4 Onground interventions – Pillar 3

- The Whole of Life Plan will identify the management interventions to be undertaken.
- Detailed design of the interventions and their placement must be done in consultation with relevant experts.
- Consultation must occur with relevant jurisdictional government agencies to determine legislative and administrative requirements.
- A works program should schedule the management interventions and outline the resource and funding requirements.
- The works program and the Monitoring and Evaluation Plan must be properly coordinated.

This section provides guidance on how to undertake on ground management actions to rehabilitate ecosystem health for native fishes. It is important to involve the community in on ground management interventions such as re-snagging and riparian rehabilitation and to celebrate milestone achievements throughout the life of the demonstration reach.

The Whole of Life Plan (see Planning Pillar) should have identified the management interventions to be undertaken (e.g. riparian rehabilitation, alien fish management, fish passage restoration) and the sequence in which they are to be undertaken. Ideally all management interventions would be undertaken simultaneously throughout the demonstration reach. In reality this is not usually possible and interventions must be planned over a number of years in relation to the availability of resources and funds.

The first steps are to:

- Undertake an assessment of the current condition of the reach and the existing threats to ecosystem health.
- Document the necessary steps (actions) to mitigate each threat.
- Engage the broad community and major stakeholders to identify shared goals for the reach.
- Prioritise actions on both biological and community needs (this builds a shared ownership of the project).
- Consult with appropriate experts to design how and where the intervention will be implemented, what the resource and cost requirements are likely to be and a cost benefit analysis.
- Consult with jurisdictional agencies to determine the legislative and administrative constraints.

A works program can then be developed, scheduling the management actions over a period of time (e.g. 3 years) and the funds and resources required. When developing the works program it is important to be fully cognisant of all the issues that may arise including access to suitable contractors, ongoing maintenance costs, legislative requirements, contingency arrangements for delays due to e.g. flooding etc. The program

has to be realistic given the expected availability of funds and resources but the interventions must be of sufficient scale that they are likely to have a measurable impact on native fishes. It is also vital that the works program and the biological monitoring and evaluation program are planned together and properly coordinated.

There are number of management interventions that have been used to rehabilitate degraded rivers throughout Australia and a number of these, together with some new innovative approaches have been trialed at existing demonstration reaches **(**see examples in Appendix 4a**)**. Broad guidelines and examples of the more common interventions are given below. However, again the reader is urged to seek expert advice on these interventions as they pertain to their particular circumstances.

4.1 Instream habitat

4.1.1 Reintroducing large woody debris (snags)

- Local authorities must be contacted to ensure compliance with any regulatory requirements.
- Woody debris loads should be based on the natural load for the particular river.
- Woody debris should be native to the riparian zone but not sourced from there.
- Logging or land clearing sites are potentially good sources of woody debris but the closer to the demonstration reach the better to avoid excessive costs.
- Expertise should be sought in placing the woody debris to avoid danger to existing infrastructure etc., but low velocity areas on the outside or downstream of bends are preferred.
- Anchoring may be required to achieve stability. Trunks with root wads still intact will assist in this process.
- Heavy equipment (e.g. excavators) will be required to place woody debris in the river. Damage to the riparian zone should be avoided wherever possible.

Large woody debris consists of accumulations of woody materials (branches or whole tree trunks) that have fallen onto the stream bank or into the channel from the riparian zone. Once instream, large woody debris will become waterlogged and come to rest on the stream bed during low flow periods. They are a natural occurrence in health river systems but historically they have been considered hazards to navigation and have been wrongly thought to contribute to flooding by blocking the channel. As a consequence millions of woody debris have been removed from rivers and burnt.

More recently, the value of large woody debris to riverine ecosystems has been recognised and the re-introduction of woody material has become a major management intervention to rehabilitate degraded rivers. Large woody debris provides for:

- Habitat diversity through the development of downstream scour pools, variation in flow rates etc.

- Reduced rate of bed and bank erosion.
- Habitat for macrophytes, algae, invertebrates and microorganisms.
- Stable sites for the processing of carbon and nutrients.
- Resting areas for fish from high flows.
- Refuges from predators.
- Spawning sites for a number of native fishes (e.g. Murray cod, River blackfish).
- Territorial markers for some species (e.g. Golden perch and Murray cod).

There are a number of documents that have been produced which provide very good general guidance for restoring large woody debris in rivers. In particular, the reader is referred to Rutherfurd *et al.* (2000) and Brooks (2006). In the toolbox, a broad approach is documented together with examples from existing demonstration reaches.

There are many practical issues to consider when reintroducing snags to a river (Photos: Tony Townsend, Scott Raymond)

4.1.1.1 How many?

The aim should be to restore the river to its natural large woody debris load. Natural loads are not consistent but vary from river to river depending on the biogeographical region etc. Natural loads are best determined by direct measurements of the amounts of wood present in undegraded reaches of the river or from similar rivers nearby. Records may also be available from local river management authorities on the number of snags removed from sections of river. More woody debris may be required in areas where the riparian zone is degraded as there is no source of re-supply. Results from some existing demonstration

reaches have indicated that the more complex a snag pile is (e.g. five or six snags overlying each other) the higher number and diversity of fish the snag will accommodate. (see examples in Appendix 4b).

4.1.1.2 Type and where from?

Ideally, the woody debris used should reflect the diversity of species found naturally in the riparian zone. This way there will be a different decay rates providing a diversity of snag types. Introduced species should not be used as they do not provide a good substrate for macro invertebrates and may decompose quickly. If possible a range of sizes should be used. Snags should ideally have the root ball still attached and four or five large branches remaining. However, several sub optimal snags can be used in a snag pile with good results.

Woody debris should not be sourced from the riparian zone or the floodplain as they are providing important terrestrial habitat. Waste from logging or standing (green if possible) trees from clearing agricultural land, mine sites, road realignments and industrial developments may be good sources of woody debris. The closer the site is to the demonstration reach the better, as transport costs can be prohibitive. It is likely that the introduction of woody debris will be undertaken over a number of years. If a suitable source is found it may be worthwhile stockpiling the wood if a site is available. However, termites and borers are likely to invade fallen trees within six months on the ground. The resultant snags will be lighter and harder to anchor increasing the risk of them being washed downstream during a flood (see examples in Appendix 4c).

4.1.1.3 Where to place woody debris?

It is very important that local authorities are contacted at an early stage and that relevant expertise is sought. Wrongly placed woody debris could lead to increased bank erosion or could even endanger infrastructure (e.g. bridges) in flood conditions.

Woody debris should be placed in a variety of locations but generally they should be placed in low water velocity zones on the outside or downstream of bends (unless they are being specifically placed for erosion control or are hard to anchor in these positions). They can be placed at different angles to the flow in order to obtain a variety of habitats. Those placed perpendicular to the flow will be most likely to create scour pools. Snags should be placed in a variety of water depths, not just in the deepest sections, in order to benefit a broad range of fish species and size classes.

4.1.1.4 How to get them to the river?

Placement of woody debris in rivers requires engineering expertise and the use of heavy equipment. It should be undertaken carefully with minimum disturbance to the riparian zone. In smaller rivers, woody debris can be placed relatively easily using excavators. In larger rivers it may be necessary to use a fixed pulley and cable system (see Nicol et al. 2004).

