2.8 Management considerations for freshwater fish

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Abstract

The challenges to the health and resilience of urban wetlands and waterways also create challenges for the plants and animals that rely on them for survival. This chapter provides information on what can be done to improve conditions for freshwater fish species likely to be encountered in urban wetlands, the challenges they face and what they need to grow and thrive.

Introduction: What fish need?

Like any other animal, fish need to be able to access food and shelter, avoid predators and find a mate. In an aquatic environment this means the presence of riparian and instream vegetation, connectivity within and between waterways and wetlands, features like snags and overhangs, and good quality, aerated water.

The plants that live in the water, either fully or partly submerged, or along the banks provide several functions for fish. Firstly, plants growing on the banks ('riparian vegetation') act as a protective mechanism – their roots absorb nutrients from runoff and hold the banks together, controlling erosion and reducing sediment movement into the waterway. Overhanging vegetation shades the water and moderates changes in water temperature, as well as providing a source of food, such as terrestrial insects that fall into the water.

Leaves and twigs that drop into the water become food for microbes and aquatic invertebrates that will, in turn, become food for fish.

Submerged aquatic plants produce oxygen, slow down water movement and collect sediment.

Both riparian and aquatic vegetation act to provide shelter for small species and juveniles of larger species. In-stream plant life also acts as platforms for aquatic invertebrates including the aquatic life stages of flying insects that frequent the plant's submerged surfaces.

Larger riparian vegetation that has fallen into a wetland or waterway may form snags (woody debris) that act as shelter or breeding sites for some species that use the submerged substrate to lay their eggs. Snags and collections of woody debris are important in creating localised changes to waterway geomorphology and can form scour holes that can act as refuge holes and home sites for fish.

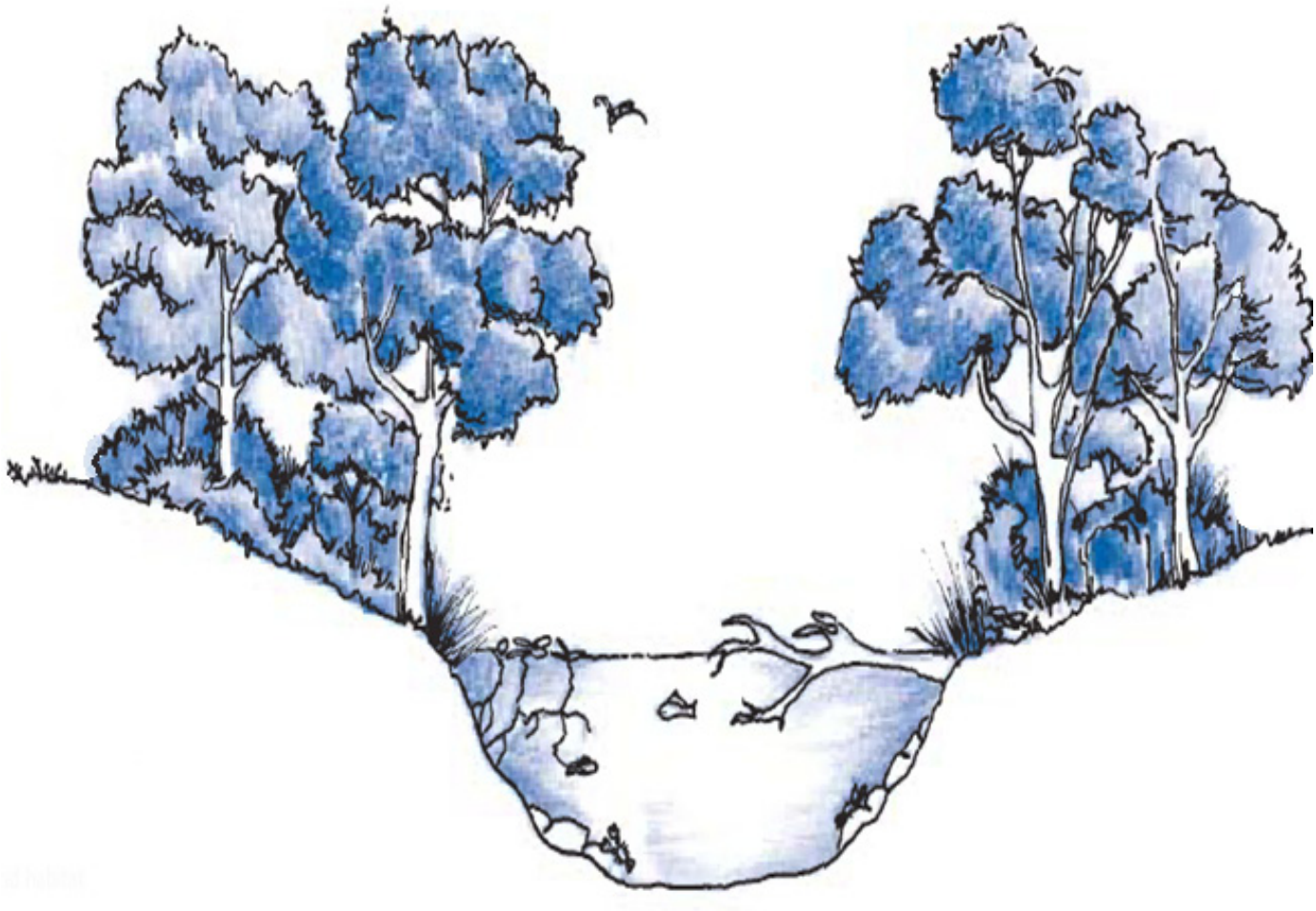


Figure 2.8.1. Good quality fish habitat: intact riparian vegetation, instream plants and snags – places to shelter, feed and breed. Adapted from Price and Lovett (2002).

(Not only) Freshwater fish of coastal NSW

Many native fish of coastal NSW will use a variety of different habitats throughout their lives including freshwater and estuarine areas. In fact approximately 70% of coastal fish species occurring in south east Australia are considered migratory and will migrate to complete their life cycle (Fairfull and Witheridge 2003).

