build up is minimal. The river bed downstream of the structure is stable.

### ***Proposed Remediation Actions***

Booloroo Weir is critical for the diversion of water down Carole Creek and irrigation for the cotton industry. Consequently, the weir is economically important to the local community, surrounding towns and agriculture. Removal or partial removal of this structure is not an option. It is recommended fish passage options be further investigated at this site.

- **Option 1** – Vertical-slot fishway

A vertical-slot fishway is the most successful type of fishway for barriers up to 6 metres high, passing large numbers of fish of all species and sizes. Fishways require attractant base flows to ensure fish migrating upstream can locate the entrance, the existing provision of environmental flows at this site could be utilised as this attractant. However, it would have to be ensured that this flow was directed through the gate closest to the fishway. Cell dimensions of 3 metres long by 2 metres wide, with slot width of 300mm are recommended for vertical-slot fishways in the Murray-Darling Basin and associated inland rivers. Maintenance of the fishway would need to be incorporated into maintenance works (e.g. debris removal) of the weir however, if an efficient trash rack covering the channel was incorporated into the design, maintenance required would be minimal.

- **Option 2** – Rock-ramp fishway

The height of Booloroo Weir to its crest is low enough for a full width rock-ramp design to be considered. Rock-ramp fishways are often regarded as a more aesthetically pleasing and natural addition to a weir. This option favours most fish species and sizes. The provision of environmental flows at this site would deliver attractant flows to the entrance of the fishway. Fishway maintenance (e.g. debris removal) would need to be incorporated into maintenance works.

### ***Projected Remediation Costs***

<b>Projected cost</b>	<b>&lt; \$50 K</b>	<b>\$50K - \$150K</b>	<b>\$150K - \$250K</b>	<b>\$250K - \$500K</b>	<b>&gt; \$500K</b>
<b>Option1</b>				✓	
<b>Option 2</b>				✓	

### ***Recommendation***

The preferred option for remediation of fish passage at this 45km reach is the construction of a vertical-slot fishway (Option 1). This would ensure the provision of unimpeded passage for a greater number, size and species of native fish. However, this could potentially be the most expensive option. Further investigation and consultation with fishway experts and engineers would be required to ensure designs were technically sound.

### ***Benefits Associated with Remediation***

The Gwydir River provides 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 Boolooroo Weir on the Gwydir River would open up access to over 30km of potential fish habitat. This could be further increased if fish passage is addressed at Tareelaroi Weir, Tyreel Regulator, Tyreel Weir and other weirs located in the Gwydir catchment.

## **GLENARBON WEIR, DUMARESQ RIVER**



**Figure 1.** Glenarbon Weir, Dumaresq Riverview from the right bank (0.0ML/day).

### ***Description and Setting***

Glenarbon Weir is situated within the locality of Glenarbon, accessible via a gazetted road through farm land from the QLD side of the border. The weir is on the mainstem Dumaresq River located in the Middle Macintyre catchment, approximately 11km downstream of Cunningham Weir and 57km from the confluence of the Dumaresq River with the Macintyre River. The weir is a fixed crest, steel sheet piling structure that is back-filled with concrete. Measuring 60 metres along its crest and standing approximately 2 metres high, Glenarbon Weir pools water over 4km upstream at depths of approximately 0.5-1.5 metres, resulting in a total submerged area of 28.3ha and a storage capacity of 353ML. The weir currently has an ineffective pool-type fishway (Figure 2). A stepped vertical fall over the weir creates a “waterfall effect”, restricting fish passage due to this excessive headloss (200cm) and increased turbulence, prior to structure drown out, (which occurs when the water level exceeds 246.89 metres EL).

Prioritisation of weirs in the Border Rivers Gwydir CMA region highlighted Glenarbon Weir as a high remediation priority within the Border Rivers Gwydir CMA due to the following factors:

- The Dumaresq River is a Class 1 fish habitat, supporting a diverse range of habitat types and native fish species including: vulnerable silver perch (*Bidyanus bidyanus*), threatened Murray cod (*Maccullochella peelii peelii*), and endangered populations of olive perchlet (*Ambassis agassizii*) and purple spotted gudgeon (*Mogurnda adspersa*);

- The Dumaresq River is included in the Endangered Aquatic Ecological Community of the Lowland Darling River catchment (Section 4 of the *Fisheries Management Act 1994*);
- Approximately 11km of unimpeded habitat is available upstream of the weir for fish passage;
- Instream habitat along the Dumaresq River is considered in medium to good condition; and
- The low number of significant barriers to fish passage on the Dumaresq River.