4.1.1.5 How to maintain stability?

In a healthy riparian zone, when large trees fall into the river, they usually remain partially anchored to the bank and relatively stable. Introduced woody debris are not likely to be as stable and may need anchoring using engineering solutions such as steel cables or by

burying part of the trunk or roots (if the root ball is still intact) in the bank to mimic the natural situation. (see examples in Appendix 4d).

4.1.1.6 Potential Issues

There are a number of issues to consider when planning to introduce large woody debris to a reach of river. These include:

- Re-snagging is not effective in all situations. For example small numbers of logs placed in a high sediment load reach of the Murrumbidgee river were soon buried in sand. Hence engineered log jams were investigated as an alternative (see other options below).
- If woody material has to be sourced a distance away from the river, transport costs may be prohibitive.
- Is a suitable area available to stockpile the logs?
- There will be jurisdictional requirements for planning permission etc.
- Is there community support to introduce logs into the river reach; are there any recreational activities that may be impeded etc?
- Is there access to the river, are relevant landowners supportive?
- Have all the risks been determined? e.g. do the submerged logs pose a risk to other water users? Is there a risk to any infrastructure e.g. a bridge if the snags move in a flood? etc.
- Have surveys been undertaken to determine the presence of any cultural heritage sites?
- There will be a need for site rehabilitation after the snags have been put in place.

4.1.2 Other options

- Reintroduction of woody debris is the preferred short-term option for rehabilitation of instream habitat, at least for large bodied fish.
- There are some alternatives if the supply of woody debris is scarce or if there are specific issues such as high sediment loads etc.
- For each example, consultation with appropriate experts is advised and jurisdictional agencies must be contacted to determine legislative and procedural requirements.

The reintroduction of woody debris is the preferred option for rehabilitating instream habitat but there will be instances where natural snags are not available. In these cases natural materials such as wood or rock should still be used whenever possible. Some options are:

- *Log Piles* (Fish Hotels)

Provision of a significant number of logs constructed together in a complex array to create diverse habitat and cover for large bodied fishes such as Murray cod and Golden perch. They need to have complexity to support native fish communities.

- *LUNKERS* (Little Underwater Neighbourhood Keepers Encompassing Rheotactic Salmonids)
  First developed in north America they provide both bank stability and edge cover for fish. They are usually made of wood and are set into the bank. They have been successfully trialled in the Dewfish Demonstration Reach.
- *ELJs* (Engineered Log Jams)
  These are purposely engineered log groyne structures, used primarily as erosion control structures and modelled on natural log jams. As such they are "soft" engineering structures that look and act more naturally in the river and also provide habitat for fish. ELJs are currently being trialled in the Upper Murrumbidgee Demonstration Reach to provide instream habitat in a stretch of river affected by a sand slug (see more details in Appendix 4d).
- *Rock Reefs*
  Installation of rock reefs can be used to create habitat diversity by changing water levels. They have not been trialled in existing demonstration reaches.
- *Rubble habitats*
  Juvenile Murray cod and Golden perch show a preference for rubble habitats (to avoid predation). These are usually located towards the head of pools in shallow water. Rubble habitats are often threatened by sedimentation and can be re-established.
- *Cod holes*
  Murray cod breed in hollows. The installation of hollow logs can increase breeding habitat. Natural logs are preferred as they provide habitat for invertebrates etc., and are more aesthetically appropriate but old concrete pipe culverts, constructed concrete 'cod balls' and plastic drums have been trialled where logs are not available or appropriate.

The literature contains many other potential examples that could be implemented in demonstration reaches but have yet to be trialled. In the long term the goal should be to restore the riparian zone sufficiently to allow natural recruitment of woody debris and reduce sediment loads etc.




Fish hotels and Engineered Log Jams (Photos: Scott Raymond, Mark Jekabsons)

A cod hole being placed instream, and a LUNKER during and after placement in stream in the Dewfish demonstration reach (Photos: Kevin Graham, Andrew Norris)

4.1.3 Habitat for small bodied fish

- Instream habitat should also be provided for small bodied fishes and the juveniles of large bodied fishes.
- There are a number of options but the effectiveness of these needs to be tested before widespread adoption.

Research conducted in the Dewfish Demonstration Reach has indicated that more focus is required on providing instream habitat for small bodied native fishes and the juveniles of large bodied native fishes, particularly when the river is recovering from recent floods.

Options include:

- Re-establishment of aquatic macrophytes (may be difficult as they may be affected by other factors apart from floods).
- Re-establishment of emergent vegetation.
- Re-establishment of long grass within a meter of the water's edge is important for small bodied native fish such as gudgeons.
- Provision of rock rubble to provide shelter and habitat diversity (ELJ's and the associated rock groynes (particularly the rock) are providing habitat for juvenile Murray cod in the Murrumbidgee demonstration reach).

These options and others need to be investigated before widespread adoption.

4.2 Riparian rehabilitation

- The current status of the riparian zone should be assessed to determine key sites for management.
- All riparian management activities must be undertaken in cooperation with riparian landowners.

- Priority should be given to protecting healthy riparian vegetation by preventing clearing, stock and vehicle access.
- Bank stabilisation should be a priority before rehabilitation works are undertaken.
- Rehabilitation of degraded riparian habitat may be achievable at low cost by fencing and allowing natural revegetation.
- Active rehabilitation will involve reseeding or planting of seedlings together with weed control.

Rehabilitation of riparian vegetation is the most widespread management action undertaken in Australia to restore river health. Riparian zones have been cleared or the vegetation cover fragmented along many river systems. In agricultural land riparian vegetation is often confined to narrow strips subject to overgrazing and weed infestation. In many areas native vegetation has been replaced by introduced plants such as willows.

A healthy riparian zone provides for:

- Reduction in bank and bed erosion.
- Increased water quality by trapping sediments, nutrients and contaminants before they enter the river.
- Shading and cover for aquatic organisms.
- Reducing water temperature to limit evaporation and the occurrence of low dissolved oxygen
- Energy input through leaf fall etc.
- Input of woody debris into the waterway.
- Control of noxious weeds.
- Important habitat for terrestrial flora and fauna and landscape connectivity.

Good riparian land management is becoming widely practiced in Australia and there are a number of excellent documents that provide practical guidance. In particular the reader is referred to Rutherfurd *et al.* (1999) and Lovett and Price (1999 and 2007). Here the broad approach as it pertains to demonstration reaches is documented together with examples from existing demonstration reaches.

4.2.1 Where?

The first step is to assess current riparian condition in the reach and determine where protection and rehabilitation should be targeted. The highest priority should be to manage riparian vegetation that is in good condition. This is the most cost effective approach in the long term. It may also be possible to connect lengths of river with good riparian condition by rehabilitating relatively short sections of river bank.

There are a number of simple techniques that can be used to provide a broad assessment of riparian condition for example the Rapid Assessment of Riparian Condition (RARC) outlined by Jansen et al. (2005) . Aerial photographs, orthophoto maps and results of flora and fauna surveys in the area can also yield important information.