Fish have a number of different life strategies to allow them to cope with their natural environment and to breed successfully and enable recruitment to occur. These can be categorised according to the type of movement they undertake. In Australia there are 3 common types of movement: catadromous, potamodromous and amphidromous (see Table 2.8.1). Some species, such as Australian bass and galaxias (jollytails), are catadromous and will spend most of their life in the freshwater environment but move to the estuary (or out to sea) to breed before adults and juveniles move back upstream to mature. Freshwater mullet is an example of a species that moves between the estuary and freshwater areas, but not necessarily for breeding are referred to as amphidromous. Other species will remain in one or other of the environments for their entire lives, but move within that environment to feed, breed and avoid predators. Where this occurs entirely within the freshwater environment, these species are said to have a potamodromous life strategy. The Eastern freshwater cod, found in the far north of NSW, is an example of a potamodromous species.

The fourth type (anadromous) is uncommon in Australia and in NSW is limited to a single species, the short-headed lamprey. It describes a type of migration that is familiar to most people as it undertaken by well-known Northern Hemiphere fish, such as salmon and some species of trout, where adults make large migrations upstream to lay their eggs and the larvae move back out to sea to mature.

In addition to the 'freshwater' life strategies above, some estuarine species, such as flathead, whiting, luderick and bream will move to the sea to lay their eggs. Larvae and adults will make their way back into the estuary and take advantage of different habitat types within the estuary including seagrass, saltmarsh and mangroves.

Connectivity between habitats is therefore essential to many species for their survival.

The urban environment

The main threat to the health, abundance and diversity of fish in NSW is the destruction of their habitat. Urban and industrial development has seen loss and degradation of freshwater and estuarine wetland habitat, including the removal of riparian vegetation, drainage and reclamation of wetlands, channelization or piping of waterways underground, and dredging for waterfront housing, canals or improved harbour access.

Removal of riparian vegetation removes the filter system for a waterway, leading to increased potential of sediment and nutrients entering the aquatic environment from runoff. Channelling

Table 2.8.1. Fish life strategies and example species from coastal draining systems of NSW.

Life strategy	Definition	Example species from coastal draining systems (NSW)
Potamodromous	Species that live and migrate wholly in freshwater.	• Eel-tail catfish • *Gudgeon* sp.
Catadromous	Species that live mostly in freshwater, and migrate downstream to the estuary/sea to breed. Juveniles and adults returning upstream for growth.	• Australian bass • *Galaxias* sp. • Freshwater herring • Congolli
Amphidromous	Species that migrate between fresh and saltwater environments, but not for the purposes of breeding.	• Australian smelt • *Gudgeon* sp. • *Galaxias* sp. • Sea mullet
Anadromous	Species that live mostly in saltwater, and migrate upstream to freshwater spawning grounds. Juveniles return to the saltwater for growth.	• Lampreys • Salmon (northern hemisphere)

Figure 2.8.2. Bunbury Curran Creek is one of many waterways that have been channelised in the Sydney region.

or piping of the waterway removes all habitat completely and renders the area uninhabitable to fish and other aquatic organisms.

Increased construction and habitation activity around wetlands and waterways leads to increased sediment, nutrient and pollutant (chemical or rubbish) influx to the aquatic environment from stormwater, poorly managed worksites or accidental spills. Chemicals and rubbish may directly affect fish as they come into contact or ingest them. Elevated nutrients can lead to algal blooms and fish kills as organic material decomposes and oxygen is removed from the water. Increased sedimentation can clog fish gills or smother fish eggs and aquatic vegetation, leading to loss of habitat, decreased oxygen levels if these plants begin to die or the potential loss of a whole cohort of fish.

Loss of connectivity

In an urban environment the connection between, and sometimes within, habitats has often been severed due to the development of infrastructure to manage water and traffic movement. Roads, weirs and floodgates can all act to isolate fish populations and lead to an increased potential for predation or disease transfer as individuals accumulate around a barrier while attempting to pass. In NSW alone there are over 4,000 licensed weirs and dams, with more unlicensed structures likely to be present. Throughout the state there are over 2,000 road crossings which are considered barriers to fish passage, over 1,300 of these occur along the coastal fringe where the human population is greatest. In addition, the coastal zone has over 1,000 floodgates that are likely to act to block fish movement.

Nearly all instream structures will affect the ability of fish to migrate in some way – the extent to which this will occur will be dependant on structural characteristics (e.g. structure height, culvert type, how often the structure is covered by water), the swimming ability and type of movement undertaken by the fish species present, and the flow characteristics of the waterway.

If you think like a fish, it is upstream movement that is the most difficult and therefore where structural characteristics will limit movement. This is especially so for catadromous species that move downstream to the estuary or ocean to breed then adults and juveniles make their way back upstream. Juvenile fish and smaller fish species will have poorer swimming abilities than their larger or more mature counterparts. These fish can therefore be greatly affected by instream barriers, which will restrict opportunities to move upstream or block them altogether. Where there are multiple barriers present on a waterway, fragmentation of populations is likely, leading to potential localised extinctions of some species over time.

Structural characteristics

Instream structures can form physical or behavioural barriers to fish. How water moves over or through a structure will determine how easy or difficult it is for a fish to navigate.

Physical characteristics that will affect fish movement include:

- A physical blockage as is the case with floodgates with flap gates. These gates act to control water movement past the structure, preventing high tides to move upstream, but allowing flows in the catchment to be released when the flap gate is raised (as a result of a build up of water pressure on the upstream side). Depending on water velocities present, this is the only time fish will be able to access and pass the structure. A physical blockage may also be created when sediment or debris build up against or within a culvert to an extent that it prevents fish movement.
- Headloss (the 'waterfall' effect on the downstream side of the structure) present across the structure can prevent fish from moving in an upstream direction. Sometimes a height difference across a structure of as little as 100mm can be enough to limit the movement of some smaller species, or juveniles of larger species. In roads, headloss can be created when a structure is built incorrectly,

so that the structure base is above the surrounding water level; or it can result from downstream bed erosion which lowers the channel downstream and exposing the base of a structure and creating a perched culvert.

