Culvert Fishway Planning and Design Guidelines

Part D – Fish Passage Design: Road Corridor Scale

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James Cook University School of Engineering and Physical Sciences
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1 INTRODUCTION

In order to identify those road-waterway crossings in a road project where provisions for fish passage are to be made, road designers, waterway

2 ROAD CORRIDOR SCALE PLANNING AND DESIGN

Planning and design for fish passage at the road corridor scale is undertaken in new and existing road projects that cross one or more waterways where provisions for fish passage may be required. Road corridor scale assessment provides the necessary context for site scale planning and design of fish passage at adopted road-waterway crossings on the road corridor (Guidelines Part E – Fish Passage Design: Site Scale). Aspects of the road corridor scale assessment method can also be used to inform site scale planning and design for a single road crossing or other waterway structure, or for several waterway structures on a single waterway.

Scope, purpose and timing

Road corridor scale assessment for fish passage identifies the road-waterway crossing locations where fish passage provisions are to be made, establishes the goals for fish passage design at these sites. For agencies such as the Department of Transport and Main Roads Queensland, this applies mainly to mitigation of potential impacts on fish passage at new structures, but it also encompasses remediation of fish migration barriers by retrofit at existing structures. Road corridor scale assessment is usually undertaken in conjunction with preliminary environmental assessment to provide input to route selection, alignment design and evaluation of alternatives for the road in the *Concept* and *Preliminary Design* phases of road and other infrastructure projects.

Planning and design activities

The major planning and design activities outlined in this *Guideline* (referring where appropriate to Guidelines Part B – Fish Migration and Fish Species Movement Behaviour) include:

- assessment of waterway character – stream flow characteristics, waterway type
- fish habitat assessment – type, location, movement corridors, fauna connectivity and barriers
- fish species assessment – diversity, abundance and distribution (see Guidelines Part B)
- fish movement behaviour and characteristics for design – movement directions, timings, swim capabilities (see Guidelines Part B)
- fish movement corridor locations and classification – habitat, fauna connectivity, fish values
- priority road-waterway crossings for fish passage – classification of type and class
- preliminary assessment of fish passage provisions at crossings – hydraulic conditions, aquatic fauna connectivity / fish passage goals, fish passage options

Site investigation and characterisation (site assessment)

Site assessment tasks forming part of road corridor scale planning and design may include the following, undertaken through field investigations or as desk top studies:

- catchment and regional characterisation (e.g. bioregion, climate, ecosystems, landform, contributing catchment, land use, conservation status, institutional arrangements, management plans)
- waterways, flow paths and flow characteristics (e.g. waterway type, channel form, permanence, flow paths, catchment hydrology, waterway hydraulics, human activities and pressures)
- fish habitat areas and fish movement corridors (e.g. waterway type, habitat type, crossing location, riparian condition, instream condition, disturbance, human activities and pressures, rehabilitation opportunities)
- other fish migration barriers (e.g. barrier type, barrier significance, remediation effectiveness, remediation feasibility, barrier location)
- fish species assessment (e.g. diversity, abundance, distribution, life stage, maturity)
- fish movement behaviour (e.g. fish movement group, fish movement direction and timing, fish movement capabilities, fish swim speeds)

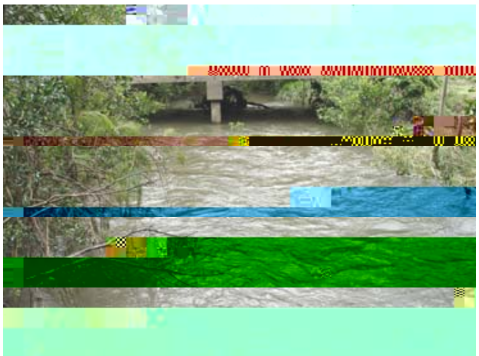
3 WATERWAY CHARACTER AND FISH HABITAT ASSESSMENT