Riparian management should also be coordinated with existing natural resource management activities in the area (e.g. LandCare initiatives) and use existing networks to

work cooperatively with landholders to deliver the best results. Good riparian management on one property may provide an example for other landholders to follow. (see examples in Appendix 4e).

4.2.2 Protecting riparian vegetation

Where riparian vegetation is in a healthy condition the goals should be to:

- *Maintain the riparian zone at a width that will retain its structural integrity and effectiveness (maintaining bank stability, filtering sediment, nutrients etc).* The effective width will vary depending on the position in the catchment, topography etc. but Ashley-Doran (2005) suggests a minimum of 30 to 50m as a general rule. The width of the riparian zone to be protected has to be negotiated with the landholder as it is removing land from productive use.

- *Avoid disturbance to the riparian zone.* This includes working with landowners to avoid any unnecessary clearing etc. Vehicle access may also be an issue particularly along riverine recreational reserves where camping etc. may be permitted. Here it will be a matter of restricting vehicle access to the riparian zone and will involve working with the local council.

- *Restricting stock access.* Continuous grazing in the riparian zone will lead to damage to riparian vegetation, reduced levels of recruitment and regeneration of riparian flora, increased levels of weed infestation, stream bank erosion and reduced water quality. Fencing of the riparian zone is the most common approach to restricting stock access. The fences must be sufficiently strong to keep cattle out and to resist flood damage.

- *Control weed infestations.* Healthy riparian vegetation with restricted stock access should have limited issues with weed infestations.

A healthy riparian zone is a key feature of a healthy river (Photos: Jason Lieschke)

Riparian zones can be damaged by clearing, weed infestations and unrestricted stock grazing. Fencing and weed control can help protect riparian zones. (Photos: Scott Raymond, Fern Hames)

4.2.3 Rehabilitating riparian vegetation

All the points listed above under "Protecting Riparian Vegetation" should also be implemented here with the additional requirement to undertake rehabilitation actions. Actions that can be undertaken will depend on the funds and other resources available. In highly degraded areas the first question to ask is are there any stream bank stability issues? If the answer is yes, these need to be addressed first before resources are directed at rehabilitating the riparian zone.

- *Natural Regeneration.* Where there are limited resources, the area can be fenced off and natural regeneration allowed to occur. There will be a requirement for some initial and ongoing weed treatment.
- *Revegetation.* This involves the active reintroduction of plants either through seeding or planting of seedlings. The priority should remain one of replicating nature so replanting native vegetation of local genetic provenance is essential. It is also important to plant the correct species in the right areas. For example small,

pliable species should be planted within the banks of the river so that they do not increase flooding.

(see examples in Appendix 4f).

Riparian vegetation can be rehabilitated by providing suitable conditions for natural regeneration, as well as planting and direct seeding (Photos: Tony Townsend, Karly Learmonth)

4.3 Water quality

- Event based monitoring is required to identify water quality issues and their sources.
- Rehabilitation of riparian vegetation etc. will help protect the reach from a number of water quality problems e.g. turbidity, nutrient input, high temperatures.
- Point source pollution will have to be tackled at the source.
- Some large scale problems e.g. cold water pollution, salinity will be expensive to ameliorate and difficult to tackle during the life of a demonstration reach. They may be a reason for locating a demonstration reach elsewhere.

Water quality may cause significant problems in demonstration reaches. Rutherfurd *et al.* (2000) lists six ecologically important categories:

- *Turbidity/fine sediments*. Can impact directly on fish by clogging gills. Can also smother the bed, reducing habitat diversity, smothering fish eggs and reducing macro invertebrate numbers. Turbidity can also restrict photosynthesis and the growth of aquatic macrophytes.
- *Increased nutrient loads.* Can lead to algal blooms and increased macrophyte abundance. In extreme cases it can lead to depletion in dissolved oxygen and fish kills.
- *Reduced dissolved oxygen.* Can lead to fish kills through high nutrient levels and excess organic waste entering the river. Can also be caused by large lengths of unnaturally shallow water.
- *Temperature, high and low.* Changes from the natural temperature regime can disrupt life cycles of fish and macro invertebrates. High temperatures may result

from removal of riparian vegetation etc, and unseasonally low temperatures may result from cold water release from dams for example.

- *Salinity*. Saline intrusions to rivers due to land clearing and consequent rising water tables can significantly impact on aquatic biota. For example, River blackfish are sensitive to salinity increases as are the larvae of many fish species and some macro invertebrates.
- *Toxicants*. Organic and inorganic chemicals such as pesticides and detergents etc elicit a wide range of responses depending on the particular chemical from reduced reproduction in fish and invertebrates to pathological changes in fish gills.

A variety of water quality issues can affect the health of a river system (Photos: Di Crowther, Jarod Lyon, Mark Jekabsons, Tom Ryan)

4.3.1 Is there a problem?

Monitoring needs to be undertaken to determine if there are water quality problems in the demonstration reach and identifying the sources of these problems. It may be possible to link in to existing monitoring programs carried out by state or local natural resource management agencies or by community driven programs such as WaterWatch. Event based monitoring will be required, for example high turbidity levels will be linked to high flow events. Once any problems have been identified and their sources located, appropriate rehabilitation actions can be undertaken.

4.3.2 Rehabilitation actions that address multiple issues

A number of the rehabilitation actions already described will assist in maintaining good water quality. For example, riparian rehabilitation will help reduce turbidity, nutrient and high water temperature problems and the introduction of large woody debris can assist with bed and bank stability. It may still be necessary to target these actions where they can be most effective, for example undertaking riparian rehabilitation next to a cattle feedlot will reduce the risk of high nutrient loads entering the river. It will also be necessary to ensure that there are no drainage lines that run through the riparian zone.

4.3.3 Point source pollution

Where toxicants are entering the river from point sources, the issue will have to be addressed at that source. (e.g. as factory).

4.3.4 Large scale problems

Some water quality problems will be difficult to address. For example, cold water pollution from a large dam can only be ameliorated by the provision of a highly expensive multilevel off take tower. In this situation in may be inappropriate to locate a demonstration reach downstream of such a structure as it would be unrealistic to expect a resolution. On the other hand, if a multilevel off take tower is under construction, there is an ideal opportunity to tie this in with a demonstration reach.

Salinity management is likely to be a large issue that needs to be planned at a catchment or even a regional scale. However, small scale salinity problems may be manageable (see example Appendix 4g). The amelioration of sediment input may in the long-term have to be addressed at the catchment scale by replanting and improved catchment management. Neither are likely to be resolved in the life span of a demonstration reach.

(see example in Appendix 4 g).

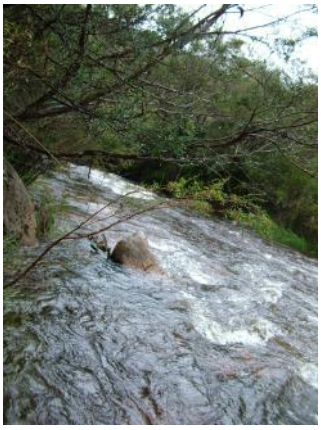
4.4 Environmental flows

- Rehabilitating flow regimes through the provision of environmental releases is normally beyond the scope of a demonstration reach program.
- The sites for planned environmental releases could be used to develop demonstration reaches.

