BRINGING BACK THE FISH – IMPROVING FISH PASSAGE AND AQUATIC HABITAT IN COASTAL NSW

FINAL REPORT

TO THE

SOUTHERN RIVERS CATCHMENT MANAGEMENT AUTHORITY

NSW GOVERNMENT Industry & Investment

Australian Government

Southern Rivers CMA CATCHMENT MANAGEMENT AUTHORITY

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EXECUTIVE SUMMARY

"With the spread of the movement for water conservation, more and more dams will be erected, until there will be many hundreds of such throughout the length and breadth of the land. Without the provision of fish-passes there is a grave danger of fish fauna being cut up into isolated colonies…"
(NSW Department of Fisheries 1913)

Nearly 100 years ago the NSW Department of Fisheries recognised the importance of fish migration and the potential for the proliferation of instream structures to impact on the health of fish populations. Since this time, as our knowledge of the native fish fauna has grown, we have witnessed the deleterious impact of poorly designed weirs, road crossings, and floodgates; and have realised that their effect is far greater than first postulated.

Stream connectivity and habitat diversity are critical components of healthy waterways, with many native fish having evolved to be reliant on a variety of different habitat types throughout their life cycle. The free passage of fish within rivers and streams and between estuarine and freshwater environments is therefore a critical aspect of aquatic ecology. Understanding that the majority of native Australian fish need to migrate at some stage during their life, and that their swimming abilities differ significantly from Northern hemisphere species, has led to current policies and legislation that require the incorporation of fish passage into the design of all new instream structures as originally suggested in 1913. Unfortunately, a legacy of poorly designed structures continues to detrimentally affect migratory fish communities.

The Bringing Back the Fish Project was designed to address 75 priority fish passage barriers and 5 key fish habitat sites within the five NSW coastal Catchment Management Authority (CMA) regions. The $3 million project was funded by the Federal Government and administered through the Southern Rivers CMA, with Industry and Investment NSW managing project deliverables.

The Bringing Back the Fish Project resulted in improved migratory fish access to 1,235 km of additional waterway in coastal NSW through the remediation of 94 priority sites including 10 weirs, 22 road crossings, and 54 floodgates. Native fish populations also benefitted from aquatic habitat rehabilitation projects that improved core habitat health to 1,907 ha at 8 sites using innovative techniques including seagrass friendly moorings and bank stabilising rock fillets. The Bringing Back the Fish project provided approximately $2.5 million towards the completion of onground works; with in-kind funding from project partners approaching $4.5 million and total project expenditure being $9 million.

The Bringing Back the Fish project provides a successful model for fish passage and aquatic habitat remediation in NSW. The 3 year project time frame along with adequate seed funding allowed high priority fish passage barrier sites to be addressed. The networks formed, education activities undertaken, and fish passage design options demonstrated will guide future remediation projects within NSW. Moreover, capacity built by the project through education activities and enhanced relationships are already proving fruitful, with a number of priority fish passage barrier sites being addressed beyond the scope of the Bringing Back the Fish project.

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GLOSSARY

Anadromous: type of migration where species live primarily in saline environments and migrate to freshwater to breed.

Amphidromous: type of migration where species migrate between fresh and saline environments, but not for the purposes of breeding.

Base flow: 'average' or regular flows in a waterway – non flooding flows.

Catadromous: type of migration where species live primarily in freshwater and migrate to saline environments to breed.

Head differential: (also known as headloss) refers to the difference in elevation between the water level downstream and upstream of the structure.

Hydraulic: operated by the pressure created by forcing water through a comparatively narrow orifice.

Hydrologic: the properties of the waters.

Lentic: still water

Lotic: flowing water

Migratory/migration: movement of a large proportion of a population between two or more distinct habitats with a regular pattern.

Monosulphidic black ooze (MBO): formed when sulphate reducing bacteria break down accumulated organic matter in an environment of low or no oxygen. Hydrogen sulphide gas ("rotten egg gas") is produced and causes soluble iron and monosulphides to precipitate. When exposed to oxygen, these oxidise, releasing the sulphate component and oxidised iron.

Perched: where the base of the culvert is elevated above the stream bed.

Potomodromous: type of migration where species live entirely in freshwater, undertaking movements to breed, but remaining within the freshwater.

Riparian: any vegetation on land that adjoins, directly influences or is influenced by a body of water.

ACRONYM LIST

ASS: Acid sulphate soils

DECCW: Department of Environment, Climate Change and Water

LGA: Local government area

LPMA: Land and Property Management Agency

MBO: monosulphidic black ooze (see above)

NRM: Natural resource Management

REF: Review of Environmental Factors

STP: Sewage Treatment Plant

SWC: State Water Corporation

TAMP: Total Asset Management Plan

NRCMA: Northern Rivers Catchment Management Authority

HCRCMA: Hunter / Central Rivers Catchment Management Authority

HNCMA: Hawkesbury – Nepean Catchment Management Authority

SMCMA: Sydney Metropolitan Catchment Management Authority

SRCMA: Southern Rivers Catchment Management Authority

1 INTRODUCTION

1.1 Fish passage in NSW

Within flowing waterways, Australian native fish have evolved to be reliant on a variety of habitat types to complete their life cycle, thereby requiring free movement within rivers and streams and between estuarine and freshwater environments. Of the 55 freshwater species found in New South Wales, 32 are considered 'migratory' as defined by the movement of a large proportion of a population between two or more distinct habitats with a regular pattern (Thorncraft and Harris 2000; Northcote 1978). However, all fish species display the inclination to move between varying aquatic environments (Barrett, 2008).

While fish migrations are commonly associated with breeding events, additional motivations for species to disperse include the search for food and shelter, and the avoidance of predation and competition pressures. Unfortunately, riverine connectivity has been severely disrupted within Australia by the proliferation of instream barriers to migratory fish that limit habitat and resource availability and threaten the fitness of species to adapt to changing environmental conditions (Pethebridge et al. 1998; Gehrke et al. 2002).

Due to these impacts, the installation and operation of instream structures, and the alteration of natural flow regimes, have been recognised as *Key Threatening Processes* under the *Fisheries Management Act 1994* (FM Act) and the *Threatened Species Conservation Act 1995*. Additionally, current policy within NSW legislates for the incorporation of fish passage into the design of all new waterway crossings; however, a legacy of poorly designed structures exists that detrimentally affects native fish. Starting in the late 1990's, NSW Fisheries (now Industry & Investment NSW) initiated extensive audits of fish passage barriers across the State that encompassed weirs, dams, road crossings, and floodgates, with over 5,000 structures being identified as barriers to migrating fish.

1.2 Fish Passage Barriers

Australian fish are generally poor swimmers and jumpers, especially when compared to their northern hemisphere counterparts (Mallen-Cooper 1992). As a result, structures such as weirs, dams, gauging stations, road crossings, levees, and floodgates can act as physical, hydrological, and/or behavioural barriers to migrating fish. The vertical walls of dams and weirs are the most commonly perceived barriers to migrating fish due to the creation of excessive head differential[1], otherwise known as the 'waterfall effect'. Hydrological barriers resulting from poorly designed fishways and culverts further impede migrating fish due to excessive water velocity and turbulence that limit a fish's ability to successfully ascend the structure (Vidler and Wardle 1991, Mallen-Cooper 1994).

Changes in habitat features associated with instream structures may also present behavioural barriers to migrating fish. Species that are able to pass into weir reservoirs may find the pooled, still water system unsuitable due to the loss of critical 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 downstream of weirs can also deter migrating fish (Gehrke et al. 2001).

[1] Head differential (also known as headloss) refers to the difference in elevation between the water level downstream and upstream of the structure.

The location of instream structures within the catchment is another factor determining the impact of barriers on fish. Structures located lower in the catchment often drown out several times a year when rising water levels overcome head differential barriers, 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.

Despite higher frequencies of drownout, structures located lower in the catchment are generally viewed as a higher priority due to the increased impact they have on juvenile fish. After spawning in the estuary, juvenile catadromous[2] species such as the iconic Australian Bass (*Macquaria novemaculeata*) will attempt to move upstream into freshwater habitats. On doing so, when an instream structure is encountered, they are forced to accumulate below the structure until flow conditions permit migration past the overtopped barrier. However, such drownout events rarely coincide with a species' migrational timing, leading to increased exposure to predation and the potential loss of a population cohort.

1.2.1 Weir and Dams

In NSW alone, over 4,000 licensed weirs and dams occur on rivers and streams (NSW Fish Passage Barrier Inventory), with two general classifications being applied based upon their design: fixed crest or adjustable release (Fig. 1.2.1). Fixed crest 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 relatively minor impacts on 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[3] habitat.

A. **B.**

FIGURE 1.2.1: Fixed crest weirs (A) inhibit fish migration primarily through excessive head difference (physical blockage), while adjustable release weirs (B) can also act as hydrological barriers (e.g. high water velocity). Adjustable release weirs (B) allow the regulation of downstream water flows.

[2] Catadromous – Species that live primarily in freshwater and migrate to saline environments to breed.
[3] Lotic - flowing

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 a greater range of 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 head differential) or hydrological barriers (high water velocity).

1.2.2 Road Crossings

'Road crossing' is a collective term for bridges, roads, causeways, culverts and other similar structures. The extent to which waterway crossings impact on the migration of fish in waterways can depend on a) the design of the waterway crossing structure; b) the nature of flow, debris and sediment movement in the waterway; and c) the swimming capabilities of resident fish.

In general, **bridges** and **arch structures** promote natural, unimpeded stream flow, allowing the free movement of fish underneath the structure during a wide range of hydrological conditions (Fairfull and Witheridge, 2003). However, bridges that are built too low, or whose piers and footings constrict the channel, can affect hydrological flows (e.g. excessive velocity) or collect debris that create physical blockages (Fig. 1.2.2 A).

Culverts are waterway crossings with round or box-shaped cells, designed to convey flow beneath the roadway (Fig. 1.2.2 B-C). Culverts can result in significant modification to channel bed form and flow conditions due to increased flow velocities, turbulence and reduced flow depth through the structure. Fish passage at culverts is inversely related to flow velocity (Warren and Pardew 1998), with velocities as low as 0.35 ms^{-1} displaying significant impacts on migration success (MacDonald and Davies 2007). Additionally, culvert crossings often display perched outlets (Fig. 1.2.2 C) which result in excessive head differential (i.e. > 100 mm) at base flows that act as a physical migration barrier.

Low-level crossings such as **causeways** are generally constructed at or near bed-level and are designed to convey water across the road surface as sheet flow (Fig. 1.2.2 D). Although causeways drownout relatively quickly, fish passage is often obstructed due to excessive head differential formed on their downstream side and shallow flow depth (< 100 mm). In some cases, causeways may possess low-flow culverts beneath the roadway that can further restrict fish passage as outlined above.

1.2.3 Floodgates

Floodgates are one-way hinged flap structures (Fig. 1.2.3) that seal against a near-vertical face, and are commonly found on coastal floodplain drainage systems that were constructed to promote agricultural opportunities. A number of natural creek systems have also been floodgated. Floodgates function to prevent saline tidal water from inundating low-lying agricultural land, as well as to avert river rises from back-flooding urban and rural areas (Johnston et al., 2003). The passive design of the majority of floodgate structures presents an obvious physical barrier that directly impacts fish passage between estuaries and tidal tributaries, especially when the hinged flap is in the closed position (Fig. 1.2.3 B). Even when gates are opened, water quality attributes including low pH, temperature differentials, and low dissolved oxygen levels can further deter migrating fish from entering a drain (Gehrke et al. 2001).

FIGURE 1.2.2: Road crossing barriers to migrating fish include A) bridges, B) pipe culverts, C) box culverts and D) causeways. Barrier types demonstrated in the photos include debris accumulation (A), high water velocities (B), excessive head differential (C-D), and shallow flow depths (C-D).