**Figure 2.** Pool-type fishway, Glenarbon Weir.

### ***Hydrology***

The flows within the Macintyre catchment are largely controlled by Glenlyon Dam. With a capacity of 253,000ML the dam provides regulated flows for irrigation, stock, town and industrial purposes to users as far as Mungindi Weir. Glenarbon Weir is located on the Dumaresq River, within the Campbells Creek subcatchment of the Macintyre catchment, a major tributary of the Darling – Barwon River system. The total catchment area upstream of the weir is 9194km<sup>2</sup>, approximately 19% of the total Border Rivers Catchment area. Upstream of the weir pool, the Dumaresq River ranges from 10-18 metres wide, with depths generally between 0.5-1 metres.

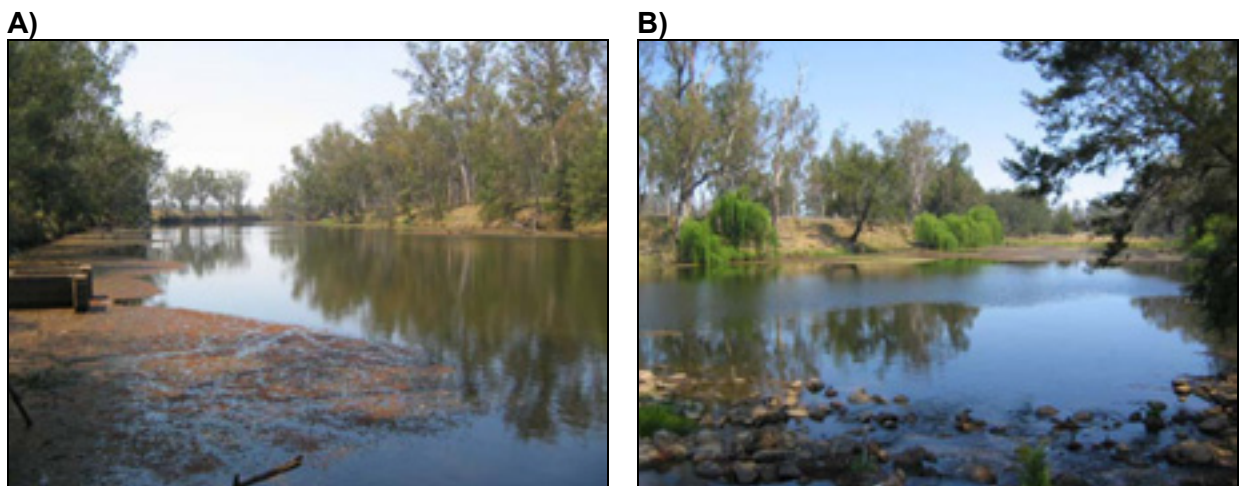
Hydrological flows for the Dumaresq River referred to in this report were determined from DNR river gauge #416040 located immediately downstream of this weir site and sourced from the DNR website and staff members of SunWater. Flows within the Dumaresq River are dictated by rainfall levels in the upper reaches of the catchment and regulated water release from Glenlyon Dam. Flow is fairly continuous over the crest of Glenarbon Weir, with structure drownout occurring when water levels exceed full supply level (FSL) at EL 246.89 metres.

### **Operational Details**

Glenarbron Weir was constructed in 1959 for irrigation purposes. The weir is now owned by the Border Rivers Commission and operated and maintained by SunWater. Maintenance, including removal of debris, and opening of the two siphon outlets (for up to a week at a time) occurs 3 to 4 times a year. The weir is still used for its original irrigational purposes. Additionally, the weir pool is used for recreational purposes, specifically by local fishing groups.

### **Ecological Considerations**

Glenarbron Weir (AMTD 57km) is one of three weirs located on the mainstem Dumaresq River below Glenlyon Dam. Cunningham Weir (AMTD 67.9km) and Bonshaw Weir (AMTD 126km) are both barriers to fish passage and have been assessed as part of this review. Cunningham Weir is a decommissioned structure in severe disrepair and currently under review for possible removal due to concerns over public safety or remediation options with regard to fish passage. Bonshaw Weir, although a working structure, has been mentioned for review with regards to use in the future. The remediation of fish passage at these structures and Glenarbron Weir could potentially open up approximately 200km (not including tributaries) of unimpeded habitat for native fish species.