The nature of the waterway and the fish habitat areas potentially affected by fish migration barriers at road-waterway crossings are primary factors in assessing provisions for fish passage at waterway crossings in a road corridor scale study. Considerations of waterway and fish habitat characteristics for the road corridor are set within a regional and catchment context that helps define the significance of fish passage issues to the road project. Road corridor scale assessment provides the context for site scale considerations of waterway and fish habitat characteristics for particular crossings (see Guidelines Part E – Fish Passage Design: Site Scale), and a similar approach to that outlined here can be adopted for waterway and fish habitat characterisation for

the fish passage design condition, was used as indicator of inundation and flow paths that might apply for fish passage flow events, and provided some discrimination between principal flow paths and other areas of inundation for these conditions. Mapping of peak water levels and peak water velocities for the design flow events were used to interpret fish movement corridors and significant road-waterway crossings for fish passage across the road corridor.

Field inspections of the waterways and waterway structure sites assist in defining waterway characteristics and in confirming fish movement corridor locations. For the Tully-Murray floodplain, flow monitoring observations and measurements undertaken for the flood event associated with Tropical Cyclone Larry in March 2006, provided invaluable information on principal floodplain waterways and the hydraulic characteristics (velocities, depths, flow patterns) of waterways and road crossing sites (Kapitzke 2007a). Major waterways on the Tully Murray floodplain in medium flow conditions are illustrated in Box D3.1.

Box D3.1: Tully Murray floodplain waterways and fish movement corridors (Source: Ross Kapitzke)



Major stream in medium flow condition – Corduroy Creek at existing Bruce Highway bridge (24/03/06)

Major floodplain waterway in medium flow condition – flood channel and lagoon system south of Lagoon Creek (24/03/06)

3.3 Fish habitat areas and fish movement corridors

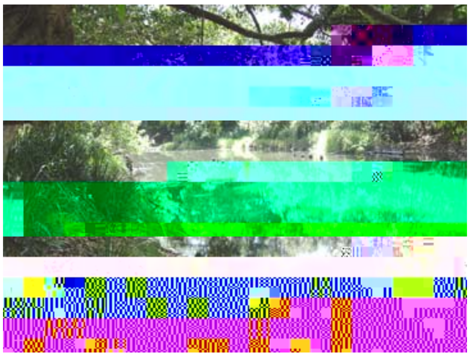
The location, extent and nature of the fish habitat areas and waterways adjoining the road corridor will define the fish movement corridor crossings of the road, and will guide the provisions to be made for fish passage at designated road-waterway crossings. Information used to describe fish habitat for the categorisation of fish movement corridors includes waterway type, habitat type, riparian condition, instream condition, integrity and disturbance. Examples of the type of information that should be examined for road corridor scale assessment are presented below. This may require specialist advice on fish habitat and aquatic fauna connectivity.

Data category	Example of information to assess
waterway type	x freshwater stream, saline wetland, constructed wetland
habitat mapping	x regional ecosystems, terrestrial fauna, aquatic fauna
fish habitat type	x spawning, growth, refugial
structure location relative to habitat	x estuarine, lowland, upland, tributary stream
riparian condition	x native vegetation, continuous or fragmented corridor
instream condition	x structural diversity, aquatic vegetation, water quality
integrity and disturbance	x channel form, flow connectivity, isolation, ecosystem function
human activities and pressures	x agriculture, wetland drainage, exotic animals and plants
rehabilitation opportunities	x riparian corridor, aquatic habitat, connectivity, stream process

For the Tully-Murray floodplain, extensive freshwater and tidal wetlands, rivers and estuaries provide important breeding and nursery areas for fish and other aquatic fauna. Fish habitat areas are located in a range of natural freshwater and marine landscapes, but waterways, fish habitat and fish movement capability have often been altered by development pressures on the floodplain. For example, many freshwater wetlands that have been severely degraded to swampy depressions through weed infestation and artificial drainage, are no longer functioning as fish habitat. Some lagoons had been completely filled for farming and no longer exist. Conversely, fish habitat is often enhanced through stream rehabilitation initiatives such as riparian revegetation, and some artificial wetlands have been constructed and revegetated in agricultural areas for flood mitigation, sediment retention, and enhancement of aquatic and riparian habitat.