- Flow depth – or lack thereof - will limit the ability of fish to move past a structure. A lack of flow depth will occur in weirs that have no gates or fishways as water is held back on the upstream side until it reaches the top of the structure and can flow over it. It is also common in causeway road crossings which act in a similar way to a weir, with water forming sheet flow across the road surface, or may result as pipes present under the road surface become blocked and force water over the structure. Other examples are where a road culvert is either set incorrectly so that its base is above the downstream water level, or where too many culverts are set at the same level, leading to water being distributed across a number of openings, creating sheet flow.
- Water velocity – is an issue where inadequate culverts are used in a road crossing, leading to water jettisoning through a small opening (normally a pipe) and creating linear velocities that fish cannot physically swim against. This can also become an issue at some sites in higher flows, where culverts may cope with the transfer of water at low river flows, but are unable to do so as water levels rise. Water turbulence may also be an issue at some sites, leading to fish avoiding an area or being unable to navigate through/past it.
- The slope of a structure may also cause issues for fish movement, mostly as it will create water velocity or poor flow depth within a structure.

How to help the fish

The three things that can be done to improve management of urban wetlands and waterways and create conditions suitable for native fish are: to retain the habitat or to put the habitat back; improve water quality; and remove barriers.

As a first step, existing wetlands should be retained in their natural state as much as possible – it's far easier and cheaper to maintain an existing wetland than to create a new one with the necessary ecological processes.

Figure 2.8.3. Fish passage barriers – natural (waterfall), floodgate, road culvert and weir.

Putting the habitat back will provide areas for fish to shelter, feed and breed. In terms of wetland features this means areas of variable water depth, including shallow and deep water zones as well as overhangs and riffles. Overhangs will provide areas for sheltering and temperature control. Riffles (shallow areas of 'bubbling' water as it moves down hill) will improve water aeration and provide vital habitat for shelter and resting for juvenile fish. Riffles could be constructed as connections between wetland areas or where water enters the wetland.

Replanting the riparian zone with emergent sedges, shrubs and trees will improve the water quality by acting as a filter for overland flow. Overhanging vegetation will provide food from falling insects and moderate temperature extremes.

At locations of water inflow to a wetland, water quality can be improved by installing gross pollutant traps (GPTs) to remove larger anthropogenic debris (litter). Care should be taken for the placement of GPTs in natural systems, placing them 'offline', so that these in themselves do not form barriers to fish passage. Where the water source for a wetland or waterway is from a piped stormwater outlet, GPTs can be placed in the direct line of flow ('online'), with no concern for fish passage.

Reed beds can be used to filter the water and slow water movement before it enters a wetland or waterway. This will reduce the potential for bank erosion of the wetland in high flow events and allow sediment to drop out of suspension before entering the wetland under lower flow conditions. Similarly, distribution systems in a constructed wetland can be used as natural filters to remove sediments, nutrients and other pollutants from water.

In addition to replanting or enhancing the riparian vegetation, planting aquatic vegetation will also help improve water quality, shelter and food potential for fish.

As riparian vegetation matures, fallen timber should be allowed to remain in the water as it will provide fish with shelter, a location to lay eggs, and will act as a substrate for algal and invertebrate food source for fish. This process may take a number of years and can be 'fast-tracked' by installing fallen logs into the wetland directly. Unlike waterways, wetlands are unlikely to experience high water velocities, however care should be taken when installing large woody debris (snags, fallen logs) to ensure they do not move and cause damage to the surrounding area and/or infrastructure or life.

Improving connectivity

In terms of allowing fish to go where they need to, various options exist for roads, weirs and floodgates.

In waterways, the basic premise is to try and mimic the cross section of the waterway as closely as possible to minimise water velocities, increase light penetration and reduce potential for blockage with debris. In general, NSW DPI (Fisheries NSW) recommends removal of problem structures where possible (e.g. redundant structures). Not only is this usually the cheapest option, it allows for free passage of fish and a return of the stream environment back to its natural state.

If removal of the structure is not possible, then there are fish-friendly alternatives. For example, replacing a road crossing barrier with a bridge is the next best option, followed by installation of low flow box culverts (see below).

In addition to the above considerations, alternative uses for the structure must be considered. For instance if it is acting to control erosion within the waterway (and is therefore a bed control structure), the structure will not be able to be removed and installation of culverts may not be possible. In that case alternative remediation options must be considered, such as installation of a fishway.

Finally, budgetary constraints will inevitably dictate the remediation option applied. Cost/benefit for a structure must therefore be considered in relation to the site and the fish fauna present. Piped road crossings are a very cheap option in comparison to fishways, but if the fish fauna is diverse, threatened or migratory species are present and the structure does not overtop or drown out often, a piped road crossing will potentially devastate the local fish population. The pros and cons of different structure types are discussed further below.

Roads

Road crossings should use box culverts to facilitate water and fish movement, but should not be used to create sheet flow by spreading flow across a number of large cells. Where possible, the box culvert should be partially set into the stream bed so that some of the surrounding material covers the base of the cell(s) and allows water to be present in the culvert at a sufficient depth to allow fish passage at all flows. In larger structures

Figure 2.8.4. Road with low flow cell (left) and second cell which will take higher flows, reducing overall water velocities present.

where a number of box culverts are used, at least one cell should be set into the stream bed, with the remaining cells set at a slightly higher level. This will allow water (and fish) to move through the lowest set cell during low flows, with the other cells passing water as water levels rise. By having cells set in such a way water velocities will be minimised for the majority of the time as water levels rise and then fall and fish passage will be maintained, even during periods of low flow.

Small diameter pipes should be avoided, especially where they transfer water across a wide structure, as they will create high velocity conditions within the pipe when under flow and also may form a behavioural barrier to fish that are unwilling to move into a dark culvert.