Regulation of natural flow regimes and the extraction of water for consumptive use has significantly impacted on riverine fishes in the Murray-Darling Basin and throughout Australia. Regulation alters the hydraulic nature of flows often resulting in a reduction in flow diversity and hence habitat diversity. In the Basin, high volume, high velocity irrigation flows in summer are the opposite to natural low flow periods resulting in a decline in the abundance, distribution and recruitment of many native fishes. The decline in regular natural floodplain inundations has impacted on a wide variety of native fishes including floodplain wetland specialists. It has also reduced the nutrient exchange between the floodplains and the river. In the lower Murray weir pools have changed a flowing

environment into a non-flowing one disadvantaging some species. Changes in flow timing have reduced spawning and movement cues for native fishes.

Changes to legislation and policies in the Basin have led to more water being made available for the environment through the provision of environmental water allocations. Determining flow requirements (quantity and timing) for a demonstration reach requires expert input and coordination with jurisdictional and Commonwealth natural resource management agencies. Such negotiations are normally outside the scope of a demonstration reach project but where environmental flow releases are planned it could be advantageous to enhance the impact of these releases but undertaking habitat rehabilitation through the establishment of a demonstration reach. (see example in Appendix 4h).



Environmental water allocations are outside the scope of demonstration reach projects, although the impacts of environmental flow releases can be enhanced by undertaking habitat rehabilitation (Photos: Jason Lieschke)

4.5 Fish passage

- The first priority is to identify the movement requirements of the fish community in the demonstration reach.
- The reach can then be surveyed to determine potential barriers and their likely impacts on fish passage. Engineering and fish biology expertise is required early on in the process and through to the construction and commissioning stage.
- When sites have been prioritised, conceptual designs can be drawn up and likely costs estimated. These can be used to seek funding.
- If funds are available, detailed designs can be drawn up followed by construction and commissioning of the fishway.
- It is important to negotiate operational and maintenance requirements with appropriate jurisdictional and local government agencies. Well-designed fishways do not operate without specific flow allocations and ongoing maintenance will be required.

Native fishes move both within and between habitats. Movements may be meso-scale (short-term movements within the normal home range) or macro-scale (prolonged long-term, large scale movements between habitats. They may be longitudinal (up and downstream) or lateral (channel to the floodplain for example). Movements have been documented in both large bodied fish (e.g. Murray cod, Golden perch) and small-bodied species (e.g. Gudgeons and Spangled perch) and in all life history stages of species. Connectivity within and between habitats is vital to maintaining health and resilient native fish populations.

Barriers to fish movements include physical barriers ranging from large dams and weirs to gauging weirs, culverts and road crossings and may also include shallow areas of river caused by reduced flows. Behavioural barriers may also be present caused by low water temperatures (cold water pollution) and changes in flow regimes resulting in a lack of flow cues for migratory species such as Golden perch.

4.5.1 Identifying problem sites

The first step in to identify potential problem sites, these can be identified by going through the following process:

- *What fish species are present and what are their movement requirements*?
  Data will be available on fish species present in the demonstration reach and there is now sufficient information available in the literature to indicate the movement requirements of most species including the seasonality of that movement. The presence of any threatened species will increase the need for action.

- *Identify potential barriers*
  The next step is to identify potential barriers. Dams and weirs are obvious ones but other structures like small culverts and road crossings can potentially form barriers to fish movement and should be investigated.

- *Frequency of present fish passage*
  How much fish passage do the current structures allow? What is the drown out frequency of weirs etc? What velocities are experienced through culverts etc? Expert advice from hydrologists and fish biologists will be required.

- *Habitat area impacted*
  What habitat would be opened up to fish and what quality is that habitat? In a demonstration reach where habitat rehabilitation is being undertaken, consideration should be given not just to current habitat condition but expected condition of the habitat in the future.

- *Other factors*
  Are there factors that cannot easily be controlled within the demonstration reach? For example, is there a cold water pollution issue that cannot be addressed or are there flow regime issues etc?

If the above process reveals significant fish passage issues that can be addressed, the next step is to investigate solutions at each site and the costs of rehabilitation actions.

4.5.2 Determining potential solutions and their costs

Once sites for rehabilitation are prioritised, it is a matter of developing conceptual designs for these sites. Here both engineering and fish biology expertise relating to the design and costs of fishways are essential. Fortunately, over the last 20 years a significant amount of expertise has been built up in designing fishways for Australian conditions and for native fishes. This expertise is available in a number of jurisdictional natural resource management agencies and through consultants. At this stage it is important to involve all stakeholders to establish ownership of the project.

This conceptual design stage will enable a realistic cost estimate to be made. The type of fishway may vary from rock ramp structures, baffles in culverts to vertical slot fishways or fish locks on high structures and costs will vary accordingly. Fish passage improvements can also be undertaken when road crossings etc. are being upgraded by ensuring that fish friendly river crossings are installed (see Hyperlink: http://www.dpi.nsw.gov.au/_data/assets/pdf_file/0004/202693/Why-do-fish-need-to-cross-the-road_booklet.pdf).

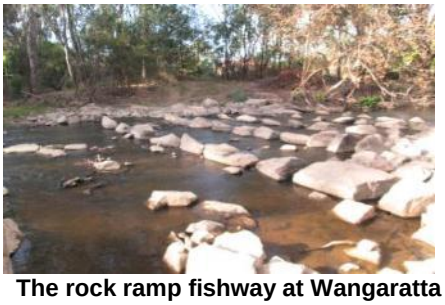
4.5.3 Funding

Funding for fishways is highly variable but can seem prohibitive where highly engineered structures such as vertical slot fishways are required. However, funding may be available even for these structures were jurisdictional fishway programs are in place and a good case can be made. A concept design together with the logic for selecting the particular site and the likely benefits can add credibility to an application. The Whole of Life Plan indicating other complementary habitat rehabilitation actions with also support the application.

4.5.4 Construction

If funding is obtained, detailed design will then be undertaken followed by construction and commissioning of the fishway. It is important that negotiations are undertaken with both jurisdictional and local government agencies to ensure that the operational requirements of the fishway are agreed to (including watering requirements) and that a maintenance schedule is agreed to, including removal of debris after flooding etc.)

Provision of fish passage is one of the most common rehabilitation activities undertaken at existing demonstration reaches occurring at five out of seven reaches. (see examples in Appendix 4i).




The rock ramp fishway at Wangaratta on the Ovens River demonstration reach (Photos: Scott Raymond)


Vertical slot fishways are highly engineered structures (Photos: Fern Hames, Wayne Tennant)

4.6 Screening of irrigation offtakes

- Demonstration reaches are well placed to undertake trail screening programs for water diversions.
- The program must be developed in consultation with all stakeholders especially irrigators.
- Recent work by Boys *et al.* (2012) together with overseas literature should be used to develop design criteria for screens. Demonstration reaches provide the ideal opportunity to trial the preliminary designs used by Boys *et al.* (2012) on a longer-term basis.
- Incentives may be necessary to assist irrigators in overcoming the additional costs for screening.