Additional impacts of floodgates and associated drainage works include the fragmentation and degradation of wetland habitat, the reduction of water quality, and the potential exposure of acid sulphate soils (ASS). In order to improve agricultural productivity, extensive drainage channels were constructed on floodplains to reduce periods of inundation. Unfortunately, these drains resulted in the loss or isolation of significant wetland areas that act as vital habitat for the recruitment and growth of estuarine fish species. Floodgates also restrict water exchange which impacts directly on water quality parameters. Stagnant water that is often found behind floodgates encourages the accumulation of organic matter, thereby promoting high nutrient levels, episodic algal blooms, and the formation of monosulphidic black ooze (MBO). Drainage networks associated with floodgates are also characterised by low pH levels from ASS drainage (Johnston et al., 2003). Acidification occur when natural sulphidic sediments in the floodplain that are close to the ground surface are exposed to air and oxidised as a result of drain construction (Wilson et al., 1999). The resulting ASS discharge enters the waterway either through groundwater seepage or surface run-off, resulting in detrimental effects within the drain and associated receiving waterways.

A.

B.

FIGURE 1.2.3: Floodgate design typically incorporates a hinged flap design (A), that presents a physical blockage to migrating fish when maintained in the closed position (B).

1.3 Fish Passage Remediation Options

1.3.1 Weirs

The first attempt to remediate fish passage in NSW was in 1913 in Sydney with the construction of a fishway at Audley Weir (NSW Department of Fisheries 1913). Fishways (also known as fish ladders) are the primary remediation option for low level weirs (< 6 m high), and function by allowing species to negotiate excessive head differentials by providing a series of small hydraulic rises and resting pools that allow fish to "step" their way up and over the barrier. Fishways can take numerous forms depending on the hydraulic characteristics of the water, the fish fauna present, structure location, geomorphic characteristics, and budget constraints. Appendix G provides an explanation of the most common fishway designs.

Where a weir is no longer providing a significant benefit to the owner or user, the structure can be considered for removal, taking into consideration the environmental impact of such action. Removal of redundant weirs is supported by the *NSW Weirs Policy (1997)* whose goal is to "halt and, where possible, reduce and remediate the environmental impact of weirs."

1.3.2 Road Crossings

Despite representing the majority of fish passage barriers in Australia, the impact of road crossings on fish migration was generally overlooked for most of the 1900's with weirs and dams receiving the primary attention. Starting with the *Fisheries Management Act (1994*), guidelines were developed to detail fish friendly design principles for road crossings (see Fairfull and Witheridge 2003 and Appendix F). Recommended road crossing designs for fish passage depend on a range of factors including location in the catchment[4], stream order[5], and waterway class[6].

4 Generally the provision of fish passage at waterway crossings located lower in the catchment will be more important than sites in the upper catchment.
5 Refer to Appendix F
6 Refer to Appendix F

Where fish passage at an existing road crossing barrier is determined to be a priority, one option is to redesign the structure. Channel spanning bridges are the preferred design option for ensuring unimpeded fish passage. In general, bridges promote natural, unimpeded stream flow, thereby allowing the free movement of fish underneath the structure during a wide range of hydrological conditions (Fairfull and Witheridge, 2003). Additionally, box culverts can be considered for Class 2 or Class 3 waterways (see Appendix F). Design consideration should be given to the size of the waterway area, height of approaching abutments, and hydrological flow conditions when determining the number and size of box culvert cells to incorporate into the crossing. In all cases, the culvert should be designed to maximise the geometric similarities of the natural channel profile. Low-flow box culvert cells should be considered in the design to pool water during base flows to ensure adequate depth (0.5 m ideally) through the crossing.

Due to changes in river geomorphology, the design of some culvert and causeway crossings cannot be altered due to bed stability concerns. In order to address fish passage at such crossings, fishways as discussed above for weirs need to be considered (see Appendix G). Where no bed stability concerns exist, and the road crossing is obsolete, the structure should be considered for removal, taking into consideration the environmental impact of such action.

1.3.3 Floodgates

The main remediation option to assist fish passage at floodgate structures is the initiation of active floodgate management. Active floodgate management involves the controlled opening of floodgates during non-flood periods to allow tidal water exchange in the drainage system. This form of management usually requires the modification of floodgate structures to allow efficient opening and closing of gates, whilst still allowing for the normal drainage of low-lying land and the control of water levels. The primary design options used to actively manage floodgates on coastal floodplains include auto-tidal floodgates, ‘smart gates’, sluice gates, and winch gates. A description of each of these forms of active management is presented in Appendix H.

Where a floodgate is facilitating the drainage of ASS, and fish passage is not a priority, drain shallowing (i.e. raising the drain invert) can be considered to reduce ASS oxidation and discharge into receiving waterways. Drain shallowing can coincide with drain widening in order to maintain existing drainage capacities. These works can be complimented by various designs of water control structures that maintain high groundwater levels, further limiting the oxidation of acid sulphate soils.

1.4 Aquatic Habitat Health

Maintaining and promoting healthy habitats is equally important to reinstating stream connectivity in ensuring sustainable native fish populations. The distribution, abundance, and diversity of fish species is positively correlated to the quality and quantity of habitat available. Therefore, the protection and rehabilitation of aquatic and riparian habitats is a key requirement to maintaining viable fish stocks in NSW.

2 PROJECT SCOPE & OBJECTIVES

Starting in the late 1990's, I&I NSW (formerly NSW Fisheries and NSW Department of Primary Industries) initiated extensive audits of fish passage barriers in coastal NSW that contributed to the development of priority lists of fish passage barriers requiring remediation. Although remediation works to address migrational barriers and aquatic health issues were completed as part of these previous programs; the scope, timing, and level of funding provided limited key priority sites from being addressed.

The primary aim of the Bringing Back the Fish Project was to enhance aquatic ecosystems across the five NSW coastal Catchment Management Authority regions by restoring stream connectivity and rehabilitating key aquatic habitats. Using the prioritisations developed previously, priority instream barriers in each coastal CMA region were targeted for modification to improve fish passage. In addition, rehabilitation of key aquatic habitats was undertaken in each region to assist migratory fish communities. Over a three year period, the project aimed to:

- Remediate (modification, removal, or fishway installation) 10 priority weirs to enhance fish migration (2 / CMA).
- Improve fish passage through structural redesign or removal at 20 road crossings (4 / CMA).
- Modify and improve management of 45 floodgates in coastal NSW to provide improved fish passage and/or aquatic health.
- Rehabilitate 5 key habitat sites (1/CMA).
- Improve fish access to greater than 1000 km of stream length.
- Enhance habitat quality (250 ha) through activities including floodgate management, wetland reinundation, riparian revegetation, and Large Woody Debris insertion (LWD).
- Engage the commercial fishing industry and recreational fisheries in regional NRM program delivery.
- Complete an extended monitoring program at 5 key rehabilitation sites – 2 weirs (fishway and one other site), 1 road crossing, 1 floodgate, and 1 rehabilitated habitat site.

3 PROJECT METHODOLOGY

3.1 Barrier Audits and Site Prioritisation

Following preliminary investigations by Williams et al. (1996), Pethebridge et al. (1998), Thorncraft and Harris (2000), and NSW Fisheries (2002); extensive audits of fish passage barriers along coastal NSW were completed during the following projects:

- Initial Weir and Floodgate Review (2002)
- Reducing the Impact of Weirs on Aquatic Habitat - NSW Detailed Weir Review (2006)
- Reducing the Impact of Road Crossings on Aquatic Habitat in NSW Coastal Waterways (2006)
- Sydney Metropolitan CMA – Reviewing and Restoring Fish Passage in Urbanised Waterways, Sydney Catchments (2006)
- Stream Health: Road Crossings & Fish Passage – Mid North Coast New South Wales (2005)

- River Health: Fish Passage & Road Crossings – Upper North Coast, New South Wales (2005)
- Reducing the Impact of Road Crossings on Aquatic Habitat in Coastal Waterways – Northern Rivers, NSW. (2005)
- North Coast Floodgate Project (2004)

However, a detailed assessment of floodgates outside of the Northern Rivers CMA region was lacking at the start of the Bringing Back the Fish Project. As such, funding was provided during the first year of the project to identify and prioritise floodgates for remediation in the southern NSW coastal catchments (NSW Department of Primary Industries 2007a).

The audits identified over 3000 fish passage barriers in coastal NSW, with the findings of these investigations inserted into the *NSW Fish Passage Barrier Inventory* – a database of weirs, dams, roads, and floodgates that require remediation from a fish passage or aquatic habitat perspective. Natural barriers to migrating fish (e.g. waterfalls) were also included in the Barrier Inventory, as their location can significantly influence the prioritisation of nearby man-made obstructions.

Given the magnitude of barriers identified in the audits, a prioritisation process was conducted to determine regional (CMA) priorities based primarily on the structure's impact on fish passage (e.g. weir height), the location of the barrier in the catchment, and surrounding environmental conditions (e.g. Habitat Class). Within each barrier type (i.e. weirs, roads, and floodgates), the prioritisation process provided numerical rankings as well as a priority status – High, Medium-High, Medium, Medium-Low and Low.

3.2 Priority Site Selection & Remediation

Synthesis of previous aquatic habitat and fish passage work across the NSW coast provided a list of priority sites for remediation within each CMA region. As the structural audits utilised a rapid assessment technique, numerical rankings were used primarily as a guide, with greater emphasis placed on the priority status of the structure (i.e. High vs. Low). As such, I&I NSW primarily focussed initial investigations on High and Medium-High priority ranked barriers. When opportunities arose, Medium priority sites were also considered when the expenditure (funding and time) justified the outcome (e.g. removal of obsolete causeway). Low or Medium-Low priority barriers were not considered for the project. Where new sites were identified during the project, the barriers were inserted into the database and their priority status was calculated.

Initial priority sites were highlighted to CMAs and associated regional steering committees during the project's first six months. Following initial discussions with the steering committees, relevant asset owners / managers (e.g. local councils, private landholders) were contacted to commence dialogue as well as to determine future capital work programs. Following favourable discussions, detailed sites assessments were initiated to identify and address complex environmental, social, cultural, and economic considerations including:

- Waterway bed level surveys
- Geomorphic investigations of creek bed and bank stability
- Flora and fauna assessments with emphasis on threatened species
- Fish passage / fishway assessments
- Hydrology and tidal modelling
- Cadastral surveys

- Landholder / community attitude surveys
- Heritage assessments (European and Aboriginal).

Some priority sites initially tabled to the regional steering committees were eventually excluded from further consideration due to factors including lack of stakeholder support, limited funding, inadequate timeframes, or reduced priority status (e.g. a new barrier being identified within close proximity). However, select sites were determined to be viable options for further consideration. Site assessment results were presented to the regional steering committees for discussion, with agreement being reached on priority site selection. I&I NSW then approached relevant stakeholders to develop formal agreements concerning designs, project funding, and contractor engagement.

Statutory authorisation was obtained for sites prior to the initiation of on-ground works, generally in the form of a Review of Environmental Factors (REF). Although site dependent, additional permits and documentation included:

- Part 7 Permit under *Fisheries Management Act (1994*)
- Crown Lands Access Permit
- Office of Water concurrence for Controlled Activity Approval (DECCW)
- DECCW concurrence on threatened species, water quality and noise.
- Local council concurrence

With the start of on-ground works, the primary responsibility of I&I NSW was to ensure contractor compliance with design specifications and environmental mitigation measures. Site rehabilitation occurred where adjacent banks and access paths were disturbed during instream works. Finally, where possible I&I NSW monitored site adjustment and recovery to ensure that project benefits continued to be realised.

3.3 Role of Regional Steering Committee

Regional steering committees were convened in each CMA region, with representation comprised of members of the commercial fishing industry, recreational fishers, local government, State agencies (I&I NSW, CMA, DECCW), and community organisations. Steering committees assembled at least annually, with communication occurring between meetings as deemed necessary.

The role of the steering committees, particularly the commercial fishing industry and recreational fishing representatives, was to provide a regional perspective in the assessment of migrational barriers, including appraisals of a barrier's priority status as well as the identification of additional sites that may have been overlooked during the initial audits. Moreover, the steering committees assisted I&I NSW in short listing and approving priority sites for remediation based upon results from initial and on-going detailed investigations. Factors considered in the approval of priority sites included:

- Results of feasibility studies (e.g. bed surveys, designs),
- Proposed designs, budgets, and timeframes,
- Environmental assessments (e.g. Review of Environmental Factors),
- Acquisition of statutory approvals and matching contributions, and,
- Equitable and representative distributions of sites within CMA regions.