Fish movement corridors on the Tully-Murray floodplain in the vicinity of the new Bruce Highway Corduroy Creek to Tully road were identified from a spatial assessment of fish habitat areas, waterway connectivity between habitat areas, and prominent waterway crossings of the road corridor (see Kapitzke 2006a). The location and condition of these fish habitat areas and

Box D3.3: Fish habitat areas on Tully Murray floodplain (Source: Ross Kapitzke)



Freshwater stream habitat – Murray River Old Highway crossing (10/11/05)

Constructed wetland on floodplain adjoining Murray River – Fleglers lagoon (10/11/05)

3.4 Other fish migration barriers on the waterways

The significance of providing for fish passage at a waterway crossing of the road corridor will be influenced by fish passage connectivity between habitat areas in these waterways or fish movement corridors remote from the road corridor. Existing fish migration barriers at road-waterway crossings or other waterway structures downstream of the proposed crossing site will affect fish migration upstream to the site. Fish migration barriers upstream of the crossing site will fragment habitat within the fish movement corridor, and restrict access for fish to habitat areas further upstream. Information used to define other fish migration barriers on the waterway includes barrier type, barrier significance, ease of remediation, location relative to road crossing. Examples of the type of information that should be examined for a road corridor scale assessment are presented below.

Data category	Example of information to assess
barrier type and configuration	x dam, weir, barrage, grade control, culvert, water quality
barrier significance	x total, partial, temporal – related to fish species and flows
remediation effectiveness	x compete, restricted, limited
remediation feasibility	x minor constraints, major constraints, limited likelihood
barrier location relative to habitat	x estuarine, lowland, upland, tributary stream, habitat denied

Barriers to fish migration on waterways crossing the road corridor may occur due to adverse hydraulic conditions at road crossings and other waterway structures (e.g. water surface drop, high velocity, turbulence); poor water quality (e.g. low dissolved oxygen, excess nutrients); or other physical barriers associated with waterway modification (e.g. infestation and blockage with aquatic weed, habitat loss associated with channelisation). See Guidelines Part C – Fish Migration Barriers and Fish Passage Options for Road Crossings. Scientists, managers and designers involved in road corridor scale studies may need to obtain specialist assistance in evaluating the effect of existing barriers on fish movement in the vicinity of the road.

For the Tully-Murray floodplain, the extent of existing barriers on waterways crossing the road corridor was assessed from previous studies on fish migration barriers and remediation measures on the floodplain, and from field inspections of waterway crossings. Existing fish migration barriers at floodplain locations remote from the Bruce Highway corridor, although potentially significant locally, were not considered likely to affect fish movement in waterways crossing the new road alignment. The extensive inter-connection of fish movement corridors across the floodplain in flood conditions will further minimise any restriction to fish movement.

however allow discrimination between design provisions for various waterways and road-waterway crossings according to the target fish community for that crossing.

As an illustration of the fish community for the Corduroy Creek project, an extract from the fish species list for the Tully Murray catchment is presented in Box D4.1, where they are grouped by family names and listed alphabetically by comm

with respect to seasonal flow and flood conditions in the stream, which can be considered in terms of flood flow (wet season), low flow, and tidal flow conditions.

Examination of the generalised relationship between movement directions and fish movement groups shows that critical movement events are typically adult upstream spawning migration (AUS) and juvenile upstream dispersal migration (JUD). Potamodromous Group P1 is typically the only group clearly displaying adult upstream spawning migration (AUS), which is the critical movement event for adult fish. Juvenile upstream dispersal migration (JUD), which is the critical movement event for juvenile fish, typically occurs for Catadromous Group C1 and Group C2, and for Potamodromous Group P2, Group P3 and Group P4. Adult upstream dispersal migration (AUD) typically applies to the same five groups as for juvenile upstream dispersal, but this movement event is usually less critical than juvenile movement.