There is a significant amount of evidence that large numbers of native fishes are being lost to rivers through water abstraction. The scale of the impact may differ from location to location and between seasons but given the volumes of water that are diverted from Australian rivers, fish entrainment is a significant issue. It encompassed a wide range of species and sizes from large bodied species to small bodied species as well as eggs and larvae of large bodied species. Overseas, particularly in North America, fish entrainment by water abstraction is taken very seriously and specific screening programs have been set up with regional guidelines. While Australian guidelines do not exist at present, recent work by Boys *et al* (2012) has shed some light on the likely screen designs for native fishes. The study was undertaken in the Namoi demonstration reach. Similar work in other demonstration reaches would help “spread the message” paving the way for a Basin wide fish screening program for water diversions. The following broad guidelines are based on the recommendations of Boys *et al.* (2012).

4.6.1 Consultation

Consistent with all interventions in a demonstration reach it is essential to work with all stakeholders. In this instance irrigators and water user groups will be the key stakeholders.

4.6.2 Determine the extent of the problem

The next step is to take an inventory of the numbers and types of diversions present in the demonstration reach. Although more work needs to be done at specific localities to determine the extent of fish loss through specific diversion sites, there is enough evidence to suggest a precautionary approach should be taken and the loss of fish should be assumed significant.

4.6.3 Determine solutions

In the absence of Australian design criteria, Boys *et al*. (2012) suggest taking an evidence based approach to setting screen design and criteria for Australian species and vulnerable age classes. Their work suggests that approach velocities should not exceed 0.1m/sec and that perforated plate material is suitable for Australian species. They also point out that extensive development has already taken place in North America and this knowledge should be utilised.

4.6.4 Implementing a screening program

It is essential to work with irrigators as screening of pumps to stop fish entrainment will cost money. Incentive funding may be required to assist them. It will also be necessary to factor in ongoing maintenance costs.

4.6.5 Monitoring

The advantage of setting up a screening program in a demonstration reach is that rigorous monitoring will be undertaken and an adaptive management approach adopted. The program will contribute to the broad knowledge of screen designs to stop the loss of fish to water abstraction. Demonstration reaches have the opportunity to use the trial work and preliminary screen designs used at the Namoi demonstration reach and test them on a more permanent basis.

Irrigation screens being trialed along the Namoi demonstration reach (Photos: Craig Boys)

4.7 Alien species management

- An integrated pest management approach must be taken when dealing with alien fishes including the development of a management plan.
- The management plan should be developed in consultation with the community and have clearly stated goals.
- The plan may involve actions to prevent incursions of new species as well as the control of established species. Control actions should be aimed at reducing the impacts of alien species to an acceptable level.
- A range of management actions should be taken to ensure an integrated approach (e.g. community education, removal tools – electrofishing, netting etc., screening, habitat rehabilitation etc.).

Fish assemblages in the Murray-Darling Basin are becoming increasingly dominated by alien species –that is species that originate from overseas but have become established in Australian waters (Harris 1995) or native species that have become established outside their natural range. There are 12 alien fish established in the Basin (see Lintermans 2007) of which Carp (*Carassius auratus*) is the most widespread and abundant. Gambusia (*Gambusia holbrooki*) is also widespread and has significant impacts on native fishes, particularly small bodied species. Other species such as Tilapia (*Oreochromis* spp.) are established in catchments close to the Basin and could be introduced in the future. Alien species have contributed to the decline of native fishes, impacting in many ways including: direct predation, competition and habitat alteration. Alien fish impede the recovery of native fish even when other threats are being addressed. Most alien fish thrive in aquatic habitats disturbed by human activities. They can significantly reduce the impact of habitat management interventions in demonstration reaches.

Some alien fish management activities are being undertaken at six of the seven existing demonstration reaches. Most of the work has concentrated on Carp management, however, there is a community driven Gambusia removal program in the Upper Murrumbidgee demonstration reach (see Appendix 4j). At most of these reaches Carp musters (community run fishing competitions) are the only activity. These musters are a very valuable community engagement, awareness and education tool but do not control Carp numbers. At the Dewfish and Upper Murrumbidgee demonstration reaches a more integrated approach has been taken using the principles outlined below. Although these principles have been chiefly used for Carp, they are equally applicable to the management of other alien fishes.

It is important to take a systematic and strategic approach to managing alien fish in a demonstration reach. This approach must be driven by first establishing the goals of the program and then working out the most cost effective actions to take given the limited

resources that are available. The reader is referred to Braysher and Barrett (2000) and Braysher and Saunders (2003) for more details but the points below outline the framework for developing an Alien Fish Management Plan for a demonstration reach:


Many demonstration reaches have held Carp musters (Photos: Tony Townsend, Matt Barwick)


Local schools in Wangaratta have incorporated Gambusia removal from wetlands in their curriculum. (Photos: Tony Townsend). **Tilapia training workshops have been held in Queensland** (Photo: Greg Ringwood)

4.7.1 What is the nature of the problem?

The first thing to do is to understand the problem and to set the objectives for a management plan. This should be done in full consultation with the community to ensure local ownership.

- *Are there alien species that may become established in the demonstration reach?* For example, Tilapia are not present in the Basin but are established in south east catchments in Queensland, very close to the Dewfish demonstration reach on the Condamine. Management actions to prevent an incursion are priorities for this reach and the whole Murray-Darling Basin.

- *Are there established alien species in the demonstration reach?*
  Are there established alien fish populations within the reach, what impact are they having on native fishes? Are they widespread within the reach or are there isolated populations that could be contained?

4.7.2 Setting priorities for management

4.7.2.1 Preventing incursions of new species

For prevention, priority actions will include; a targeted education and extension program to prevent human added translocations of alien species into the reach, setting up a surveillance program to detect any incursion as soon as possible, setting up a rapid response strategy with the relevant jurisdictional agency.

4.7.2.2 Managing established species

This should focus on management actions that will reduce the damage caused by alien fish to an acceptable level. The demonstration reach should be broken up into management units and these can then be ranked based on the perceived threat of the alien species to native fishes. For example are there floodplain wetland areas were Carp recruitment is occurring? Are Carp threatening spawning sites of native fishes? Are there wetland areas where Gambusia populations could be removed, to protect small bodied native fishes?

4.7.3 Management techniques

There are no “silver bullets” control alien fishes but there are a range of tools available including: capture techniques (electrofishing, nets, traps etc.), Habitat manipulation (draining waterways, draw down of fish breeding areas), Fish exclusion devises (fish screens, Carp cages) etc. Rehabilitation of the habitat and native fish populations will also make the reach more resilient to alien fish disturbance. Invasive species such as Carp, Gambusia and Tilapia appear to thrive in disturbed waterways. Improving the river health in the demonstration reach should remain the overarching management technique. Management actions should be undertaken where environmental conditions maximize the outcomes.

4.7.4 Monitoring

Monitoring of alien fish management interventions should be included in the Monitoring and Evaluation Plan and be hypothesis driven. (see example in Appendix 4j).

4.8 Fish Stocking

- Fish stocking should only be undertaken if the need had been clearly established and there are no alternatives.