3.4 Project Communication

The ability to negotiate improved fish passage outcomes at priority barrier sites was dependent upon an effective project communications strategy. Communications during the first year of the project had three primary goals: promote the overarching objectives of Bringing Back the Fish, discuss opportunities at priority fish passage barrier sites, and identify additional priority barriers that were overlooked during the initial audits. Target audiences included local council asset managers, NRM representatives (CMAs, I&I NSW Conservation Managers), recreational and commercial fishermen, indigenous communities, Landcare groups, and the general public. Dissemination of project objectives occurred via a project brochure, workshops, seminar presentations, newsletters, magazine articles, natural resource conferences, radio interviews, and newspaper articles. Additionally, members of the regional steering committees conversed with their constituents to assist in identifying priority fish passage barriers.

Following initial site assessments and the selection of priority barriers requiring remediation, communication efforts shifted towards targeted stakeholder engagement including structural owners and adjacent landholders, respective local Councils, and relevant government agencies including the Office of Water (within the Department of Environment, Climate Change, and Water; formerly the Department of Water and Energy), Land Property Management Agency (formerly the Department of Lands), and Department of Environment, Climate Change, and Water (formerly the Department of Environment and Climate Change). Primary topics of consideration included structural design options, project costs and funding allocation, timing of on-ground works, and statutory requirements.

The final stage of the project involved the communication of on-ground outputs, primarily following the completion of remediation works. For larger projects, or sites with considerable community interest, communication outputs were produced prior to and during fish passage remediation. Media outlets utilised included television, newspapers, radio, newsletters, and the internet. Section 4.5 outlines project communications outputs.

4 PROJECT OUTPUTS

4.1 Project Remediation Outputs

The overarching aim of the project was the remediation of fish passage and aquatic habitat health at 80 priority sites along coastal NSW. The Bringing Back the Fish project resulted in the completion of rehabilitation works at 94 priority sites including 10 weirs, 22 road crossings, 54 floodgates, and 8 priority habitat sites (see Table 4.1). Additionally, migrating fish now have improved access to 1,235 km of coastal waterways through the remediation of instream barriers.

Of the 10 weirs remediated, four structures were removed providing permanent positive results to the migratory fish community. An additional four weir sites involved the insertion of fishways to assist migrating fish to ascend the barriers, while remediation works at the two remaining weirs (Lansdowne Weir, HCRCMA; and Ingleburn Weir, SMCMA) involved structural design adjustments. Improvement of fish passage at weirs resulted in the greatest output of stream length opened to fish passage compared to road crossings and floodgates.

TABLE 4.1: Remediation outputs delivered during the Bringing Back the Fish Project

STRUCTURE TYPE	EXPECTED OUTPUT	DELIVERED OUTPUT	KMS OPENED	KEY HABITAT IMPROVED (Ha)
WEIRS	10	10	611	0
ROADS	20	22	453	50
FLOODGATES	45	54	123	1,694
HABITAT	5	8	48	163
TOTAL	**80**	**94**	**1,235**	**1,907**

The primary road crossing remediation option employed during the Bringing Back the Fish project was the removal of obsolete structures (9). As with redundant weirs, road crossings that were no longer serving a defined purpose were removed to provide lasting benefits to migratory species, while also restoring natural hydrology and sediment regimes to the waterways. Alternatively where the structure could not be removed or redesigned due to social or environmental (e.g. bed control) considerations, fishways (8) were inserted. Finally, low-flow box culverts were inserted at the remaining 5 road crossing sites addressed during the project.

A total of 54 floodgates were remediated during the project. Traditional flapgates were replaced with modifications to enable controlled water flows upstream of the structure during non-flood periods. The majority of sites had tidally activated designs installed that enabled automated opening and closing of an aperture within the main floodgate (see Appendix C.) In some cases, the modified floodgate was complimented by the further installation of upstream structures to prevent the extra water in the drain from overtopping onto adjacent low-lying paddocks. At Mamboo Island, floodgates were replaced at a higher invert to maintain high groundwater levels, thereby improving upstream wetland values and reducing acid sulphate soil oxidation.

Remediation works were completed at 8 key fish habitat sites along the NSW coast, resulting in improved habitat condition to 1,907 ha (target 250 Ha). On-ground activities varied from site to site, demonstrating the full range of rehabilitation options available to freshwater and estuarine species. Works conducted in the lower Clarence Estuary (NRCMA) involved the insertion of a two cell box culvert structure into a 120 m long causeway to improve tidal flushing, water quality, and resident seagrass health; while works conducted at nearby Lake Wooloweyah resulted in the stabilisation of severely eroding banks through the insertion of rock fillet structure to assist mangrove recruitment. In Pittwater estuary (HNCMA) and Manly Cove, Sydney Harbour (SMCMA), a total of 67 seagrass friendly moorings were installed, enabling recolonisation of vital seagrass communities that form essential nursery grounds for estuarine species.

TABLE 4.2: Remediation outputs delivered during the Bringing Back the Fish Project by CMA region and structure type.

CMA REGION	WEIRS	ROADS	FLOODGATES	HABITAT	TOTAL
NRCMA	4	9	45	2	**60**
HCRCMA	3	5	4	1	**13**
HNCMA	0	3	1	2	**6**
SMCMA	3	2	0	2	**7**
SRCMA	0	3	4	1	**8**
TOTAL	**10**	**22**	**54**	**8**	**94**
TARGET	**10**	**20**	**45**	**5**	**80**

4.2 CMA Project Outputs

An overview of project remediation outputs delivered in each CMA region are presented in Table 4.2; while Appendix A – E provided detailed outcomes per site per CMA.

The majority (65 %) of remediation outputs occurred within the NRCMA, a result that is attributed to pre-existing relationships developed with structural stakeholders during previous road crossing (since 2004) and floodgate programs (since 2000). Such programs, which pre-dated the Bringing Back the Fish project, meant that partnerships and capacity were already developed, with structural owners having clear knowledge of remediation design options and management responsibilities. Alternatively, in southern CMA regions (HNCMA, SMCMA, SRCMA) such partnerships had to be developed during the first two years of the Bringing Back the Fish project, with stakeholder understanding and acceptance of remediation design options taking additional time to foster.

An additional explanation for the high percentage of remediation sites located within the NRCMA is attributed to the number of floodgates located within the region relative to other coastal CMAs. Due to landuse practices and size, the NRCMA displays over twice the number of floodgates compared to the remaining NSW coastal catchments. Between the HNCMA and SMCMA, only 11 floodgates were recommended for remediation, with the majority of these structures considered low priorities.

TABLE 4.2.1: NORTHERN RIVERS CMA PROJECT OUTPUTS

SITE NAME	CATCHMENT	STRUCTURE IMPACT*	REMEDIATION RANKING	REMEDIATION OUTPUT	PROJECT BENEFIT	SITE EXPENDITURE
WEIRS						
Manyweathers Weir	Richmond	HD (800 mm)	High	Removed obsolete weir	288 km	$165,241
Mullumbimby Ck Weir 2	Brunswick	HD (750 mm)	Medium-High	Removed weir, inserted rock-ramp fishway	9 km	$53,974
Hickeys Creek Weir	Macleay	HD (300 mm), WV	High	Removed obsolete weir	62 km	$51,105
Duroby Creek Weir	Tweed	WB, HD	High	Removed obsolete weir	10 km	$23,970
ROADS						
Old Lismore Rd Culvert	Tweed	HD (500 mm)	High	Low flow box culverts (4)	16 km	$153,930
Casuarina Lane Causeway	Clarence	HD (1100 mm)	High	Rock-ramp fishway & box culvert	96 km	$197,625
Stuarts Island Causeway	Nambucca	WB	High	Low flow box culverts (2)	1 km	$128,020
Lorne Road Obsolete	Camden Haven	WV	High	Removed obsolete crossing	15 km	$3,332
Houghlahans Ck Obsolete	Richmond	HD (200 mm), WV	High	Removed obsolete crossing	1 km	$2,936
Tucki Tucki Obsolete	Richmond	HD (1200 mm)	Medium-High	Removed obsolete crossing	7 km	$2,265
Lacks Ck Obsolete 1	Brunswick	FD, BE	Medium	Removed obsolete crossing	1 km	$1,232
Lacks Ck Obsolete 2	Brunswick	FD, BE	Medium	Removed obsolete crossing	3 km	$1,232
Upper Burringbar Rd Obsolete	Tweed	HD (750 mm)	Medium	Removed obsolete crossing	6 km	$1,780
FLOODGATES**						
Tweed (22)	Tweed	WB	--	See site review	43 km / 50 ha	$761,457
Richmond (6)	Richmond	WB	--	See site review	8 km	$121,000
Clarence (16)	Clarence	WB	--	See site review	50 km / 442 ha	$900,297
Macleay (1)	Macleay	WB	--	See site review	6 km / 571 ha	$561,880
HABITAT						
Clarence Estuary	Clarence	WB, BE	--	Low flow box culverts (2) & Lake Wooloweyah	7 km	$607,652
Vallances Road STP	Brunswick	WB, BE	--	Fencing, causeways, revegetation, rock fillets	1 km	$620,000
				TOTAL	**629 KM / 1,130 ha**	**$4,358,929**

* HD = Head Differential; WV = Water Velocity; WB = Waterway Blockage; FD = Flow Diversion; BE = Bank Erosion
** Numbers in parentheses indicate number of floodgates remediated per catchment

4.2.1 Northern Rivers CMA

A total of 60 priority sites representing 4 weirs, 9 road crossings, 45 floodgates, and 2 key habitat sites were remediated in the NRCMA region. Overall, remediation of priority sites within the NRCMA has reinstated access to 629 km of upstream fish habitat, and improved the condition of 1,130 ha of key habitat. Table 4.2.1 summaries site deliverables within the region, while individual site based reports appear in Appendix A that detail remediation works, project benefits, associated costs, and project partners. Additionally, before-after pictures are provided along with GIS maps that detail the location of remediated structures relative to surrounding fish passage barriers.

Of the four weirs remediated in the NRCMA, three were owned by NSW State Water Corporation (SWC). While undertaking Total Asset Management Plans (TAMP), SWC deemed Manyweathers Weir, Mullumbimby Creek Weir 2, and Hickeys Creek Weir as financial, legal, and environmental liabilities. A partnership was developed between I&I NSW and SWC where I&I NSW was charged with the investigation of remediation options and the production of a detailed project plan in the form of a Review of Environmental Factors (REF) that addressed environmental, social, and economic considerations. I&I NSW was also responsible for obtaining permits and approvals for the projects, while SWC managed on-ground works including the implementation of the REF recommendations. All three weirs were removed as part of the project; however, due to bed stability concerns at Mullumbimby Creek Weir 2, a full-width rock-ramp fishway was inserted to limit bank and bed erosion while still permitting fish passage.

Nine road crossings were remediated in the NRCMA, with 6 sites involving the removal of an obsolete crossing. Removal of obsolete barriers represents a low cost, high reward outcome. On-ground works involve no design or construction costs, with structural excavation normally being completed in 1 – 2 days. The primary consideration for the removal of redundant road crossings is to ensure that the structure is not acting as a bed control structure, where removal of the crossing will result in significant upstream bed and bank erosion upstream through the progression of a headcut. To offset this risk, detailed bed surveys were obtained followed by advice from qualified geomorphologists regarding the viability of removing the crossings. Benefits achieved at removal sites include unimpeded fish passage and reinstated hydrological regimes and sediment fluxes.