An illustration of the fish movement direction and timing characteristics for the Tully Murray fish community is provided in Guidelines Part B. This information on upstream, downstream or localised movement under various flow conditions, which was established for the Bruce Highway Corduroy Creek to Tully road project (see Kapitzke 2006a), allows provisions for specific species to be made if required at particular waterway crossings of the road corridor.

4.4 Fish movement capabilities and design swim speeds

The fish movement categorisation and movement characteristics for the fish community are used to determine fish swimming capabilities for fish passage design. The fish movement direction and timing characteristics can be used to determine those species facing the most adverse

5 FISH MOVEMENT CORRIDORS AND PRIORITY WATERWAY CROSSINGS

In a road corridor scale study or other fish passage assessment at waterway structures, a number of waterways crossing the road corridor located at these structures may represent fish movement corridors where fish naturally move between fish habitat areas in the landscape. The road crossings and other structures may affect fish migration in these movement corridors, and it is necessary to identify the relevant fish movement corridors and provisions that should be made for fish passage at priority road crossings as well as for other waterway structures. Fish passage provisions for the structures will depend on the nature of the fish movement corridor and fish passage goals established for the site.

The road corridor scale assessment of fish movement corridors at road crossings and other waterway structures uses the information on waterway character, fish habitat, and fish community from Chapters 3 and 4, along with design proposals for road and drainage facilities that govern the configuration of the road crossings and other structures. Provisions to be made for fish passage at the adopted structures are outlined in Chapter 6, and site scale planning and design for these facilities is described in Guidelines Part E – Fish Passage Design: Site Scale

The following sections describe the fish movement corridor classification, and outline the method for establishing fish movement corridors and priority road-waterway crossings for fish passage. This is illustrated for the Tully Murray floodplain north Queensland, where more than 20 fish movement corridors on the floodplain were potentially affected by the Bruce Highway Corduroy Creek to Tully road project (Kapitzke 2006a; Kapitzke 2007a). A similar approach to that outlined here can be adopted for fish movement corridor classification for an individual crossing or other waterway structure (see Guidelines Part E – Fish Passage Design: Site Scale).

5.1 Fish movement corridor classification

The classification system presented here for prioritisation of road-waterway crossings and assessment of fish passage provisions at waterway structures is based on classification of the fish movement corridor at the road crossing or other structure rather than merely the fish habitat areas in the waterway adjacent to the structure. This is more appropriate for fish passage planning and design at the road corridor scale than other habitat assessment methods, such as waterway condition surveys focussing on fisheries resources (e.g. Russell and Hales 1997); prioritisation methods for fish passage remediation at dams, wecond552 -1.76rveyInotuchles 137 -1.1585 TD .0005 T fish movement corridor are used (Class A, Class B, Class C), and representative descriptions for these in terms of the above factors are presented in Box D5.2.

Assessment of these characteristics of the fish movement corridor can be undertaken using a combination of field investigations, desktop review and stakeholder / community consultation, as appropriate for the site and for the particular fish passage issue that is being addressed (see Chapters 3 and 4 for habitat and fish community assessment approaches). Investigations should encompass local areas adjoining the waterway structure at the road corridor, as well as a broader regional coverage of waterways upstream and downstream of the structure sites. Site inspections are valuable for habitat assessment, particularly at times of flow or when stream channels or wetlands have sections with ponded water.

Detailed field investigations of fish habitat characteristics, fish movement corridor connectivity, and fish species diversity will, however, typically not be required where information is available from resource mapping data and other documentation (e.g. existing regional or local fish species survey). A phased assessment process would, for example, use broad scale reconnaissance level investigations in initial stages, supplemented by more intensive investigations involving field surveys where required for confirmation and detailed habitat assessment for design. Classification of the fish movement corridor should adopt a precautionary approach, with the higher class chosen in borderline cases (e.g. Class A if borderline Class A / Class B).