- Genetic management is vital if wild genetic diversity is to be maintained ensuring the wild population maintains the ability to adapt to environmental change, disease and competition.
- Fingerlings must be obtained only from hatcheries where there is a quality assurance program. Stocking should only be undertaken when a five year program has been developed and funds are guaranteed over this period.
- All hatchery released fish should be marked (e.g. tagged in some way so they can be distinguished from wild fish) so that the contribution of stocked fish to the population can be monitored.

Stocking hatchery reared fingerlings of native fish species (particularly recreational species like Murray cod and Golden perch) is widely practiced in most parts of Australia and all jurisdictions in the Basin apart from South Australia. It is a common fisheries management tool and has created recreational fisheries in artificial impoundments and has temporarily boosted fish numbers in riverine situations. There are however potential negative impacts from fish stocking. These include:

- Impacts on wild population genetics from interbreeding with genetically inferior hatchery reared fish.
- Introduction of disease.
- Overstocking.
- Translocation of non-target species (including non-desirable fish species and invertebrates).
- Masking of underlying causes for wild stock depletion.
- In demonstration reaches, masking the impacts of habitat rehabilitation activities on fish populations (e.g. are population increases due to stocking or habitat rehabilitation?).

Stocking is a short term fix that should only be used as a last resort for example where there is a spawning bottleneck that cannot be resolved by habitat rehabilitation. It may also be appropriate where an endangered species is being re-introduced to its native habitat.

4.8.1 Is there a need to stock?

Is there compelling evidence that wild populations are severely depleted and that other actions e.g. habitat rehabilitation, changes in fishing regulations etc., cannot be used to rehabilitate wild populations. Is there an identified bottleneck (e.g. lack of recruitment) that cannot be overcome any other way? Is it an endangered species that is being re-introduced to its native range?

If the answer to any of these questions is affirmative then stocking could be considered as a management tool. It should be undertaken with the goal of rehabilitating wild populations, not to enhance recreational fisheries. In the long-term, together with habitat rehabilitation it may well lead to enhanced recreational fisheries.

4.8.2 Do we understand the genetic profile of the wild stock?

Do we understand the genetic variability inherent in the wild population and can suitable fingerlings be produced in a hatchery? If our understanding of the wild population genetics is unclear, can sufficient broodstock be harvested from the river and used in hatchery production of the fingerlings.

4.8.3 Quality assurance

Is there a hatchery available where there is sufficient quality assurance to reduce the risks of disease transfer, translocation of non-target species etc. to an acceptable risk level (e.g. some NSW hatcheries are part of a Hatchery Quality Assurance Program).

4.8.4 Developing a stocking management plan

Stocking should occur over a five year period with sufficient numbers released to ensure the establishment of a population structure. Is the hatchery able to produce fingerlings over this time frame; are funds available to purchase the fingerlings?

4.8.5 Release of the fingerlings

All fingerlings should be marked before release so that their contribution to future sampling is known. (see example in Appendix 4k).

Local communities participating in the release of native fish (Photos: Tony Townsend, Scott Raymond)

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4.10 Appendices for Intervention Pillar

4.10.1 Appendix 4a – Table of Interventions

	B to Bre	Namoi	Dewfish	Hollands	Ovens	UM	Katfish
Instream - Re-snag	*	*	*	*	*	*	
Instream - other			*			*	
Alien	*	*	*	*	*	*	
Riparian	*	*	*	*	*	*	
Passage	*	*	*		*	*	*
Screening		*					
Flows							*
Stocking		*	*	*		*	

4.10.2 Appendix 4b – Woody debris loads (snags)

Hume Dam to Yarrawonga Resnagging Program

(see hyperlink: http://www.mdba.gov.au/sites/default/files/archived/mdba-tlm-reports/2092-Resnagging_the_River_Murray_factsheet.pdf

The program, funded under the Living Murray initiative, has resnagged 14 sites along the River Murray. A plan to identify areas for resnagging and to determine appropriate snag loads was developed in 2004. Key points were:

- A "snag assessment" collected data on existing snags including location, size, complexity, snag alignment and depths.
- Associated riparian condition and connectivity were also recorded.
- Data were also available on the number and location of snags that had been removed in the past (from "river improvement" works records).
- From this information an "instream woody habitat load" was calculated.
- Priority areas for resnagging were based on the above assessment and consideration of establishing connectivity with existing good quality instream habitat.
- Consideration was also given to practical aspects such as source of snags, transport and access to the river.

4.10.3 Appendix 4c – Sources of woody debris

Dewfish Demonstration Reach

- Land clearing for industrial and farm use- The machinery contractors who clear the timber can often be used to install the snags in the river.
- Road realignments.
- Mining sites.
- Storm damage.

Hume to Yarrawonga Resnagging Program

Only felled native hardwood trees were used and were sourced from development sites, road and bridge construction sites and approved farmland clearing. Relevant authorities such as local government, development corporations etc., to ensure that trees were stockpiled for later use in the snagging program.

4.10.4 Appendix 4d – Maintaining stability of woody debris

Dewfish Demonstration Reach

Re-snagging of sections of this demonstration reach have been very successful with great stability achieved. The results suggest that:

- Important to select "good" snags in the first place e.g. with root ball intact and four or five good branches.
- Select sites not in full velocity flows during floods.
- Key the root ball into the bank.
- Four or five branches should dig into the bed to stop movement and prevent the snag from rolling.
- Face the trunk downstream.
- Pin the snag with at least 250mm hardwood logs.

Logs are most likely to move within the first six months, after which they become waterlogged and hence more stable. More complex snag piles are the most stable.

Upper Murrumbidge Demonstration Reach- Tharwa Fish Habitat Project (see reports http://upperbidgereach.org.au/node/519)

Reintroduction of large woody debris to create habitat diversity can become problematic in waterways where there is high sediment loads. Widespread catchment erosion in the late 1800s and 1900s has caused areas of sand build up in the Murrumbidgee River (e.g. Tharwa). This has resulted in sections of the river that are very shallow with little or no instream habitat. Engineered Log Jams (ELJs) are being trialled to improve river channel deepness and fish habitat.

Key points are:

- Large Woody Debris introduced in the normal way is likely to be quickly buried under shifting sand loads.
- Well designed ELJs are a proven technique in Australia that can have positive effects on river physical and ecological functions.
- They can be expensive if a local supply of timber is not available.
- A community information session was held to inform stakeholders about the ELJs project.
- The introduction of ELJs will be accompanied by other site restoration activities including riparian plantings.
- Monitoring of the fish fauna has taken place both before and after the ELJs were constructed. So far monitoring suggests that they have improved both river channel deepness and native fish assemblages.

Hume to Yarrawonga Resnagging Program

Individual logs were embedded with electronic microchips to tag the logs to identify the extent of any movement from their original position as a result of floods.

4.10.5 Appendix 4e – Determining riparian rehabilitation sites

Dewfish Demonstration Reach –Revegetation Oakey Creek

Grazing livestock has resulted in degraded riparian vegetation including loss of key tree species and ground cover. The initial aim has been to improve vegetation condition and connectivity along a 5km stretch of the 20km reach. The rehabilitation was planned to improve connectivity between two patches of Queensland Herbarium recognised regrowth vegetation and extend the width of the current regrowth area.