The three remaining road crossings were all high priority barriers, with remediation works being discussed at the sites since 2004. Old Lismore Road involved the insertion of a 10 m spanning low-flow box culvert (4 cells) into a 35 m crossing on the lower Oxley River. Stuarts Island causeway was located in the lower Nambucca estuary, and prevented tidal flow from flushing a 1 km section of river with high public visibility and strong indigenous heritage values. Remediation works involved the insertion of a two-celled box culvert that significantly improved water quality at a site displaying extensive seagrass beds. Casuarina Lane on the Orara River required the insertion of a full-width rock-ramp fishway that incorporated a low-flow channel that led up to a redesigned box culvert. Due to downstream gravel extraction in the 1970's and extensive sediment accumulation upstream of the road crossing, redesigning the causeway was not an option. Insertion of the fishway has benefitted native fish including the Endangered Eastern Freshwater Cod, of which a 600 mm specimen was recently sampled immediately above the causeway. Three recent large scale floods have occurred within the upper Orara system since March 2009;

with inspection of the fishway confirming structural stability and the maintenance of fish passage.

A total of 45 floodgates were remediated in the NRCMA area, resulting in 106 km of additional fish passage and 1,063 ha of improved wetland management and groundwater control. The breakdown of sites achieved in each catchment is shown in Table 4.2.1 below. Most sites involved the installation of tidally activated floodgate modifications. Local Councils own and maintain the floodgates in their respective areas and were integral in securing successful outcomes. In the Tweed, Richmond and Clarence catchments existing funds were available to purchase the required floodgate modifications. Bringing Back the Fish contributions covered essential costs relating to site assessment and negotiation, remediation design and installation, and post-completion monitoring. The involvement and corporate knowledge of I&I NSW was critical in ensuring that the most appropriate sites for fish passage and water quality outcomes were selected in the prioritisation process.

Two habitat sites were completed in the NRCMA. The Clarence Estuary project resulted in the culmination of 30 years of negotiation regarding the reestablishment of tidal flushing at the Shallow Channel causeway. The causeway spans the width (120 m) of Shallow Channel, thereby restricting tidal flushing with poor water quality resulting. Remediation works involved the insertion of a two-celled box culvert that reinstated tidal flows to the channel. An additional stage of the project was the improvement of bank stability within Lake Wooloweyah, which is linked to Shallow Channel in the Clarence estuary. Due to vegetation clearance, the banks of Lake Wooloweyah have experienced significant erosion that has impacted on water quality and fish habitat. Over 700 m of rock fillets were inserted along the western banks of the lake to improve bank stability through the enhancement of mangrove recruitment.

Vallances Road Sewage Treatment Plant (STP) is a project coordinated by Byron Shire Council to improve habitat health at the proposed facility. To date, Council has achieved the following outputs: construction of three causeways to improve tidal flushing to two oxbow lakes, riparian fencing (4.5 km) and revegetation (35,000 trees) along 2 km of Brunswick River, and stabilisation of 300 m of severely eroding banks through the insertion of rock fillets. I&I NSW provided ongoing advice for the reinstatement of tidal flows to the two oxbow lakes, and assisted with designs and recommendations for bank stabilisation works utilising rock fillets. Additionally, I&I NSW supported Byron Shire Council in acquiring over $100,000 in funding for the delivery of on-ground works.

TABLE 4.2.2: HUNTER / CENTRAL RIVERS CMA PROJECT OUTPUTS

SITE NAME	CATCHMENT	STRUCTURE IMPACT*	REMEDIATION RANKING	REMEDIATION OUTPUT	PROJECT BENEFIT	SITE EXPENDITURE
WEIRS						
Locketts Crossing	Coolongolook	HD (750 mm), LF	High	Rock-ramp fishway, Box Culvert	63 km	$132,402
Stroud Weir	Karuah	HD (1000 mm)	High	Full-width rock-ramp fishway	47 km	$58,675
Lansdowne Weir	Macleay	HD (400 mm)	High	Altered attraction flow, raised weir invert	5 km	$33,910
ROADS						
Clarksons Crossing	Wallamba	HD (350 mm)	High	Removed obsolete crossing	3 km	$67,191
Wang Wauk	Wang Wauk	HD (300 mm)	High	Removed obsolete crossing	85 km	$8,914
Stantons Crossing	Manning	HD (750 mm)	High	Rock-ramp fishway	2 km	$34,233
Hortons Crossing	Manning	HD (1300 mm)	Medium-High	Rock-ramp fishway	12 km	$35,957
Manning Obsolete	Manning	HD (1000 mm)	High	Removed obsolete crossing	4 km	$7,744
FLOODGATES						
Mamboo Island 1	Tweed	ASS	Medium	Inserted sill at raised invert	10 ha	$16,652
Mamboo Island 2	Richmond	ASS	Medium	Inserted sill at raised invert	10 ha	$16,652
Mamboo Island 3	Clarence	ASS	Medium	Inserted sill at raised invert	10 ha	$16,652
Tomago	Macleay	WB	Medium-High	Inserted Smartgate	1 km / 226 ha	$80,000
HABITAT						
Lower Wallamba Estuary	Wallamba	WB, BE	--	Levee decommissioning, rock fillets	107 Ha	$362,943
				TOTAL	**169 km / 237 ha**	**$871,924**

* HD = Head Differential; LF = Low Flow Depth; ASS = Acid Sulphate Soil Discharge; WB = Waterway Blockage; BE = Bank Erosion

4.2.2 Hunter / Central Rives CMA

A total of 13 priority sites representing 3 weirs, 5 road crossings, 4 floodgates, and 1 key habitat site were remediated in the HCRCMA region, with Table 4.2.2 summarising site deliverables within the region. Overall, remediation of priority sites within the HCRCMA has reinstated access to 222 km of upstream fish habitat, and improved the condition of 363 ha of key habitat. Individual site based reports appear in Appendix B.

All three weirs addressed in the HCRCMA were considered high priorities, with Locketts Crossing being ranked as the highest priority weir in the region (NSW Department of Primary Industries 2006). Acting as a tidal barrage, Locketts Crossing restricted migrating fish access to over 63 km of the upper Coolongolook River for target species such as Australian Bass and freshwater mullet. The construction of a partial-width rock-ramp fishway and a single box culvert at the causeway was the culmination of 20 years of dialogue between I&I NSW and Great Lakes Council. High public and government agency interest in the site was demonstrated by the attendance of over 40 people at the fishway opening.

Of the five road crossings addressed in the HCRCMA, three involved the removal of obsolete structures. Clarksons Crossing on the lower Wallamba River was the highest priority structure of the three, representing a tidal barrage to migrating fish returning from the estuary. The Crossing was originally constructed in the early 1900's, and served as the Pacific Highway crossing of the Wallamba River until 1958 at which time the crossing became redundant due to the construction of a new bridge downstream. Clarksons Crossing was maintained in the road network, but fell into disrepair in the 1980's when initial discussions were held regarding removal. As with Locketts Crossing, the removal of Clarksons Crossing concluded over 20 years of discussions and negotiations with the local council and surrounding landholders.

Stantons Crossing and Hortons Crossings, both located on the Gloucester River, required the insertion of partial-width rock-ramp fishways. The two crossings act as bed control structures, thus design options were limited to the insertion of a fishway. A partnership was developed with Gloucester Shire Council where rock for the fishways was sourced for a reduced price, thereby permitting the design as a viable option. Construction of the fishways required detailed expertise in the placement of rock material to ensure effective fish passage as well as the continued stability of the structures in a high energy system. Monitoring following flood events in autumn 2009 confirmed that the rock-ramp fishways were functioning as designed, with no structural instability being recorded.

Three floodgates were remediated at Mamboo Island in the Manning estuary. The constructed drains were impacting on estuarine water quality through acid discharge. As a result, floodgates were replaced at a higher invert to maintain high groundwater levels within the drains, which also improved the health of upstream wetlands. Project outcomes included reduced acid sulphate soil oxidation, enhanced wetland values, and improved downstream water quality.

The Lower Wallamba Estuary was selected as the habitat site in the HCRCMA region. Rehabilitation works were conducted at two sites, Darawakh Wetland and the Wallamba River. Within the wetland, a 1 km drain and levee were decommissioned to improve water exchange to 107 ha. These works built on previous outcomes achieved by Great Lakes Council as part of the Darawakh Creek & Frogalla Swamp Wetland Management Plan (Smith 2004). Works along the

Wallamba River centred on stabilising severely eroding banks along a 1 km stretch through the insertion of rock fillets to increase mangrove settlement and recruitment. Prior to onground works, banks were eroding up to 1 m a year. Riparian fencing and revegetation were also completed to complement the rock fillet works.

Excluding Tomago floodgate, all sites addressed in the Bringing Back the Fish project for the HCRCMA region were located in the Lower North Coast. Initial investigations were undertaken for sites within the Central Coast and Hunter regions; however, expected project outputs were not considered significant for the expenditure of funds when compared to respective opportunities in the Lower North Coast.

TABLE 4.2.3: HAWKESBURY - NEPEAN CMA PROJECT OUTPUTS

SITE NAME	CATCHMENT	STRUCTURE IMPACT*	REMEDIATION RANKING	REMEDIATION OUTPUT	PROJECT BENEFIT	SITE EXPENDITURE
WEIRS						
none	--	--	--		--	--
ROADS						
Bunnigalore Road	Wollondilly	HD (200 mm), LF	Medium	Full-width rock-ramp fishways, bank protection, alternate watering points, revegetation	29 km	$168,905
Cattai Road	Hawkesbury	HD, WB	High	Partial-width rock-ramp fishway	8 km / 22 ha	$172,794
McClymonts Road	Hawkesbury	WD (500 mm), WV	High	Partial-width rock-ramp fishway, Box Culverts	75 km	$488,540
FLOODGATES						
Bayview Golf Club	Hawkesbury (Pittwater)	WB	High	Auto-tidal floodgate	3 km	$14,374
HABITAT						
Seagrass Friendly Moorings	Hawkesbury (Pittwater)	HL	--	Install 34 seagrass friendly moorings	1 ha	$134,215
One Tree Reach Wetland	Hawkesbury	HL	--	Purchase of wetland for conservation	9 ha	$190,000
				TOTAL	**115 km / 32 ha**	**$1,168,829**

* HD = Head Differential; WV = Water Velocity; LF = Low Flow Depth; WB = Waterway Blockage; FD = Flow Diversion; BE = Bank Erosion; HL = Habitat Loss.

4.2.3. Hawkesbury - Nepean CMA

A total of 6 priority sites representing 3 road crossings, 1 floodgate, and 2 key habitat sites were remediated in the HNCMA region. Overall, remediation of priority sites within the HNCMA reinstated access to 115 km of upstream fish habitat, and improved the condition of 32 ha of key habitat. Table 4.2.3 summaries site deliverables within the region, with individual site reports appearing in Appendix C.

No weirs were addressed within the HNCMA as part of this project due to a concurrent project undertaken by Sydney Catchment Authority, Office of Hawkesbury-Nepean and Sydney Water. This project is addressing all mainstem weirs on the Hawkesbury-Nepean, installing infrastructure to provide environmental flows and fish passage within the system in order to deliver objectives of the Sydney Metropolitan Water Plan. Works are underway for several of the 13 mainstem weirs, with the first fishway due for completion in January 2010.

Two of the three road crossings addressed were high priorities (within the top 10 of all sites in HNCMA). McClymonts Road (locally known as McClymonts Crossing) has been noted as a high priority for a number of years due to its large upstream habitat area available (75 km), and because it forms a velocity and headloss barrier to fish passage at all but high flows. As part of this project, box culverts replaced a single pipe culvert, with a modified fishway incorporated to retain the upstream water levels.

The other high priority site, Cattai Road, Longneck Creek and Lagoon, reinstated fish passage to the lagoon during base flow conditions. Concurrent works on the adjacent weir structure allows NPWS to undertake improved aquatic weed management within the lagoon through actively managed wetting and drying cycles.

The third road crossing site addressed as part of this project formed part of a suite of stream restoration works undertaken by the Hawkesbury-Nepean CMA. Restoration works included installation of bed control structures with fish passage (10), erosion control works, revegetation and provision of off stream watering points. A total of four road crossings were addressed as part of this project, through installation of the bed controls and fishways (2), and elevation of water levels across track surfaces (2). The total cost of works was $327,330, with the roads component of this being $168,905.