**Figure 3.** Dumaresq River A) upstream and B) downstream of Glenarbron Weir.

The riparian areas adjacent to the weir are moderately vegetated with a variety of pasture grasses, blue gums (*Eucalyptus tereticornis*), common reeds (*Phragmites australis*) and casuarinas. This vegetation proffers stabilisation to the banks adjacent to, upstream and downstream of the structure, aiding in erosion prevention. The introduced weeping willow (*Salix babylonica*) is also present upstream and below the structure (Figure 3). Nuisance aquatic weeds are a recurring issue within the weir pool. At the time of study a large mass of ferny azolla (*Azolla pinnata*) and hornwort (*Ceratophyllum demersum*) was observed immediately upstream up the structure (as shown in Figure 3), colonising approximately 20% of the visible weir pool.

The river banks along the weir are unfenced, allowing stock regular access to the river and disturbing the banks and vegetation. The river bed downstream of the structure is stable. However, there has been a gradual accretion of silt immediately behind the weir, causing a change in bed level between the upstream and the downstream side of approximately one metre.

### **Proposed Remediation Actions**

Glenarbon Weir is regularly “over topped”, while large flood events historically occur 2 to 3 times a year resulting in structural “drown-out” of the weir. However, water levels for the majority of the year are not sufficient for fish passage requirements, thus prompting the following recommendations for improving fish passage.

- **Option 1** – Retrofit existing fishway with Denil insert

The current condition of the existing vertical-slot fishway and excessive headloss of 200cm represents a significant barrier to fish passage. There is anecdotal evidence of small fish species or juveniles using the fishway. Consequently, the opportunity exists to utilise this existing fishway structure. However, modification of the structure would be required to allow adequate fish passage for a larger range of fish sizes over a greater range of flows. This improvement could possibly be achieved with a prefabricated denil insert. However, the following criteria would need to be met:

- the site has a 1:12 slope;
- sufficient stream flow of at least 44ML/day would need to be maintained;
- low variation in headwater; and
- well-designed trash racks and covers on the channel.

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

The removal of the existing vertical-slot fishway and the construction of a new fishway redesigned to comply with NSW DPI policy and guidelines for fish passage may be an option. This option would be the most expensive; however, due to the low height of the structure a rock-ramp fishway design could be considered as an alternative to the vertical-slot fishway design.

### **Projected Remediation Costs**

Projected cost	< \$50 K	\$50K - \$150K	\$150K - \$250K	\$250K - \$500K	> \$500K
Option 1			✓		
Option 2				✓	

### **Recommendation**

Retrofitting the existing vertical-slot fishway and re-establishing fish passage to over 80km is the most cost effective option. However, concerns have been raised concerning the criteria required for efficient fish passage through Denil inserts, therefore Option 2 – the construction of a new vertical-slot fishway is the preferred option.

### ***Benefits Associated with Remediation***

The Dumaresq River provides 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 Glenarbon Weir on the Dumaresq River would open up access to approximately 11km of potential fish habitat. This could be further increased if fish passage is addressed at the weirs located upstream of this site; Cunningham Weir and Bonshaw Weir.