Upper Murrumbidgee Demonstration Reach- Riparian Surveys

In 2013, Cooma Waterwatch undertook surveys along the entire length of the NSW section of the Murrumbidge River to assess riparian health.

The Key points are:

- Assessments were made using the RARC methodology.
- Results will be mapped and used to prioritise riparian management and will also provide a baseline upon which to measure future change.
- Willow saplings are colonising previously willow free areas including areas with good native vegetation. The results will used to prioritise willow control activities (see appendix 4i).

Dewfish Demonstration Reach-Revegetation of Oakey Creek (see Thorpe 2011)

The approach was to replant in degraded areas, remove the weed African boxbrush and improve the diversity of existing regrowth together with landholder supplied fencing.

Key points are:

- Compromise may have to be made regarding the width of the riparian zone. In this case the vegetation Management Code for the Brigalow Belt Region recommends a buffer of 200m for a waterway the size of Oakey Creek. Current agricultural use limited the width to a maximum of just over 100m from the water.
- There are however significant opportunities to increase the length of health riparian zone.
- African boxthorn was mechanically removed from within the planting sites but further control measures are required.
- Mulch was used to suppress other plant growth around the seedlings. The mulch was from locally sourced bluegrass bales. This was free of agricultural propagules and provided a native grassland seedbank.
- Timing of planting was flexible to avoid drought and flood while ensuring the appropriate amount of moisture for planting.
- Plant selection was based on species already present at the site and to include a broader range of species when planting beyond the upper bank into the floodplain. Plant species were also selected to improve habitat for the Regent Honeyeater.
- Plants were selected and placed to increase long-term success in the large ranges of microhabitats present (e.g. cleared ground, gilgais, sparse regrowth canopy etc.).
- Communication between the landholder, the fencer and the planter is essential. In this case there were occasions when the fencing wasn't completed before the planting window and covered a larger area that required. Additionally gateways were sometimes narrower that was required by the landholder for maintenance purposes.

4.10.6 Appendix 4f – Approaches to rehabilitating riparian vegetation (e.g. natural regeneration, planting)

Upper Murrumbidge Demonstration Reach- Willow Control (see reports http://upperbidgeereach.org.au/node/218)

Introduced willows can dominate the riparian zone in many areas of the Basin. Willows do not provide the input of energy and woody debris that native species do and do not provide the diversity of habitat for riparian dwelling fauna. They are also prolific and "choke" shallow sections of waterways. The Upper Murrumbidgee Demonstration Reach Community Willow Control Program is funded by the NSW DPI Habitat Grant program and has the aim of controlling emergent instream willows along 45km of the demonstration reach from Bredbo to Angle Crossing.

Key points are:

- Well established willows are difficult and costly to remove. Targeting young emerging willows growing instream before they become a source of further infection is a cost effective approach.
- The project uses volunteers e.g. Willow Warriors.
- Small teams of volunteers paddle the river and remove willows along the way.
- The willow removal is carried out under the guidance of qualified professionals including trained river guides and uses best practice methods for controlling willows.
- The project also identifies high value riparian and aquatic habitat for protection against willow invasion and identifies sources of willow spread.
- Riparian Blackberry is also being mapped and the information shared with Cooma Monaro Shire Council.
- Control in high value riparian areas of the UMDR are prioritised.
- This project contributes to implement Willow control in river reaches prioritised by the UMCCC Willow Management Strategy.

4.10.7 Appendix 4g – Water quality

Katfish Demonstration Reach- Maintaining Water Quality for Murray hardyhead

The Murray hardyhead (Craterocephalus fluviatilis) is endangered under the IUCN Red List 2004, and the federal EPBC Act 1999. It can reside in habitats with a wide range of salinities, but seems to have a competitive advantage in waters with a higher salinity range. Due to numerous threats, the species has suffered a decline in distribution at both a state and basin wide scale. Numerous populations across the Murray Darling Basin are now believed to be extinct from sites where it has historically been recorded. Currently there are eight known sites within South Australia and Victoria where viable populations exist, one of these sites is the Berri Saline Water Disposal Basin, in the Riverland South Australia.

The Berri Saline Water Disposal Basin is located within the the Katfish Reach project area. In the past, the site received high volumes of saline irrigation drainage water from the Berri Irrigation Area. Between 2005 - 2010, inflows of irrigation drainage water declined significantly, through improved irrigation efficiencies due to drought conditions. This resulted in the majority of the Berri Basin drying out, forcing the Murray hardyhead population to retract into a smaller habitat area with unfavorable conditions.

Under the Katfish Reach Demonstration Reach project, the high value of this site for Murray hardyhead was identified, and a range of on-ground interventions were developed to create additional habitat for the species at the site and to upgrade existing infrastructure to achieve appropriate salinity ranges and water level variations at the site to create ideal conditions for Murray hardyhead.

During 2013 the on ground works were completed in the form of a 3km long surface channel along the western edge of the Berri Basin to corral the limited saline irrigation drainage entering the site. The salinity of the drainage water can now be diluted or increased via management of an upgraded water flow control structure which allows fresh water to enter the site from the River Murray when required. Due to these interventions, salinity and water level at the site can be managed to create and maintain ideal conditions for Murray hardyhead. Monitoring of water quality and fish populations is ongoing at the site and recent sampling of Murray hardyhead post intervention, have demonstrated a consistent significant population increase, indicating successful recruitment within the site. Due to the recent rapid decline of Murray hardyhead throughout its range, securing the Berri Basin population was critical to ensure the long term future of this species.

4.10.8 Appendix 4h – Environmental flow management

Katfish Reach – Katarapko South Australia

The Katfish demonstration reach was established in 2007 to provide a holistic approach to the management of the health of the Katarapko anabranch system and its associated floodplain. Constructions of locks and weir structures along the Murray River have created predominately lentic habitats where there were once hydrodynamically diverse lotic systems. The Katarapko anabranch and floodplain system bypasses Lock and Weir 4 and has retained hydraulically diverse aquatic habitats. However there are barriers to fish movement and a lack of environmental flows has caused widespread ecological decline of the floodplain.

Significant funding has been secured through the Murray Futures Riverine Recovery Project and an integrated hydrological operating plan is being developed. There are six flow related management interventions being implemented:

- Improve spring/summer inundation of Eckert Island at low river flows.
- Temporarily partial dry and vary pool level of Eckert Creek anabranch system.
- Achieve fish passage and increased in-stream flow for Eckert Creek anabranch system.
- Achieve fish passage and increased in-stream flow for Katarapko Creek.
- Improve flows, Carp control and fish passage at Ngak Indau Wetland.

Improve opportunities for wetland inundation frequency at a number of temporary wetlands and Katarapko Island Saline Water Disposal Basin.

4.10.9 Appendix 4i – Fish passage restoration

Loudoun Weir Fishway- Dewfish Reach-Condamine Alliance.

Loudoun Weir on the Condamine River supplies water to the town of Dalby. Originally about 4m in height it was constructed in 1959 and fitted with an ineffective pool and weir fishway. In 1995 the weir height was increased by 1.2m and a new fishway was required under state fisheries legislation. A vertical slot fishway was subsequently built but unfortunately had some design faults.