Large diameter pipes may be used in some areas where flow velocities will remain low, or as narrow connections between different wetland areas (such as providing a pedestrian crossing), however box culverts are preferable where possible.

There will be situations where installing culverts is not possible, such as at operational weirs, floodgates or road crossings acting as bed control structures which have accumulated a volume of sediment upstream of the structure ,or that are unable to have their existing cells lowered. Options for allowing fish passage in these cases include improved structure management (floodgate) or installation of a fishway (roads and weirs).

Floodgates

The main management action to improve fish passage past floodgates is to remove them where they are no longer needed or to increase the amount of time they are opened so that fish and water exchange may occur. If the main aim is to improve water quality upstream of a floodgate, then automated “Smart Gates” may prove beneficial. These structures have sensors that record water quality variables and adjust the gate opening accordingly. These structures are mainly used at sites where there is acidic water

being expelled from the drain. Acidic drainage water can be caused in areas where drains have been cut into the sediment in an effort to remove water from a wetland or low lying area quickly. These drains expose naturally occurring sulfide soil layers, which oxidise on contact with the air. As these layers are rewet after a flow or rainfall event, the oxidised material reacts with water to create sulfuric acid. Although more often seen in a rural landscape, sulfidic sediments can be present in an urban environment and must be considered when undertaking works in the coastal environment (whether this is in a freshwater wetland or an estuarine one).

Options are available to manually manage floodgates so that they are opened for periods of time when there are small variations in tidal height and little flow in the catchment. Winch or sluice management of floodgates are examples of manual management allowing an increased period for the gates to be opened and therefore improved water and fish exchange upstream of the structure. As these management options are manually operated, regular staff/volunteer time needs to be allocated so that staff can be responsive to changes in hydrological condition of the catchment.

A management alternative that requires less staff time but provides for regular water exchange and opportunities for fish movement is called an "auto-tidal gate". This modification to an existing flap gate increases the time available for fish to move past the structure and allows for a greater amount of water exchange. This is possible due to a smaller flap gate which is set into the main flap gate. This smaller gate is opened and closed with each tide as an attached hinge and float rises and falls with the tide. The float can be set at an agreed level of the tidal cycle, opening on a receding tide and closing on a rising tide when by default the larger main gate will hang shut. As during normal floodgate operation, when there are high rainfall events in the catchment the larger gate can swing open to allow water to escape. When under high tide conditions, the gate will be pushed closed so that water does not pass the structure. In the intervening times, the float will open and close the smaller flap gate and allow fish and water to move through the structure in either direction.

Fishways and bypass channels

A fishway is a structure that is attached to a weir or road crossing that breaks a large headloss (the downstream side waterfall effect) down into a

Figure 2.8.5. Smart gate (left), winch (top right) and sluice gate (bottom right).

Figure 2.8.6. Auto-tidal modified floodgate in closed and open position.

series of negotiable small water level rises, each separated by a resting pool. Each step gradually raises the water level by around 100mm until the level of the upstream weir pool is reached and fish are able to continue moving upstream. A fishway requires constant flow to operate and allow fish passage but may be installed at locations with episodic or ephemeral flow so that fish passage can be provided when water movement occurs.

Overall, fishways require a slope of 1:20 to 1:30, depending on what fish species are present, and where in the system the fishway is located. In general, the 1:20 slope is used, however where passage for small fish species is required, or when the fishway is located closer to the tidal zone or estuary, the lesser slope must be used so that the juvenile fish of catadromous species and poorer swimming small adult fish can swim upstream. Each step gradually raises the water level by around 100mm (1:20 slope) or 50mm (1:30 slope) until the level of the upstream weir pool is reached and fish are able to continue moving upstream.

At all fishways an attraction flow should be provided by creating water movement, noise, aeration and turbulence to bring fish toward the entrance, rather than to another part of the weir. The attraction flow is formed by directing flows through the fishway during low flow periods, and cutting a groove in the weir crest adjacent the fishway or at its upstream exit.

A bypass channel is a method of allowing fish passage around a structure, rather than over or through it. Essentially these are constructed waterways that have a low slope and resting pools similar to a fishway, but instead of being formed from rock or concrete, they are constructed in the riparian zone adjacent the structure.

There are several fishway designs, each with their pros and cons dependant on the water flow characteristics of the waterway, the fish species present and the funding available.

Vertical slot fishway

In this type of fishway concrete baffles act to hold water back into a series of pools separated by a small headloss that is navigable to fish. With varying headloss due to a variable hydrological regime, a vertical slot fishway is more effective at allowing passage for a greater range of fish size classes. Vertical slot fishways are considered one of

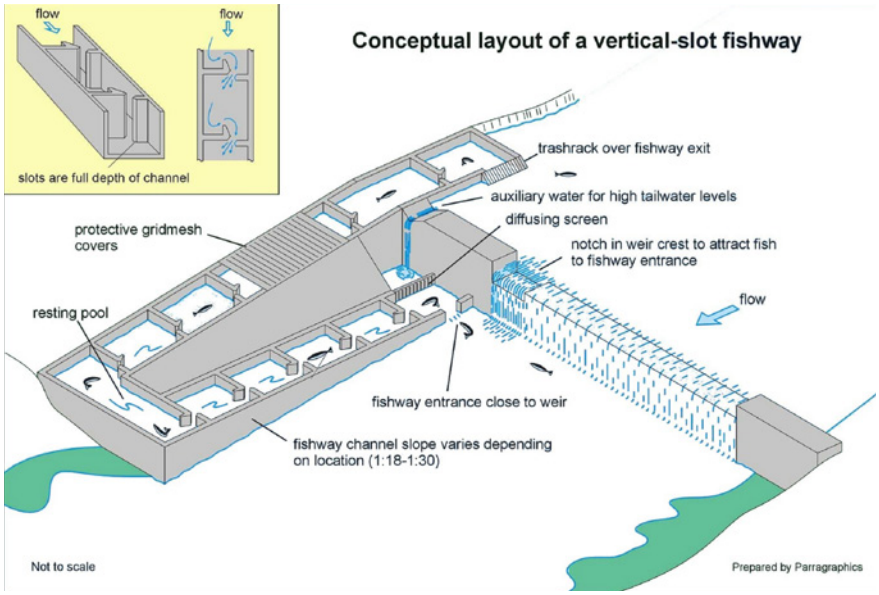


Figure 2.8.7. Conceptual layout of vertical slot fishway.