The floodgate remediated as part of this project was the highest priority site within the HNCMA. Located at Bayview near Pittwater, the structure controls water movement into a creek and lagoon system that runs through Bayview Golf Club. The upper reaches of the system currently have odour issues that Pittwater Council are looking to address through community consultation, formation of a management plan for the area, and further modification of the floodgates. Installation of the auto-tidal gate has improved tidal exchange upstream of the structure, improving water quality and providing improved fish access.

The two key habitat sites took left-of-centre approaches to habitat improvement: working with NSW Maritime, HNCMA, and Pittwater Council in the Pittwater estuary to replace 34 block and chain moorings with seagrass friendly models; and contributing to the purchase cost of a property containing off channel wetland habitat on the Hawkesbury River.

Installation of the seagrass friendly moorings involved identification of priority sites (seagrass sites with *Posidonia australis* present) and an expression of interest

process for mooring licensees. A demonstration day provided an opportunity for mooring licensees to see the seagrass friendly mooring device and ask questions about it to the inventor and installer. Mooring licensees received a seagrass friendly mooring device and free maintenance for three years. A monitoring program was also included to allow data to be collected and the benefits quantified. The monitoring program was linked to the three year maintenance program as an incentive for seagrass friendly mooring uptake and to ensure seagrass friendly moorings remained in place for the duration of the monitoring program.

One Tree Reach wetland is located on a property adjacent to land managed by Hornsby Council for environmental benefit. Purchase of the property will allow whole of system management for the 9 ha wetland complex, enabling Council to form a property management plan, and value add to previous NRM projects.

TABLE 4.2.4: SYDNEY METROPOLITAN CMA PROJECT OUTPUTS

SITE NAME	CATCHMENT	STRUCTURE IMPACT*	REMEDIATION RANKING	REMEDIATION OUTPUT	PROJECT BENEFIT	SITE EXPENDITURE
WEIRS						
Ingleburn Weir	Georges	HD (500 mm)	High	Rock repositioning	52 km	$27,131
Redundant Weir	Georges	HD (1300 mm)	High	Remove obsolete weir	26 km	$117,601
Lane Cove Weir	Parramatta	HD (300 mm), LF	High	Partial-width rock-ramp fishway	49 km	$166,940
ROADS						
Australia Avenue	Parramatta	HD (400 mm), LF	--	Partial-width rock-ramp fishway	1 km / 5 ha	$179,135
Turella Weir	Georges	HD (600 mm)	High	Partial-width rock-ramp fishway	3 km	$120,000
FLOODGATES						
none	--	--	--		--	--
HABITAT						
Seagrass Friendly Moorings	Sydney Harbour (Manly Cove)	HL	--	Install 33 Seagrass friendly moorings	1 ha	$115,704
Wharf Road Saltmarsh	Parramatta	HL	--	Weed and rubbish removal	1 ha	$85,415
				TOTAL	**131 km / 7 ha**	**$811,926**

* HD = Head Differential; WV = Water Velocity; LF = Low Flow Depth; WB = Waterway Blockage; FD = Flow Diversion; BE = Bank Erosion; HL = Habitat Loss.

4.2.4 Sydney Metropolitan CMA

A total of 7 priority sites representing 3 weirs, 2 road crossings, and 2 key habitat sites were remediated in the SMCMA region. Remediation of priority sites within the SMCMA has improved access to 131 km of upstream fish habitat. Table 4.2.4 summaries site deliverables within the region, with Appendix D providing individual site overviews.

All but one of the fish passage barrier sites addresses as part of this project were deemed high priority within the Sydney Metropolitan CMA, with the remaining site not previously assessed.

Three partial-width rock-ramp fishways were installed at sites with excessive head differentials, as structural removal was not a viable option. Following rock-ramp construction, native fish have improved access to 53 km of upstream habitat within 2 separate catchments. Additionally, all three rock-ramp sites are present at highly visible locations (Lane Cove National Park, Sydney Olympic Park and adjacent a train station in the suburb of Turella), providing valuable opportunities for raising public awareness of fish passage issues and the migratory requirements of native fish.

Of the remaining two sites, an obsolete weir on Cabramatta Creek was removed in partnership with Fairfield City and Liverpool City Councils, while fish passage was improved at Ingleburn Weir on the Georges River by repositioning rock rubble within an existing breach. As this site was of local heritage importance and in poor repair, extensive preliminary surveys were required to determine if proposed works would impact on its heritage significance or structural integrity. Works at Ingleburn Weir enabled improved access to 52 km of upstream habitat within relatively untouched waterways located in Holsworthy Army Range.

Fish monitoring activities have been undertaken at all but the Ingleburn Weir site in conjunction with local council staff (Fairfield City – Cabramatta Creek, Canterbury City – Turella Weir), Sydney Olympic Park Authority (Australia Avenue), and the Bass Sydney fishing group (Lane Cove fishway). Although generally too early to identify marked differences in fish populations upstream of these structures post-remediation, monitoring has recorded the presence of mullet upstream of Australia Avenue fishway in Sydney Olympic Park where they were previously absent.

As with the HNCMA, seagrass friendly moorings were used to replace 33 block and chain moorings in Manly Cove, Sydney Harbour. Mimicking the Pittwater process, an expression of interest offer followed by a demonstration day was held to show mooring licensees the system and allow an opportunity to ask questions of the inventor and installer. Mooring licensees received a seagrass friendly mooring device and free maintenance for three years.

As in Pittwater, a monitoring program has been developed to determine environmental benefits associated with the replacement of block and chain moorings with seagrass friendly structures. As part of this program, seagrass growth will be measured at sites with block and chain moorings, seagrass friendly moorings, and no mooring structure. The field work component of this program is undertaken by the community diving group Eco Divers with guidance from the University of Newcastle.

The second key habitat site was located on one of the remaining areas of saltmarsh on Parramatta River. Works centred on the removal of introduced vines, weeds and rubbish from 1.3 ha of saltmarsh and mangrove habitat. The area treated will allow linkage to an adjacent restored saltmarsh, and extends the area under continued maintenance.

TABLE 4.2.5: SOUTHERN RIVERS CMA PROJECT OUTPUTS

SITE NAME	CATCHMENT	STRUCTURE IMPACT*	REMEDIATION RANKING	REMEDIATION OUTPUT	PROJECT BENEFIT	SITE EXPENDITURE
WEIRS						
none	--	--	--		--	--
ROADS						
Quart Pot Road	Clyde	HD (300 mm), LF	High	Low flow box culverts (2)	20 km	$88,800
The River Road	Clyde	WV, HD (200 mm)	High	Low flow box culverts (2)	22 km	$127,360
Northangera Road	Shoalhaven	WV	Medium	Low flow box culverts (3)	43 km	$149,550
FLOODGATES						
Shoalhaven Heads	Shoalhaven	WB	High	Auto-tidal gate	1 km	$16,555
Manildra	Shoalhaven	WB	Medium	Auto-tidal gate (maintenance)	1 km	$0
Parkers Drain	Shoalhaven	WB	High	Auto-tidal gate	2 km	$28,955
Jellat Jellat	Bega	WB	Medium	Winch gate	9 km / 375 ha	$11,492
HABITAT						
The River Road	Clyde	HD (1200 mm), LF	High	Full-width rock-ramp fishway	40 km	$157,738
				TOTAL	**138 km / 375 ha**	**$580,450**

* HD = Head Differential; WV = Water Velocity; LF = Low Flow Depth; WB = Waterway Blockage; FD = Flow Diversion; BE = Bank Erosion

4.2.5 Southern Rivers CMA

A total of 7 priority sites representing 3 road crossings, 4 floodgates, and 1 key habitat site were remediated in the SRCMA region. Remediation of priority sites within the SRCMA has improved access to 138 km of upstream fish habitat, and improved the health of 375 ha of key fish habitat. Table 4.2.5 summaries site deliverables within the region, with individual site reports appearing in Appendix E.

A total of four road crossings were addressed as part of this project, with one being funded under the key habitat component. Three of the crossings were listed as high priority, with the fourth listed as medium priority.

Works at Quart Pot Road involved removal of a wet causeway and replacement with a double box culvert structure that readily drowns out, while at The River Road, Nelligen Creek and Northangera Road (Bourkes Crossing), Mongarlowe River, additional box culverts were installed to overcome excessive water velocities created by the presence of inadequate pipes. Improvement to the Bourkes Crossing structure will directly benefit the remnant Macquarie Perch population present in this waterway while The River Road and Quart Pot Road sites will improve migratory possibilities for Australian Grayling. Macquarie Perch is listed as vulnerable in NSW and Australian Grayling is listed as vulnerable under Federal legislation.

Two floodgates within the Shoalhaven region are now actively managed following installation of auto-tidal gates at Shoalhaven Heads and Broughton Creek. This has allowed improved tidal flushing and fish passage within the drains upstream. A third auto-tidal floodgate on Broughton Creek was serviced to allow effective operation following several years where the gate was closed due to excessive marine invertebrate growth. The fourth floodgate located in the Bega catchment controls water movement into a large wetland area fed by Jellat Jellat Creek. The old wood gates of the structure were in poor condition, with landholders resorting to the use of wire to string the floodgates closed for long periods as the potential for water to back up from Bega River increased. Works at this structure replaced the old wooden gates with marine grade aluminium, thereby allowing winch operation from a safe work platform. This setup reduces the need for active floodgate management when there is a perceived threat of water backing up; thereby permitting the gates to remain open for longer periods which benefits fish passage.

The final road crossing site was addressed as part of the key habitat component. The River Road, Currowan Creek acts as a bed control structure, with a height differential of 1.2 m between upstream and downstream bed levels. Removal of the causeway or installation of low flow box culverts was therefore not possible as large volumes of sediment would have been released into the downstream waterway. As such, a full-width rock-ramp fishway was constructed incorporating a low flow channel to permit fish passage. The rock-ramp also increased causeway stability during high flows due to the lack of downstream scouring and undercutting. The rock-ramp fishway, which is located at the tidal limit within Currowan Creek, allows improve migratory fish access to 40 km of upstream habitat.

4.3 Communications Outputs

A key objective of the Bringing Back the Fish project was to promote the outcomes achieved at priority remediation sites along coastal NSW, as well to raise regional public awareness concerning fish passage and aquatic health issues. A total of 185 communication events were recorded during the project, with Table 4.3 providing a breakdown of communication mode within each CMA region.

General promotion of the goals of the Bringing Back the Fish project was achieved via project brochures, posters, public presentations (e.g. seminars and workshops), and popular media (e.g. magazines). Early in the project, a *Bringing Back the Fish* brochure was produced that outlined the requirements of healthy fish populations, detailed when habitat is not fish friendly, and provided examples of how fish populations can be replenished through habitat rehabilitation (Appendix I). Additionally, a poster was developed that demonstrated rehabilitation works occurring across the state that are reinstating native fish stocks naturally (Appendix J). The poster was displayed at various venues and community events throughout the project's duration.

Presentations encompassing public forums, seminars, workshops, and school presentations were organised across the coast to promote fish friendly design principles for waterway structures to improve stream connectivity, whether on a general scale or for specific priority barriers. Two examples include the Locketts Crossing Fishway Open Day and the Tilligerry Catchment Crawl. Locketts Crossing was the highest priority fish passage barrier in the Hunter/Central Rivers CMA, with discussions occurring for the previous 20 years concerning how to improve stream connectivity at the site. Remediation works to improve fish connectivity involved the

TABLE 4.3: Outputs produced per communication mode within each CMA region during the Bringing Back the Fish project.