## 6. REFERENCES

- Baumgartner, L.J. (2005). *Effects of Weirs on Fish Movements in the Murray – Darling Basin*. Thesis Submitted for the Degree of Doctor of Philosophy. University of Canberra, Canberra, Australia.
- Baumgartner, L.J., Reynoldson, N. and Gilligan, D.M. (2006). Mortality of larval Murray cod (*Maccullochella peelii peelii*) and golden perch (*Macquaria ambigua*) associated with passage through two types of low-head weirs. *Journal of Marine and Freshwater Research*. 57: 187-191.
- Fairfull, S. and Witheridge, G. (2003). Why do fish need to cross the road? Fish passage requirements for waterway crossings. NSW Fisheries, Cronulla, 16pp.
- Gehrke, P.C. and Harris, J.H. (2001). Regional-scale effects of flow regulation on lowland riverine fish communities in New South Wales, Australia. *Regulated Rivers: Resource Management*. 17: 369-391.
- Gehrke, P.C., Gilligan, D.M., and Barwick, M. (2001). Fish communities and migration into the Shoalhaven River: before construction of a fishway. NSW Fisheries Final Report Series, no. 26.
- Harris, J., Edwards, E., and Curran, S. (1992). Bourke Weir fish passage study. NSW Fisheries Research Institute unpublished report, Sydney.
- Mallen-Cooper, M. (1994). Swimming ability of adult golden perch, *Macquaria ambigua* (Percichthyidae), and adult silver perch, *Bidyanus bidyanus* (Teraponidae), in an experimental vertical slot fishway. *Australian Journal of Marine and Freshwater Research*. 45: 191-198.
- Mallen-Cooper, M. (2000). *Review of fish passage in NSW*. Fishway Consulting Services, St. Ives Chase.
- Marttin and Graaf (2002). The effect of a sluice gate and its mode of operation on mortality of drifting fish larvae in Bangladesh. Management and Ecological Note. *In: Fisheries Management and Ecology*. 9: 123 – 125.
- NSW Fisheries (2002). Initial weir and floodgate review. Report for the State Weir Review Committee. NSW Fisheries, Ballina.
- NSW Fisheries (2003). Policy and guidelines for fish friendly waterway crossings. Fishnote Series NSW1181, NSW Fisheries, Cronulla NSW.
- Pethebridge, R., Lugg, A., and Harris, J. (1998). Obstructions to fish passage in New South Wales south coast streams. Final Report Series 4, Cooperative Research Centre for Freshwater Ecology and NSW Fisheries, Cronulla, NSW.
- Smith, A.K, and Pollard, D.A. (1998). Policy and guidelines. NSW Fisheries Office of Conservation, Sydney. 76 pp.
- Thorncraft G.A. and Harris J.H. (1996). Assessment of rock-ramp fishways. Report for the Environmental Trusts, NSW Environmental Protection Authority, Border Rivers Commission, Department of Land and Water Resources, and Wyong Council. Fisheries Research Institute, Cronulla.

Thorncraft, G. and Harris, J.H. (2000). Fish passage and fishways in NSW: A status report. Cooperative Research Centre for Freshwater Ecology Technical Report 1/2000.

Williams, R.J., Watford, F.A. and M.A. Taylor (1996). *A summary of aspects of FRDC project 94/041 "Restoration of estuarine fisheries habitat" relevant to tidal obstructions in New South Wales estuaries*. NSW Fisheries Research Institute, Cronulla, NSW, 109pp.

## 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  modification  replacement   
maintenance

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 register 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						
<b>A) STREAM HABITAT VALUE</b>						<b>SCORE</b>
<b>Primary aquatic habitat rating</b>						
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>B) STRUCTURE IMPACT CRITERIA</b>						
<b>Environmental effect rating</b>						
Physical barrier: Headloss	> 2000 mm	1000 - 2000 mm	500 – 1000 mm	100 - 500 mm		
Drown out frequency per annum	> 4	2 - 4	1			
<b>SECONDARY PRIORITISATION</b>						
<b>C) ENVIRONMENTAL CRITERIA</b>						
<b>Secondary aquatic habitat rating</b>						
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			
<b>D) MODIFICATION CRITERIA</b>						
<b>Structure use and remediation cost</b>						
Maintenance Required	Yes		No			
Redundant Weir	Yes		No			
Ease of Remediation	Removal	Modification	Fishway installation			
Ancillary uses	Flood mitigation	Bed Control	Recreation			
					<b>TOTAL</b>	

**Appendix C: Weir Prioritisation Scheme for NSW Inland CMAs**

INITIAL PRIORITISATION						
<b>A) STREAM HABITAT VALUE</b>						<b>SCORE</b>
<b>Primary aquatic habitat rating</b>						
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>B) STRUCTURE IMPACT CRITERIA</b>						
<b>Environmental effect rating</b>						
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		
<b>SECONDARY PRIORITISATION</b>						
<b>C) ENVIRONMENTAL CRITERIA</b>						
<b>Secondary aquatic habitat rating</b>						
Instream habitat condition	Good		Fair		Poor	
Riparian condition	Good		Fair		Poor	
Threatened species	Habitat Class 1-2		Habitat Class 3		None	
<b>D) MODIFICATION CRITERIA</b>						
<b>Structure use and remediation cost</b>						
Redundant Weir	Yes			No		
Ease of Remediation	Removal		Modification		Fishway installation	
						<b>TOTAL</b>