Figure 2.8.8. Vertical slot fishway installed at Mill Stream Weir 1.

the most effective fishway designs and are the preferred option where threatened species are present.

Vertical slot fishways have been installed in Sydney at Mill Stream, adjacent to Sydney Airport (above) and on the Parramatta River at Charles Street and Kiosk Weirs.

Rock ramp fishways – partial width

Partial width rock ramp fishways allow fish passage by providing a series of pools divided by rock ridges. The gaps between rocks in the ridges act to hold water back, thus forming the pools. Fish can move through the fishway by darting through very short sections of high velocity water between the ridge rocks, before resting in the pool directly upstream.

Smaller species may use the boundary layer of each rock (a narrow layer of low velocity water that surrounds the ridge rocks) to traverse the fishway. This modification can therefore provide passage to a range of fish species and size classes.

A partial width rock ramp fishway is often constructed perpendicular to a structure with a return dog-leg or, depending on the flow variations within the waterway, the fishway may operate more effectively if it were run parallel to the structure. The entrance of both designs should be located close to the structure wall and should incorporate an attraction flow to guide fish to the fishway.

Figure 2.8.9. Partial width rock ramp fishway installed at Australia Avenue raised road culvert in Sydney Olympic Park.

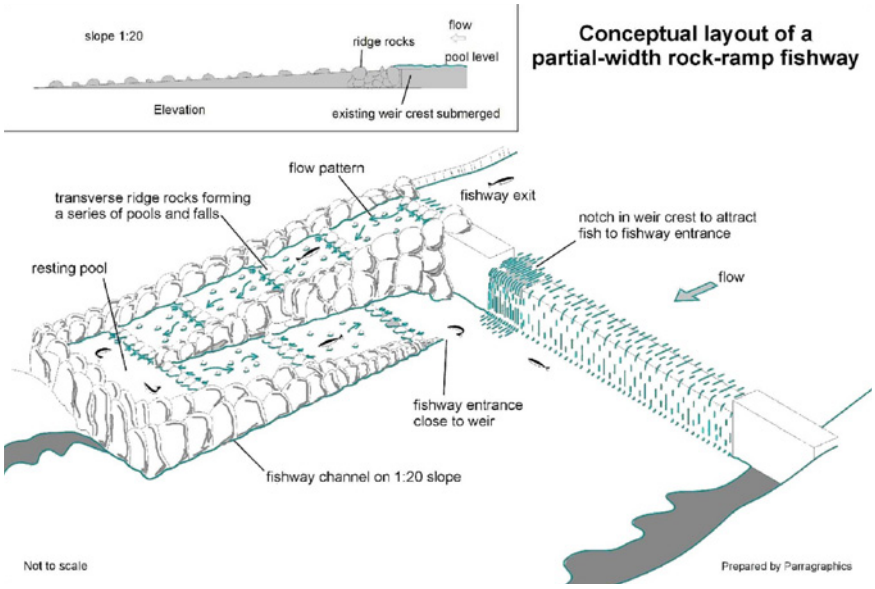


Figure 2.8.10. Conceptual layout of partial width rock ramp fishway.

Figure 2.8.11. Full width rock ramp fishway at weir on Karuah River, Hunter region.

Figure 2.8.12. A fish lock fishway has been constructed at Marsden Street Weir in Parramatta. Arrows shows the entrance channel (downstream), with the lock chamber circled.

Partial width rock ramp fishways have been constructed at Australia Avenue, Sydney Olympic Park, Lane Cove Weir, Lane Cove River (Lane Cove National Park) and Wolli Creek at Turrella. A partial width rock ramp fishway is proposed for construction at Asylum Weir, Parramatta River at Parramatta.

Rock ramp fishways – full width

A full width rock ramp fishway also provides fish passage for a range of fish species and size classes over a range of flows. As with other designs, it requires an overall gradual slope of 1:20 or 1:30 that allows fish to traverse the structure. This type of fishway has a low flow section, which is similar to a partial width rock ramp fishway, but runs down the centre of the structure (centre of the waterway). Either side of the low flow channel, larger rocks are placed on a similar slope (1:20) in the direction of flow and from the low flow channel to the bank. Flows are initially directed down the central low flow channel, but as flows increase water moves laterally out toward the river bank. At these higher flows lower water velocities are encountered toward the river bank, thus allowing fish passage to remain possible over a wide range of flows. Due to their size, these structures are more suited to larger waterways in a rural environment.

Fish lift or fish lock

This type of fishway physically moves fish over a large obstruction, usually 3 metres or more high. Fish are attracted to a vertical chamber on the downstream side of the structure, the chamber is closed and water pumped in. Fish are then directed to the top of the chamber before being released. This type of fishway requires an energy source, and is therefore costly to run.