COMMUNICATION MODE	COASTAL	NRCMA	HCRCMA	HNCMA	SMCMA	SRCMA	TOTAL
Brochures	1	2	1	4	0	0	**8**
Poster	1	0	0	0	0		**1**
Public Forum	1	6	7	4	2	3	**23**
Workshop	2	4	2	4	4	9	**25**
Seminar	6	3	3	4	4	2	**22**
School Presentation	0	1	1	0	0	0	**2**
Magazine article	2	2	2	0	0	0	**6**
Newsletter article	3	11	18	1	7	4	**44**
Newspaper article	0	23	5	2	8	1	**39**
Media Release	0	0	0	0	2	1	**3**
Radio	0	3	0	0	0	2	**5**
Television	0	4	1	0	0	0	**5**
Website	1	1	0	0	0	0	**2**
TOTAL	**17**	**60**	**40**	**19**	**27**	**22**	**185**

A. **B.**

FIGURE 4.3.1: Public forums assisted in the promotion of fish friendly design principles for waterway structures to improve stream connectivity. An Open Day was held at Locketts Crossing (A) on the Coolongolook River to detail the benefits of the partial-width rock-ramp fishway design (B).

construction of a box culvert into the existing causeway, followed by the insertion of a rock-ramp fishway on the downstream side. An open day was attended by 40 participants including recreational fishermen, farmers, local councils, and respective government agencies where the benefits of the program and design principles of the rock-ramp fishway were discussed (see Fig. 4.3.1). Alternatively, Tilligerry Catchment Crawl involved the discussion of floodgates, fish passage, estuarine health, and aquatic habitat awareness issues to 45 school kids from three local primary schools. Whilst visiting sites of varying habitat quality, interactive discussions were held concerning differences between healthy and degraded habitats and methods that could be utilised to improve habitat health and fish stocks.

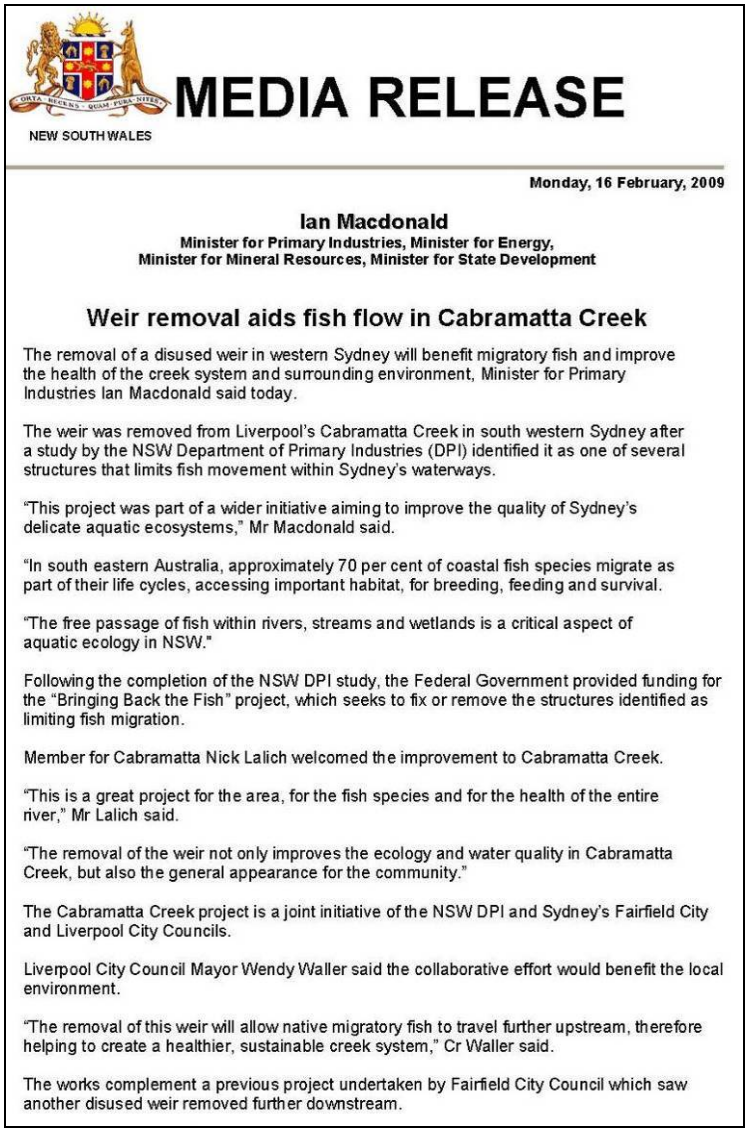
News releases utilising print media (newspapers, magazines), radio, television, and the internet were used to assist in promoting individual sites prior to, during, and following remediation works. As the greatest number of onground outcomes were achieved in the NRCMA and HCRCMA, news releases concerning Bringing Back the Fish outputs were also higher in these two regions (Table 4.3). Figure 4.3.2 displays a media release for Cabramatta Creek Weir that coveys the collaborative arrangement of the project and the environmental benefits arising from structural remediation.

4.4 Stakeholder Engagement and Capacity Building

The primary project output was the assessment, review, and remediation of 80 priority sites. In order to achieve this output, effective stakeholder engagement was required. Major groups engaged and partnerships forged during the delivery of the project are detailed in Table 4.4.

Development of partnerships over an extended timeframe permitted an effective transfer of information relating to fish passage and habitat remediation works from I&I NSW and associated consultants (e.g. Fishway Consulting Services, Streamline River Restoration, WetlandCare Australia) to relevant stakeholders ranging from CMAs, local councils, government agencies (e.g. Land Property Management Agency), and water authorities (e.g. State Water Corporation, MidCoast Water).

A.



MEDIA RELEASE

NEW SOUTH WALES

Monday, 16 February, 2009

Ian Macdonald
Minister for Primary Industries, Minister for Energy,
Minister for Mineral Resources, Minister for State Development

Weir removal aids fish flow in Cabramatta Creek

The removal of a disused weir in western Sydney will benefit migratory fish and improve the health of the creek system and surrounding environment, Minister for Primary Industries Ian Macdonald said today.

The weir was removed from Liverpool's Cabramatta Creek in south western Sydney after a study by the NSW Department of Primary Industries (DPI) identified it as one of several structures that limits fish movement within Sydney's waterways.

"This project was part of a wider initiative aiming to improve the quality of Sydney's delicate aquatic ecosystems," Mr Macdonald said.

"In south eastern Australia, approximately 70 per cent of coastal fish species migrate as part of their life cycles, accessing important habitat, for breeding, feeding and survival.

"The free passage of fish within rivers, streams and wetlands is a critical aspect of aquatic ecology in NSW."

Following the completion of the NSW DPI study, the Federal Government provided funding for the "Bringing Back the Fish" project, which seeks to fix or remove the structures identified as limiting fish migration.

Member for Cabramatta Nick Lalich welcomed the improvement to Cabramatta Creek.

"This is a great project for the area, for the fish species and for the health of the entire river," Mr Lalich said.

"The removal of the weir not only improves the ecology and water quality in Cabramatta Creek, but also the general appearance for the community."

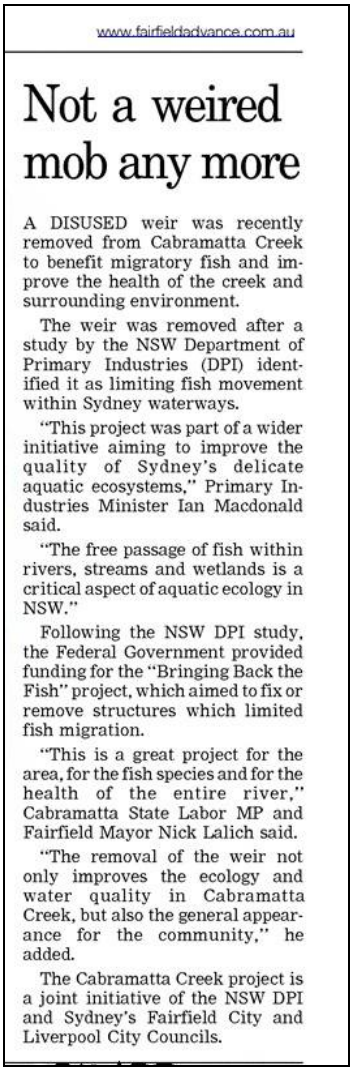
The Cabramatta Creek project is a joint initiative of the NSW DPI and Sydney's Fairfield City and Liverpool City Councils.

Liverpool City Council Mayor Wendy Waller said the collaborative effort would benefit the local environment.

"The removal of this weir will allow native migratory fish to travel further upstream, therefore helping to create a healthier, sustainable creek system," Cr Waller said.

The works complement a previous project undertaken by Fairfield City Council which saw another disused weir removed further downstream.

B.



www.fairfieldadvance.com.au

Not a weired mob any more

A DISUSED weir was recently removed from Cabramatta Creek to benefit migratory fish and improve the health of the creek and surrounding environment.

The weir was removed after a study by the NSW Department of Primary Industries (DPI) identified it as limiting fish movement within Sydney waterways.

"This project was part of a wider initiative aiming to improve the quality of Sydney's delicate aquatic ecosystems," Primary Industries Minister Ian Macdonald said.

"The free passage of fish within rivers, streams and wetlands is a critical aspect of aquatic ecology in NSW."

Following the NSW DPI study, the Federal Government provided funding for the "Bringing Back the Fish" project, which aimed to fix or remove structures which limited fish migration.

"This is a great project for the area, for the fish species and for the health of the entire river," Cabramatta State Labor MP and Fairfield Mayor Nick Lalich said.

"The removal of the weir not only improves the ecology and water quality in Cabramatta Creek, but also the general appearance for the community," he added.

The Cabramatta Creek project is a joint initiative of the NSW DPI and Sydney's Fairfield City and Liverpool City Councils.

FIGURE 4.3.2: Ministerial media release and resulting article ('Fairfield Advance') for the removal of Cabramatta Creek Weir completed in conjunction with Fairfield City and Liverpool City Councils.

General and site specific information transfer included fish passage design requirements, permitting obligations, and pertinent environmental assessments (e.g. bed surveys, geomorphic stability). As a result of such partnerships, stakeholders not only developed ownership of priority sites addressed during the Bringing Back the Fish project, but also now possess fundamental skills to undertake future aquatic rehabilitation projects. Core examples of capacity developed or assisted as part of this project are detailed below:

- Catchment Management Authorities now have an improved understanding of fish passage and habitat requirements of native fish, and how these requirements related to Catchment Action Plan targets. In some cases, projects completed during the Bringing Back the Fish project were managed directly by the CMA. Additionally, continued CMA investment into aquatic habitat rehabilitation works including fish passage has continued beyond project completion.

- Local government councils were the primary stakeholder engaged during the course of the project as a result of being the predominant asset managers of coastal waterway crossings. Councils were briefed on the results of audits and prioritisations of fish passage barriers and key habitat within their LGA, as well as on design and permitting requirements to remediate such structures. Additionally, remediation works completed at council owned assets were generally managed by the councils, ensuring information and skill transfer to engineers, environmental managers, and site work crews.
- On-ground works were often located on Crown Land, thus requiring consultation and information transfer with LPMA staff regarding permitting requirements (Crown Land Access permits). Since the inception of the Bringing Back the Fish project, a joint project between LPMA and I&I NSW has been developed and implemented to provide environmental recommendations for improved management of crown reserves, with attention given to structures deleteriously impacting on fish migration and key fish habitats.
- State Water Corporation (SWC) manages the operation of over 280 weirs across NSW. During the course of the Bringing Back the Fish project, SWC completed Total Asset Management Plans (TAMP) to ensure that their assets were being managed in an efficient, effective, safe, and financially responsible manner. Following review of the TAMPs, I&I NSW approached SWC to address three priority weirs (Manyweathers, Hickeys Creek, and Mullumbimby Creek Weir) identified as candidates for removal. Following the formation of a joint partnership agreement, all three weirs were successfully removed. A main aim of the SWC weir removal partnership was to develop a protocol and communication system for the assessment and review of remediation options at deemed asset liabilities, followed by the implementation of management recommendations. This protocol is now being extended to additional SWC weir assets that are perceived as environmental, financial, and legal liabilities.
- Waterway assets addressed during this project were primarily government owned. However, at certain sites extensive community consultation was required to detail the scope and benefits of proposed remediation works, as well as to identify public attitudes and concerns. As a result of these engagements, information was provided regarding the requirements of healthy native fish populations. Additional information transfer also occurred via popular media outlets (e.g. newspapers, radio). The effectiveness of such communications in galvanising local communities to undertake aquatic rehabilitation action is difficult to gauge; however, promising examples are present. Following the removal of Manyweathers Weir near Casino, residents along Cob-o-Corn Creek near Kyogle have organised a survey of community attitudes towards the improvement of fish passage at Cob-o-Corn Weir, a 2.5 m high State Water owned structure in the Richmond catchment. The residents intend to submit the survey to SWC, which unanimously calls for investigations into the removal of the weir.
- As with community groups, gauging the effectiveness of the Bringing Back the Fish project in raising awareness and action amongst recreational fishermen is difficult. However, subscription to recently advertised aquatic Habitat Action Grants through the NSW Recreational Fishing Trust was double the available funding allocated ($1.6 million total). These grants specifically target aquatic habitat rehabilitation works to benefit recreational fishing species (e.g. Australian Bass), with strong linkages with recreational fishing groups required for successful applications. Relationships developed with recreational fishing groups (e.g. Council of Freshwater Anglers) and local councils (e.g. Greater Taree City Council) during the course of Bringing Back the Fish was reflected in the grant applications received.