With the implementation of the Dewfish Demonstration Reach Project, the Condamine Alliance gave priority to increasing the effectiveness of the fishway. It has subsequently been upgraded in 2006 and 2012 and these upgrades together with ongoing maintenance activities have seen significant increases in native fish numbers upstream of the weir. Key points are:

- The Condamine Alliance has had to work over a long period of time with multiple stakeholders to achieve a successful result including; local, state and Commonwealth government agencies, private contractors and local communities. There has not always been agreement and the persistence of key people has been vital.
- As well as design and construction, operation and maintenance are key.
- Negotiations to achieve appropriate operating plans for the fishway have been difficult and protracted but worked through with operators. Full credit must be given to the WDRC staff that operates the fishway according to the plan. Education of the staff and management was critical to achieving this outcome
- There is a need for ongoing maintenance particularly on a river like the Condamine where flood levels can result in high sediment and wood debris loads affecting the operation of the fishway.

4.10.10 Appendix 4j– Alien species management

Integrated Carp Management Plan-Dewfish Reach-Condamine Alliance

In 2009 an Integrated Carp Management Plan was prepared for Dewfish Reach which recognised the potential for new alien fish to become established (namely Tilapia). The objectives are to:

- minimise the risk of new alien freshwater fish establishing in the catchment.
- target reduction of Carp abundance within the reach as measured using standard techniques.
- limit Carp recruitment within the geographic area of the site, without impacting on native fish recruitment.
- limit Carp emigration and migration to the site and movement within the site, without impacting on native fish movement.
- promote community awareness & increase the involvement of community & local management agencies in Carp management & therefore other rehabilitation activities within the site.

The demonstration reach was divided into management units with a number of management actions for each (e.g. install a Williams Carp Separation Cage at Loudoun weir, establish mobile instream carp traps, promote targeted Carp removal, investigate devises to exclude Carp from emergent vegetation, provide adequate disposal facilities for captured Carp. While all the proposed action are yet to be implemented (e.g. Williams Carp Separation Cages cannot be installed under state legislation), the Condamine Alliance has developed and is implementing an Action and Implementation Plan for preventing Tilapia from entering the northern MDB and has been actively removing Carp from key sites along the demonstration reach. Carp numbers have remained low at most sites apart from below Loudoun weir. Research into improved Carp trap designs will occur in 2014. It may be possible to implement a community Carp trapping program.

Community Control of Gambusia in the Upper Murrumbidgee (see Gambusia Forum 2011, http://www.mdba.gov.au/media-pubs/publications/gambusia-forum-2011)

Gambusia occur in a number of habitats in the Upper Murrumbidgee including ponds and small farm dams. The primary vector for their introduction to these habitats appears to be humans. The Upper Murrumbidgee Waterwatch (UMWW) together with ACT Conservation Planning and Research (CPR) began a program in 2011 to engage the local community in removing Gambusia from urban dams and ponds. The aims are to achieve cost-effective removal of Gambusia and to educate the community about the negative consequences of spreading this species.

Key points are:

- The UMWW has used its networks to identify bodies of water that have community interest in Gambusia control.
- These water bodies have been assessed to determine their level of infestation (dip netting and visual observations), connectivity to other waterways, locality in the catchment, size and access etc. UMWW and CPR then prioritised the ponds for control.
- Removal is undertaken in winter months when fish numbers are low and the fish congregate in warmer areas. Techniques for removal are based on recommendations from Victoria..
- The UMWW is running a concurrent community education and engagement program.
- If the project is successful and Gambusia free sites are achieved, they will be considered for introductions of small bodied native fish.
- Fish are euthanized by UMWW of CPR persons under ethics approval through the ACT government. The fish are not euthanized in the presence of children.

Upper Murrumbidgee Demonstration Reach- Carp Reduction Plan (see http://upperbidgeereach.org.au/files/domain-4/UMDRcarpplan-5-7.pdf and http://upper-bidgereach.org.au/node/1366

Carp are well established in the Murrumbidgee demonstration reach and the surrounding areas. A Carp Reduction Plan, which sits under the Implementation Plan for the demonstration reach, lists three overarching issues to be implemented:

- Promoting community engagement (e.g. "Carp out/Carp Muster" events).
- Addressing priority knowledge gaps (e.g. lack of detailed knowledge of Carp distribution, local habitat preferences, population dynamics etc.).
- Examine operating policy or regulatory 'levers" to assist Carp control (e.g. e.g. coarse fishing events, keeping of Koi Carp etc.)

The plan identifies three management units, two of which cover the demonstration reach and the third extends the area to Molonglo River and Lake Burley Griffin. The management plan also highlights that managing Carp cannot only be confined to the demonstration reach area. Individual actions include installing Williams Carp Separation Cages on fishways, screening off takes, surveillance and rapid response in Carp free zones etc. A rigorous monitoring program is also recommended. It is emphasised that Carp control is part of a suite of management interventions to rehabilitate the demonstration reach for native fishes.

The demonstration reach will undertake a cooperative research project with Bush Heritage Australia, NSW Department of Primary Industries, ACT Government, a Macquarie Perch researcher, Upper Murrumbidgee Waterwatch, Invasive Animals CRC, Capital region Fishing Alliance, and the University of Canberra to fill some of the knowledge gaps, specifically:

- Tracking Carp using radio telemetry to establish movement biology and microhabitat preferences.
- Trial trapping measures suitable to the Upper Murrumbidgee.
- Determine the population structure of Carp caught in the trapping trials.
- Examine ecosystem/native fish response to long term Carp removal.
- Collate community reports on Carp spawning and aggregation sites in the whole of the Upper Murrumbidgee catchment via an online portal supported by the Invasive Animals CRC's Feral Scan platform.
- Gather information on angling catches by working with recreational fishers.
- A regional Carp out event targeting riverine Carp in the Upper Murrumbidgee will be held in January 2015.

4.10.11 Appendix 4k – Fish stocking

Stocking with Macquarie Perch- Hollands Creek Demonstration Reach, Victoria

Macquarie perch is an endangered species, listed both nationally and at the state level in Victoria. It occurs naturally in Hollands Creek but recently only in small numbers.

Electrofishing surveys of the demonstration reach in 2008/09 recorded only five Macquarie perch from a single pool. There were no Macquarie perch smaller than 270mm in length. Reasons for the lack of small individuals were unclear but continued inability to recruit smaller individuals would undoubtedly have a negative impact on the long-term survival of the Macquarie perch population in the demonstration reach. A recommendation was made that Macquarie perch be stocked into Hollands Creek.

In 2010/11 sampling the numbers of Macquarie perch were still small but had doubled since 2008/09 and were similar to the number recorded in 2007/08. In February 2010, 300 Macquarie perch fingerlings were stocked into Hollands Creek. They were sourced from Snob's Creek Centre

Surveys in 2012 recorded the highest number of Macquarie perch since the project began and the geographic distribution increased from two to four sites. Flooding has changed the creek habitat improving connectivity between the bottom four sites enabling Macquarie perch to access habitat that has been unavailable to them over the last five years.