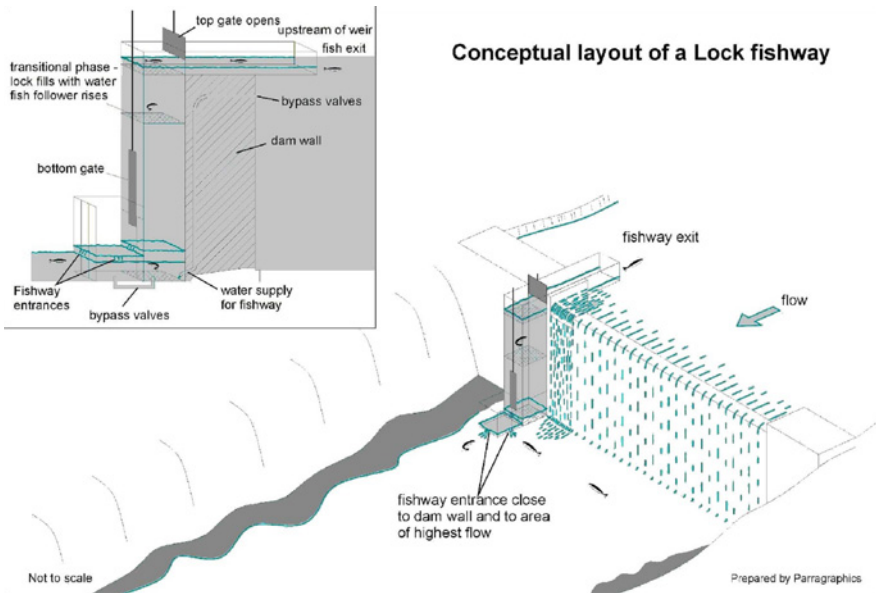


Figure 2.8.13. Conceptual layout of lock fishway.

Case Studies: Fish passage remediation

The following are examples of structure remediation projects undertaken by Fisheries NSW in partnership with other organisations or councils as part of the Bringing Back the Fish project – funded through the Natural Heritage Trust and the coastal Catchment Management Authorities.

Partial width rock ramp fishway, Boundary Creek Australia Avenue, Sydney Olympic Park

Remediation Works

- Construction of a partial-width rock-ramp fishway to overcome height differential.
- Flows directed through fish passage culvert to improve flow depth.
- Culvert baffles decrease linear velocities within fish passage culvert.
- Crown Land (Sydney Olympic Park).
- Works completed July 2008.

Remediation Benefits

- Improved access to 1km (5ha of wetland).
- Excellent education opportunities through interpretive signage – fishway located on walking path within Sydney Olympic Park.
- Monitoring shown mullet upstream following construction (not present previously).

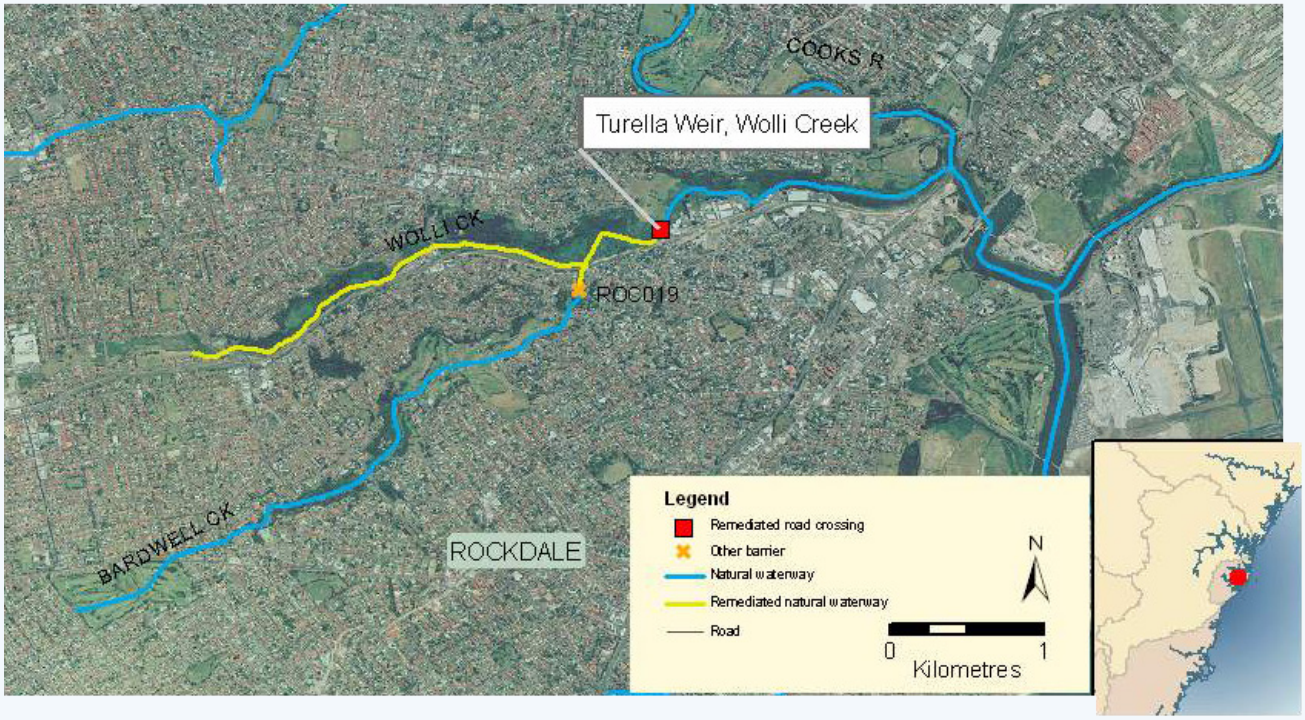
Project Costs

- Total project cost = $179,135.

Partners

- Sydney Olympic Park Authority (project managers), SMCMA (co-funding).

Partial width rock ramp fishway, Wolli Creek
Henderson Street Turella



Remediation Works

- Installation of partial-width rock-ramp fishway at tidal barrier, Turella Weir.
- Structure located on Crown Land.
- Turella Weir built on over time, leading to large high voltage power line encased within and damaged during construction, increasing costs.
- Works completed March 2009.

Remediation Benefits

- Improved access to 3km of habitat.
- Works compliment restoration projects being undertaken on Wolli Creek and Cooks River.
- Monitoring fish populations enable community involvement and education opportunities.

Project Costs

- Total cost of works - $120,000.
- Preliminary works and design - $23,000.

Partners

- Rockdale City Council and Canterbury City Council (project managers), SMCMA (co funding).