TABLE 4.4: Primary stakeholder groups engaged in the Bringing Back the Fish Project.

STAKEHOLDER	PROJECT INVOLVEMENT
Industry & Investment NSW	• Project management • Part 7 permits & concurrence • Site assessment • Advice on remediation options • Threatened species advice
Catchment Management Authorities	• Project administration • Project promotion • Site assessment • Site management and funding • Geomorphic advice for bed and bank stability • Co-funding of sites
Regional Steering Committees	• Review of priority sites • Identification of additional priority sites • Approval of site selection and funding expenditure
Local Government*	• Site management • Structural designs and costings • Provision of construction plant machinery • Site revegetation • Grant funding submission and management • Concurrence for floodgate remediation works of Council owned structures
Office of Water (formerly Department of Water and Energy)	• Geomorphic advice for bed and bank stability • Water license considerations • Concurrence for Controlled Activity Approval
Land Property Management Agency (formerly Department of Lands)	• Cadastral Lot / DP searches • River bed & structural ownership (ad medium filum) • Crown Land Access Permits
Department of Environment, Climate Change, and Water	• Concurrence on threatened species, water quality, and noise / air pollution • AHIMS searches • Concurrence for floodgate works in the Hunter (where DECCW are the owners of flood mitigation infrastructure)
National Parks and Wildlife Service	• Site management and funding • Wetland and drain rehabilitation • Concurrence for sites within their boundaries
Soil Conservation Services	• Geomorphic advice for bed and bank stability • Rock fillet consultation and construction • Rock-ramp fishway consultation and construction
State Water Corporation	• Site project management and funding • Removal of obsolete weirs

	• Completion of Total Asset Management Plans
Fishway Consulting Services	• Expert advice on fishway design and costings
Manly Hydraulics Laboratory	• Hydraulic / tidal surveys • Benthic surveys • Fishway modelling (trapezoidal fishway)
Department of Commerce	• Benthic surveys • Heritage assessment
MidCoast Water	• Remediation of Stroud Weir and Lansdowne Weir, with ongoing discussions occurring concerning Bulahdelah Weir.
Streamline River Restoration	• Rock-ramp fishway consultation and construction
Local Aboriginal Land Councils	• Advice on cultural heritage sites
Landcare / RiverCare	• Project management support (Orara Valley RiverCare)
Recreational Fishermen	• Personalised assessments of fishing stocks and fish passage priorities • Project information dissemination (e.g. NSW Fishing Monthly) • Monitoring through fish catches (e.g. Bass Sydney at Lane Cove fishway)
Council of Freshwater Anglers	• Project support and dissemination of information (i.e. Freshwater Fisher)
Commercial Fishermen	• Personalised assessment of fishing stocks and priority habitats. • Project information dissemination (OceanWatch)
WetlandCare Australia	• Grant funding submission and management • Production of site management plans • Site management
NSW Recreational Fishing Trust	• Funding of priority sites from Habitat Action Grants
NSW Environmental Trust	• Funding of priority fish passage sites
*Local Governments engaged during this project included: Tweed Shire Council, Byron Shire Council, Ballina Shire Council, Lismore City Council, Kyogle Shire Council, Richmond Valley Council, Richmond River County Council, Armidale-Dumaresq Shire Council, Clarence Valley Council, Coffs Harbour City Council, Nambucca Shire Council, Kempsey Shire Council, Port Macquarie Shire Council, Greater Taree City Council, Gloucester Shire Council, Great Lakes Shire Council, Port Stephens Shire Council, Singleton Shire Council, Cessnock Shire Council, Lake Macquarie Shire Council, Wyong Shire Council, Gosford Shire Council, Hawkesbury City Council, The Hills Shire Council, Pittwater Council, Campbelltown City Council, Fairfield City Council, Liverpool City Council, Canterbury City Council, Rockdale City Council, Shoalhaven City Council, Eurobodalla Shire Council, Palerang Council, and Bega Valley Shire Council.	

4.5 South Coast NSW Floodgate Audit

A preliminary aim of the project was to identify and prioritise floodgate structures for remediation in all coastal-draining catchments of southern NSW. The south coast floodgate audit, which complimented a previous audit of floodgate structures undertaken in the Northern Rivers CMA (NSW Fisheries 2002), completed a comprehensive database of floodgates on the NSW coast and complemented our knowledge of existing fish passage barriers within NSW coastal draining waterways.

A separate report entitled *The Assessment and Management of Floodgates on the NSW South Coast* (NSW Department of Primary Industries 2007a) was produced outlining the findings of the study relevant to the south coast region, which for this project was defined as the area from the Manning catchment in the Hunter/Central Rivers CMA area to the Victorian border. The overarching findings of this report are summarised below.

Approximately 576 sites were identified for assessment in the south coast region, with a desktop analysis used to focus field assessment on priority sites. From this stage, 521 sites were identified as requiring detailed field assessments to investigate the potential impact on fish passage and aquatic habitat, as well as to explore management options. Field assessment of these sites determined that 383 floodgates (73.5%) were acting as obstructions to fish passage and were recommended for remediation.

The number of floodgates assessed, as well as the number of sites that were recommended for remediation, varied considerably between the four coastal CMA areas assessed during this project (Table 4.5). This variation was predominantly due to the difference in size of the CMA regions within the project area, as well as varied landuse requirements within each CMA region. The HCRCMA region possessed the greatest number of floodgates requiring remediation (84%), followed by the SRCMA (13%), HNCMA (3%), and SMCMA (< 1%) where a single structure was recommended for remediation.

TABLE 4.5: Summary of floodgates assessed and recommended for remediation in southern coastal CMAs (NSW DPI 2007).

FLOODGATE TYPE	CMA REGION								TOTAL	
	HCRCMA		HNCMA		SMCMA		SRCMA			
	Tot	RR	Tot	RR	Tot	RR	Tot	RR	Tot	RR
Hinged Flap	340	238	14	9	1	0	54	44	**409**	**291**
Winch	78	76	1	1	1	1	0	0	**80**	**78**
Auto Tidal	5	5	0	0	0	0	1	1	**6**	**6**
'Smart Gate'	0	0	0	0	0	0	5	5	**5**	**5**
Sluice	0	0	0	0	1	0	0	0	**1**	**0**
Combination	1	1	0	0	0	0	0	0	**1**	**1**
Other	15	2	0	0	0	0	4	0	**19**	**2**
TOTAL	**439**	**322**	**15**	**10**	**3**	**1**	**64**	**50**	**521**	**383**

Tot – Total number of floodgates assessed during the study.
RR – Total number of floodgates identified as fish passage barriers and recommended for remediation.

Within the NSW south coast region, the most common floodgate structure identified was the hinged flap design (78% of all structures identified), with winch (15%), auto tidal (1%) and 'smart gates' (1%) being the next most common structure types. This trend reflects the traditional use and installation of floodgates, which were implemented as passively managed structures to prevent the inundation of low-lying land from tidal and flood waters. Similar trends were also reported in the previous North Coast floodgate audit (NSW Fisheries 2002).

A prioritisation scheme was developed to assist in ranking floodgate structures within each CMA region that required active management. The scheme was developed to determine regional fish passage barrier priorities based on habitat value, with additional factors related to structural modification also considered. Results of the prioritisation process per CMA region can be found in NSW Department of Primary Industries (2007a).

4.6 Monitoring Outputs

Because of the short-term scope (biologically) of the Bringing Back the Fish program, comprehensive monitoring of five priority rehabilitation sites was not feasible. Such an approach, which would require significant investment and a minimum of two years pre- and two years post-works monitoring, would aim at detecting changes in fish assemblage likely to be sensitive to associated fish passage works. Instead, I&I NSW completed a rapid evaluation of three priority sites to reveal whether important ecosystem processes responsible for the integrity of native fish stocks, primarily fish passage, had been restored. The three sites selected from the project were:

- Full-width rock-ramp at Stroud Weir, Karuah River
- Double box culvert at Quart Pot Road crossing, Buckenbowra River
- Auto-tidal floodgate at Yarrahapinni Broadwater, Andersons Inlet, Macleay River.

As with the South Coast NSW Floodgate Audit, results from the monitoring program are presented in a separate stand-alone report.

4.7 Project Funding

Bringing Back the Fish project funding totalled $3 million and included project management, site development, onground works (94 sites), site monitoring, and communication costs (see Table 4.7.1). However, total project expenditure was just over $9 million. When considering matching contributions, overall in-kind funding more than doubled the allotment provided by Bringing Back the Fish, and accounted for 50 % of total project expenditure. When broken down between project component (Table 4.7.1) and CMA region (Table 4.7.2), matching in-kind contributions were achieved across the board except for the SRCMA region.

In-kind contribution included cash and non-cash contributions from project partners (e.g. local councils, water authorities, landholders), or provision of funds from alternative State government sources such as the NSW Environmental Trust and the NSW Recreational Fishing Trust. Federal funding (obtained through additional grants) was not included as in-kind, but was used to supplement total remediation costs.

TABLE 4.7.1: Bringing Back the Fish project expenditure per structure type.

PROJECT COMPONENT	DELIVERED OUTPUTS	BBTF FUNDING	IN-KIND	FEDERAL FUNDING	TOTAL EXPENDITURE
WEIRS	10	$166,950	$519,434	$144,563	$830,948
ROADS	22	$678,328	$1,002,012	$461,138	$2,141,477
FLOODGATES	54	$226,343	$1,395,888	$923,734	$2,565,965
HABITAT	8	$614,620	$1,282,383	$376,664	$2,273,667
TOTAL	**94**	**$1,686,241**	**$4,199,717**	**$1,906,099**	**$7,792,057**
SITE DEVELOPMENT	--	$900,534	--	--	$800,534
PROJECT MANAGEMENT	--	$96,838	--	--	$96,838
MONITORING	--	$216,387	--	--	$216,387
COMMUNICATIONS	--	$100,000	--	--	$100,000
GRAND TOTAL	**94**	**$3,000,000**	**$4,199,717**	**$1,906,099**	**$9,105,816**

The level of funding provided in the Bringing Back the Fish project for remediation of fish passage at weir, road crossing, and floodgate barriers was a marked increase compared to previous projects, thus allowing priority structures to be targeted that were formerly viewed as cost prohibitive. However, Bringing Back the Fish funding accounted for only 30 % of total project expenditure, highlighting the high costs associated with fish passage restoration. Focussing on onground expenditure to the exclusion of site development costs, fish passage remediation averaged:

- $85,000 per weir
- $100,000 per road crossing
- $35,000 per floodgate[7]

Restoration of fish passage is unavoidably a costly exercise, as capital works within proximity to water bring a range of engineering challenges. Bringing Back the Fish funding provided necessary financial incentives to develop partnerships with asset owners that lacked the financial resources to make substantial contributions, or that did not see the rehabilitation of fish habitat as a core part of their business.

TABLE 4.7.2: Bringing Back the Fish project expenditure per CMA region.

CMA REGION	DELIVERED OUTPUTS	BBTF FUNDING*	IN-KIND	FEDERAL FUNDING	TOTAL EXPENDITURE
NR	60	$442,753	$2,786,898	$1,129,278	$4,358,929
HCR	13	$318,204	$296,832	$256,888	$871,924
HN	6	$296,801	$542,093	$329,934	$1,168,829
SM	7	$259,330	$362,596	$190,000	$811,926
SR	8	$369,153	$211,297	$0	$580,450
TOTAL	**94**	**$1,686,241**	**$4,199,717**	**$1,906,099**	**$7,792,057**

*BBTF funding is exclusive of site development and project management costs

[7] Yarrahapinni floodgate in the Macleay catchment involved land parcel acquisition at a cost of $550,000 that is not representative of the normal expenditure required for floodgate modification. As such, average cost of floodgate remediation was determined minus this site expenditure.

5 PROJECT MANAGEMENT CONSIDERATIONS

5.1 Milestone Evaluation

The Bringing Back the Fish project successfully achieved the majority of milestones identified at project inception. Table 5.1 summarises the milestones as set out in the project's contractual agreement and the outcomes achieved during project delivery.

The overarching aim of the project was the assessment, review, and completion of on-ground works at 80 priority sites, as delineated by 10 weirs, 20 road crossings, 45 floodgates, and 5 key habitat sites. The Bringing Back the Fish project exceeded the total projected number of rehabilitation sites by completing works at 94 sites. Moreover when considering the sub-category milestones, the project either met or exceeded structural-specific activities with 10 weirs, 22 road crossing, 54 floodgates, and 8 key habitat sites being remediated. Additionally, the length of stream re-opened for migratory fish (1,235 km) exceeded the contracted 1,000 km target, while the area of aquatic habitat rehabilitated (1,907 ha) was nearly four-fold greater than the 250 ha target. One aspect of the site outcomes that differed from the contract milestones was the breakdown of activities per CMA region with respect to weirs and road crossings. Although the overall number of project sites was met for both categories, the number of weir and road crossings remediated within each region differed from CMA to CMA due to a range of external factors that are discussed in Section 5.2.

Compilation of a complete fish passage barrier dataset was completed following the finalisation of the NSW South Coast Floodgate Audit (NSW Department of Primary Industries 2007a) as detailed in Section 4.5. Results of the floodgate audit were updated into the *NSW Fish Passage Barrier Inventory* managed by I&I NSW. Reports detailing prioritised sites requiring fish passage / fish habitat remediation in NSW coastal catchments were produced and are discussed in Sections 2 and Section 3.1 of this report.

Regional public awareness and education activities concerning fish passage and aquatic health issues occurred throughout the Bringing Back the Fish project, with 185 communication events recorded during the project. Section 4.3 details the use of promotional documents, public presentations, and popular media outputs to highlight project aims and outputs. In addition to engaging the general public, the Bringing Back the Fish project also engaged commercial and recreational fishers, particularly during regional NRM program delivery. Commercial and recreational fishers were represented on all regional steering committees (see Section 3.3), with additional consultation and representation occurring at site specific rehabilitation locations with relevant stakeholders.

An extended monitoring program was initially proposed at 5 key rehabilitation sites including 2 weirs, 1 road crossing, 1 floodgate, and 1 rehabilitated habitat site. Following initial site assessments and a review of viable monitoring outcomes that could be achieved within the allocated timeframe and budget, the monitoring program was scaled down to 3 sites (1 weir, 1 road crossing, and 1 floodgate) to ensure effective assessment of ecosystem processes responsible for maintaining the integrity of native fish stocks, primarily fish passage. Additionally, the floodgate site at Yarrahapinni Wetlands was also originally targeted as a key fish habitat monitoring site within the NRCMA; however, proposed timeframes for the wetland remediation component were outside those identified for the Bringing Back the Fish project. Results from the extended monitoring program are presented in a stand-alone report (I&I NSW 2009).

TABLE 5.1: Bringing Back the Fish project outputs quantified.

PROPOSED PROJECT OUTPUTS	REALISED OUTPUTS
Assessment, review & preliminary works for remediation sites (80 sites)	94 Site Completed
On-ground works & environmental evaluation commenced (80 sites)	94 Sites Completed
Remediation (modification, removal or fishway installation) of 10 priority weirs (2/CMA)	10 Sites Completed *(not 2/CMA)*
Remediation (modification or removal) of 20 road crossings - e.g. high priority barriers including causeways and culverts (4/CMA)	22 Sites Completed *(not 4/CMA)*
Modification and improved management of 45 floodgates in coastal NSW	54 Sites Completed
Rehabilitation of 5 key habitat sites (principally instream works) (1/CMA)	8 Sites Completed
Over 1000 kms of stream length opened up to fish passage	1,235 kms
250 ha of improved habitat	1,907 ha
Compilation of a complete fish passage barrier dataset (see Section 4.5)	Completed
Publication of a report detailing prioritisation of sites requiring remediation in coastal catchments of NSW (see Section 3.1)	Completed
Regional public awareness & education activities (see Section 4.3).	Completed
Promotion & education (see Section 4.3).	Completed
Engage the commercial fishing industry and recreational fishers in regional NRM program delivery (see Section 3.3)	Engaged via Steering Committees
Extended monitoring program at 5 key rehabilitation sites – 2 weirs (fishway and one other site), 1 road crossing, 1 floodgate and 1 rehabilitated habitat site.	Partial Completion: *Extended monitoring at 3 key sites complete*

5.2 Project Considerations and Limitations

Outside of the ecological benefits accrued from the 94 on-ground works sites, the most significant achievement of the BBTF project came through the coordination of all levels of government, multiple community stakeholder groups and various industries working towards a common goal. Not only did this allow the project to access a variety of expertise and skills from the wider community, the focus on enhancing river health through improved management and modification of assets will have lasting benefits. The high level of involvement of local councils allowed improvements to be made to individual structures within a given LGA region, as well as educating council staff about appropriate management at other sites throughout their LGA. This experience was repeated within Water Management Authorities such as NSW State Water Corporation, government authorities such as the RTA, and private landholders. The engagement of so many partner organisations in delivering

onground works will have a positive legacy for coastal river health (see Table 4.4 for examples of project partnerships).

Bringing Back the Fish aimed to remediate 80 priority fish habitat sites over a three year timeframe. In order to effectively address social, economic, and ecological issues at proposed sites, extensive assessments and negotiations were required. As a result, the timing of onground works was generally back-ended, with a number of site projects proposed during the final 6 months of the contract. During this period, coastal NSW experienced a number of major floods that significantly delayed the implementation of instream works. In order to address these delays, a three month contract extension was provided, at the end of which 88 priority sites (target 80) were completed with an additional 6 sites requiring a further three month extension. Although disappointing that all sites were not completed on time, delays experienced at the remaining sites highlight the complex nature of aquatic habitat rehabilitation works and draws attention to the need for extended project timeframes as provided during this project. Remediation works at Locketts and Clarksons Crossings (HCRCMA) were first being discussed in the 1980's; while outcomes achieved at Skewes Crossing and Slippery Crossing (NRCMA) were actively being discussed in 2004. Remediation of high priority fish habitat sites requires extensive consultation, adequate timeframes, and significant levels of base funding; three factors which were provided during the Bringing Back the Fish project.

Another consideration for project timeframes is the specialised nature of aquatic rehabilitation works, particularly rock-ramp fishway construction. Rock-ramps are a specialised design, with few contractors displaying the necessary construction expertise. This dearth of suitably qualified contractors placed pressures on the timing of coastal-wide projects following a series of floods along the NSW coast in autumn 2009, which was the year of greatest construction activity. As a result of the flooding, rock-ramp contractors working on projects in the Northern Rivers and Hunter/Central Rivers CMAs were delayed from initiating on-ground works in the south coast regions. Although efforts are occurring to expand the range of qualified rock-ramp contractors in NSW; such efforts require continued investment into fish passage works in order to facilitate contractor training, as well as to provide a viable, competitive market within which such skills would be economically beneficial to obtain.

The involvement of the five coastal CMA's within the project was beneficial on many levels; however, complexities were experienced when attempting to attain a breakdown of 2 weirs and 4 road crossings within each region. Factors including the extent, location, and priority status of fish passage barriers varied markedly between CMA regions, making an equitable distribution of outcomes and associated funding a difficult task. Such limitations were identified early in the project as potential risks by I&I NSW and the SRCMA, and despite efforts to achieve equitable distributions, certain regions such as the NRCMA accounted for a larger percentage of rehabilitation sites.

As previously discussed in Section 4.2 (CMA Project Outputs), an additional factor affecting the breakdown of project outputs was stakeholder willingness. Partnerships and stakeholder capacity were already well developed within the NRCMA due to continuing road crossing (since 2004) and floodgate rehabilitation programs (since 2000). As such, asset owners (e.g. local councils) in the Northern Rivers already possessed a clear knowledge of remediation design options and management responsibilities. Alternatively, in southern CMA regions (e.g. SRCMA, SMCMA, and HNCMA) such partnerships had to be developed during the first two years of the Bringing Back the Fish project, with stakeholder understanding and acceptance of

remediation design options taking additional time to foster. Continual funding towards aquatic rehabilitation projects in these southern CMA regions will assist in shoring up partnerships developed over the previous three years, and further assist in kick-starting stakeholder initiated rehabilitation projects as is occurring within the Northern Rivers.

The development of a border-to-border communications strategy for the whole project was limited during the project due to the nature and timing of on-ground works. Rehabilitation works were of a scale more suited to local and regional promotion. As such, communication efforts were focused on developing individual communication strategies with each of the CMA's during the course of the Bringing Back the Fish Project. Additionally, as a majority of sites were completed in the latter stages of the contract, cross regional promotion of overarching outcomes achieved by the Bringing Back the Fish project will occur after the onground component of the project is completed.

Bringing Back the Fish: Monitoring and Evaluation Program – Outline of Design and Methods (NSW Department of Primary Industries 2007b) was prepared by I&I NSW during the first year of the project to detail the scope and intention of the monitoring program. Although the project contract originally stipulated an extended monitoring program at 5 key rehabilitation sites, the scope was downscaled by I&I NSW to 3 sites upon assessment of remediation site options and the goals of the monitoring program (see NSW Department of Primary Industries 2007b). Assessment of the 3 sites allowed I&I NSW to specifically target whether remediation works had re-established fish passage at a site for a broad range of species and size classes over an extended timeframe. Despite the submission of the monitoring proposal report, the variation to the monitoring program was not formalised within the contract, and highlights a breakdown in management communication between I&I NSW and the SRCMA regarding the monitoring program outputs.

The role of the regional steering committees could be reviewed in future projects to ensure they best meet the need for local input. Given the size of the CMA regions, very few individuals had knowledge of the breadth of structures within the region, and at times members expressed concern that they could only provide meaningful advice on barriers in the immediate local area. With this in mind, the role of the steering committee could be considered as more of providing oversight of the prioritisation process, rather than providing specific information on individual sites or local areas. This would bring greater equity to the prioritisation process, as the size of the CMA regions does not allow for each area within the CMA to be represented on each of the steering committees.

6 FUTURE CONSIDERATIONS

The Bringing Back the Fish project has undoubtedly made a significant contribution to riverine health in coastal NSW. The improved access to and quality of aquatic habitat at 94 priority sites is a significant achievement over a three year period. During the implementation of the project, a number of important lessons were learnt that could inform future projects with similar goals.

The sheer scale of the problem remains an issue to be adequately addressed. Despite the excellent outcomes of the project, over 300 high priority barriers to fish passage remain in coastal NSW. The efforts over the three years of the Bringing Back the Fish project modified only a small percentage of the State's high priority sites, and the impact on migratory fish populations within NSW is still a major threat

to their long-term survival. A sustained effort to address fish passage issues is required to make a significant impact on the problem. Furthermore, the 94 rehabilitation sites involved the development of partnerships with a range of government, industry and community organisations (see Table 4.4). The ongoing benefit that can be derived from these relationships is at risk unless there is a sustained effort towards addressing coastal fish passage issues into the future. The time and resources invested in developing these partnerships and relationships was a significant part of the project and should be recognised in the development of future activities.

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