Auto-tidal floodgate, Cahill Creek, Bayview Golf Club Pittwater Road, Bayview

Remediation Works

- Installation of an auto-tidal floodgate to allow greater tidal exchange within the lagoon.
- Negotiation with Bayview Golf Club, Pittwater Council, Roads and Maritime Services (RMS) to develop a management plan for the structure.
- Auto-tidal gate seen as a "prototype" or trial for improving odour issues within the system.
- Structure located on Crown Land (RMS road).
- Works completed September 2009.

Remediation Benefits

- Improved access to 3km of wetland habitat.
- Improved tidal flushing within the lagoon to improve odour issues in upper reaches.

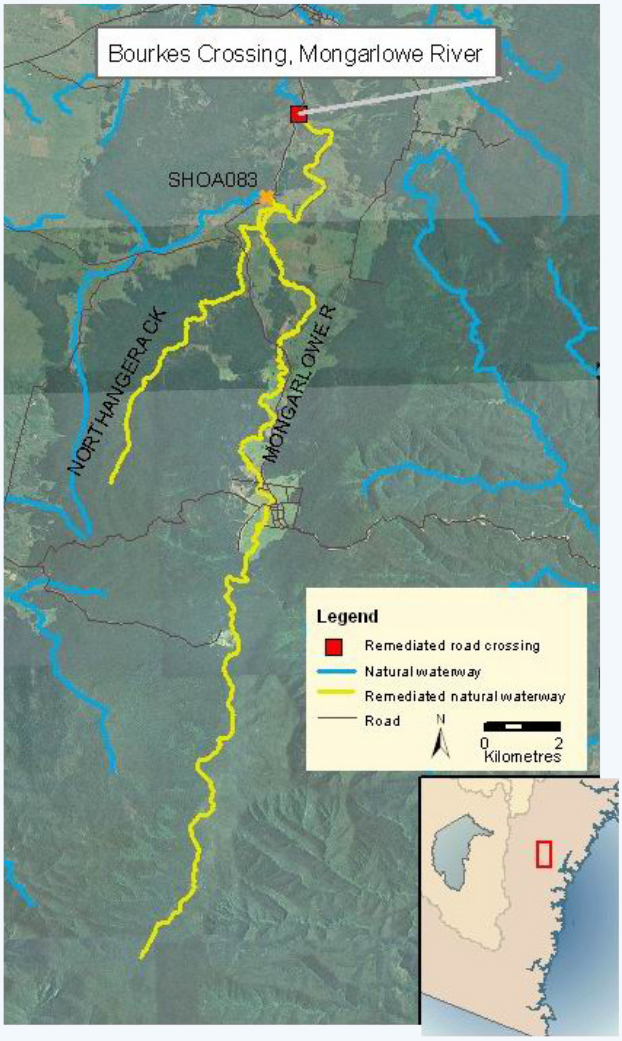
Project Costs

- Total cost of works - $14,374

Partners

- Bayview Golf Club, Pittwater Council, RMS.

Low flow culvert, Mongarlowe River Northangera Road, Mongarlowe



Remediation Works

- Replacement of 3 inadequate pipe culverts with box culverts (1 old pipe culvert retained).
- One low flow cell and one higher set cell installed at main channel, additional higher set cell located on a secondary flow path.
- Low flow cell ensures adequate depths at base flows. Higher set cells ensure lower velocities at higher flows.
- Structure located on Crown Land.
- Works completed October 2009.

Remediation Benefits

- Improved access to 43km of habitat.
- Works will benefit the threatened Macquarie Perch population present in Mongarlowe River.

Project Costs

- Total cost of works - $149,550.
- Preliminary works and design - $9,760.

Partners

- Palerang Council (project managers).

Legislation and considerations for works in a waterway

In order to determine the most appropriate form of remediation for these structures, consideration must be given to 1) the impact of the structure; 2) the species present; and 3) the type or class of waterway on which the structure is located. Different remediation options trigger different legislative requirements.

Waterway class relates to the permanency, presence, and condition of appropriate fish habitat. Waterway class is divided into 4 habitat types: Class 1 = major fish habitat, Class 2 = moderate fish habitat, Class 3 = minimal fish habitat, and Class 4 = unlikely fish habitat. Generally the lower in the system (closer to the estuary or tidal zone) will have a higher class than ephemeral upper tributaries, and will therefore be likely to support a greater diversity of fish species and fish habitat.

Legislative requirements, policies and guidelines for works within a waterway or wetland are available in the Council and Developer toolkit page within the fisheries section of the NSW DPI website www.dpi.nsw.gov.au/fisheries/habitat/protecting-habitats/toolkit.

Specific legislative requirements and design considerations for waterway crossings and instream structures can be found in Fairfull (2013) and Fairfull and Witheridge (2003).

Whilst the above documents specifically address waterway crossings, a multi-agency policy has been devised for weir structures. Acting under the *Environmental Planning and Assessment Act* 1979, it states that any new or refurbished weir structures must include provision for fish passage. This policy can also be found on the NSW DPI website.

Most activities undertaken in a waterway will require approval under Part 7 (Division 3) of the *Fisheries Management Act* 1994 to dredge and/or reclaim. Private individuals, local government, and public authorities have varying requirements under this approval process, but in all cases the Minister for Fisheries must be notified of works (whether directly or via the approval of a permit application). One can apply to obtain a permit to dredge and reclaim from www.dpi.nsw.gov.au/fisheries/habitat/help/permit.

In addition to the approval required under the *Fisheries Management Act* 1994, approvals may be required under the *Water Management Act* 2000. In order to gain approval for works under the *Water Management Act* 2000, a "controlled activity" permit must be obtained from the Department of Primary Industries Office of Water (www.water.nsw.gov.au/Water-Licensing/Approvals/Controlled-activities/default.aspx). However in many instances approvals will be concurrent, meaning that one or the other will suffice, and that the administrative departments will notify the other and seek concurrence regarding the works in question.

Fish of NSW wetlands and streams

The following list of fish species is found in NSW coastal wetlands and streams and with potential to be found in urban wetlands and waterways. Some species are more common than others; some are listed as vulnerable or endangered.

As a general rule, smaller species are more likely to use wetland habitats, but also may be found in the flowing waters of rivers and creeks. Larger species will prefer deeper water that is more common in waterways than wetlands. As mentioned above, many of these species will use a variety of habitats, including those in the estuary where they may breed or pass through to access the inshore environment to breed.

A description of all NSW freshwater species can be found in the document "What fish is this? A guide to freshwater fish of NSW", which is published by NSW Department of Primary Industries. This document includes photographs of each fish, their distribution, habitat preferences and breeding behaviour. It can be downloaded from www.dpi.nsw.gov.au/fisheries/recreational/freshwater/fw-fish.

Table 2.8.2 summarises some of the common species, their size and habitat preference.

Table 2.8.2. Freshwater fish of NSW which may be found in urban wetlands and waterways.

Species	Small, medium or large fish	Fresh or Estuary	Wetland or Waterway
Australian bass *Percalates novemaculeata* (Previously in genus *Macquaria*)	Large	Fresh, moving to estuary to breed	Waterway
Australian smelt *Retropinna semoni*	Small	Fresh	Both
Bullrout *Notesthes robusta*	Medium	Fresh, moving to estuary to breed	Waterway
Common jollytail *Galaxias maculatus*	Small	Fresh, moving to estuary and beyond to breed	Waterway
Cox's gudgeon *Gobiomorphus coxii*	Medium	Fresh	Waterway
Dwarf flathead gudgeon *Philypnodon macrostomus*	Small	Fresh and upper estuary	Both
Empire gudgeon *Hypseleotris compressa*	Small	Fresh and upper estuary	Both
Firetail gudgeon *Hypseleotris galii*	Small	Fresh and upper estuary	Both
Flathead gudgeon *Philypnodon grandiceps*	Small	Fresh and upper estuary	Both
Freshwater mullet *Trachystoma petardi* (Previously in genus *Myxus*)	Large	Both	Both, prefer waterway
Long-finned eel *Anguilla reinhardtii*	Large	Fresh and sea to breed	Both, prefer waterway
Sea mullet *Mugil cephalus*	Large	Sea, estuary and lower freshwater reaches	Waterway
Short-finned eel *Anguilla australis*	Large	Both	Both
Southern blue-eye *Pseudomugil signifer*	Small	Both	Waterway
Striped gudgeon *Gobiomorphus australis*	Medium	Fresh, upper estuary	Waterway
North Coast only			
Crimson-spotted rainbowfish *Melanotaenia duboulayi*	Small	Fresh	Both
Olive perchlet* *Ambassis agassizii*	Small	Fresh	Both
Ornate rainbowfish* *Rhadinocentrus ornatus*	Small	Fresh	Both
Oxleyan pygmy perch* *Nannoperca oxleyana*	Small	Fresh	Both

Table 2.8.2 (cont.). Freshwater fish of NSW which may be found in urban wetlands and waterways.

Species	Small, medium or large fish	Fresh or Estuary	Wetland or Waterway
Purple-spotted gudgeon* *Mogurnda adspersa*	Small	Fresh	Both
South Coast only			
Congolli *Pseudaphritis urvillii*	Medium	Both, prefer estuary	Waterway
Introduced species			
Common carp N3 *Cyprinus carpio*	Large	Fresh	Both
Gambusia # *Gambusia holbrooki*	Small	Fresh, upper estuary	Both
Goldfish *Carassius auratus*	Medium	Fresh	Both
Oriental weatherloach N1 *Misgurnus anguillicaudatus*	Small	Fresh	Both
Introduced species - North Coast only			
Tilapa@ *various species*	Medium	Fresh	Both
Pearl cichlid@ *Geophagus braziliensis*	Medium	Fresh	Wetland
Swordtail@ *Xiphophorus sp.*	Small	Fresh	Both
Platy@ *Xiphophorus maculatus*	Small	Fresh	Both

** Protected or threatened species.*

 # Class N1 noxious species, except in the Greater Sydney Region where it is Class N3.

@ These species have been found in localised occurrences in the far north coast NSW. Vigilance with regard to these species will aid their control and prevent further spread. Occurrences should be reported to NSW Department of Primary Industries (Fisheries NSW): www.dpi.nsw.gov.au/fisheries/pests-diseases/reporting.

The Class 1 noxious listing prohibits sale and possession.

Class 2 prohibits sale but allows possession in fully contained aquaria.

Class 3 allows sale and possession.

It is strongly recommended that noxious species are not returned to the water.

If you want to find out what fish are in your wetland, you will need to obtain a permit from Fisheries NSW to undertake collection for research purposes. The Section 37 research permit can be found at www.dpi.nsw.gov.au/fisheries/info/section-37-permits.

Before any sampling, consult with Fisheries NSW, who will be able to provide information on appropriate techniques, timing etc.

Rules about threatened and protected species are complex and the species listed in these categories also change. For more details visit www.dpi.nsw.gov.au/fisheries/species-protection or contact your local Fisheries NSW office.

It's illegal to catch and keep any protected or threatened species, and any that are caught accidentally must be returned immediately to the water unharmed. To reduce harm to fish being returned to the water, follow these basic guidelines:

- Minimise the length of time the fish is out of the water;
- Handle fish carefully and support the weight of its body; and
- Take care to revive fish upon release if they appear exhausted. If there is any water current, hold the fish facing towards the current until it starts to show signs of recovery.

Conclusion

Fish living in urban wetlands and waterways rely on good management of these systems for their survival. It is not a case of "set and forget" – ongoing management is required to maintain fish passage, good water quality and for fish to have the shelter and food they require. Retention or re-establishment of riparian and instream vegetation therefore plays a vital role in managing sediment and nutrient loadings of a wetland or waterway, as well as providing shelter and food to the fish fauna present. The ability for fish to move within and between habitats is also important for their survival. For this reason it is also important to maintain any structure that may affect fish movement so that they do not become clogged by natural or anthropogenic debris. Ensuring these wetland elements are in place will ensure a healthy fish population in your wetland or waterway.

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