Box D5.1: Factors for classification of fish movement corridors at road-waterway crossings
Waterway and fish habitat characteristics

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Box D5.2: Fish movement corridor classification for road-waterway crossings (After: Kapitzke 2006a)			
Fish movement corridor class	Typical fish habitat, connectivity and fish community characteristics (any or all of these characteristics may apply)		
	Waterway and fish habitat characteristics	Habitat connectivitiy and fish movement corridor significance	Fish community, fisheries values and conservation status
Class A	x major stream, minor stream, natural wetland, constructe wetland or tidal waterway in good condition x intermittent or permanently flowing stream with relatively natural flood flow or tidal flow regime x clearly defined and relatively natural channel form, wi diverse habitat structure (bank, bed, substrate, debris) x fish spawning, growth or refugial habitat areas in goo condition (e.g. pools, riffles, runs) x intact and relatively continuous riparian vegetation corridor, with instream vegetation in good condition x relatively good water quality	x extensive flood flow or tidal flow connectivity with other watercourses or wetlands upstream, downstream or laterally x good fish movement corridor connectivity with significant habitat areas upstream and downstream x no significant barriers to fish passage at waterway structures upstream or downstream	x fish community with substantial species diversity, rare or threatened species, iconic species, species with obligatory migration stage x major fisheries values (e.g. commercial, recreational, traditional, biodiversity) x watercourse and fish movement corridor with established conservation status (declared fish habitat area, environmental reserve)
Class B	x minor stream, natural wetland, constructed wetland or tidal waterway in moderate-poor condition x intermittent or permanently flowing stream with moderately altered flood flow or tidal flow regime x well defined but moderately altered channel form, wit limited habitat structure and diversity x fish spawning, growth or refugial habitat areas in moderate condition (some pools, riffles, runs) x moderately fragmented riparian vegetation corridor, wit instream vegetation in poor condition x moderate water quality	x some flood flow or tidal flow connectivity with othe watercourses or wetlands upstream, downstream or laterally x limited fish movement corridor connectivity with habitat areas upstream and downstream x some barriers to fish passage at waterway structu upstream or downstream	x fish community with moderate species diversity, some species with obligatory migration stage x moderate fisheries values (e.g. commercial, recreational, traditional, biodiversity) x watercourse and fish movement [illegible] no established conservation status (declared fish habitat area, environmental reserve)
Class C	x minor stream, stormwater drain, farm drain, constructed wetland or tidal waterway in poor condition x intermittent or permanently flowing stream with substantially altered flood flow or tidal flow regime x poorly defined and substantially altered channel form with poor habitat structure and diversity x fish spawning, growth or refugial habitat areas in poor condition x severely fragmented riparian vegetation corridor with instream vegetation x poor water quality	x negligible flood flow or tidal flow connectivity with other watercourses or wetlands upstream, downstream or laterally x negligible fish movement corridor connectivity with habitat areas upstream and downstream x substantial barriers to fish passage at waterway structures upstream or downstream	x fish comm2 Tw (fishm 0 019 0 462.18 378.2305 TD .00 0 0.002

Box D5.3: Extract from fish movement corri

crossings on the new road and / or on the existing road (see Kapitzke 2007a). A two-stage prioritisation process was used in which a short list of Stage 1 (first and second) priority sites at box culverts on the new road was chosen on the following criteria related to the significance of the fish movement corridor. Further discrimination between short listed crossings on the new road was undertaken in a Stage 2 prioritisation process (see below) to select top priority crossings, and the overall list of top priority sites for provision of fish passage was then developed from these crossings on the new road alignment and top priority crossings that have been retained on the existing road where it crossed the same waterway.

Stage 1 prioritisation criteria for provision for fish passage at box culverts on new road – Bruce Highway Corduroy Creek to Tully road project	
Class A movement corridor	Prefer to adopt the highest value Class A corridors – based on habitat value, relative waterway size and connection to major streams and floodplain lagoons
Potential to enhance corridor value	Consider potential of Class B or Class C corridors for environmental enhancement of the waterway or adjoining land
Distribution across the floodplain	Aoptain ln 3.8 0 0 159.3corrd

Box D5.5: Top priority road-waterway crossings for fish passage on new and existing road alignments for Corduroy Creek Road project (After: Kapitzke 2007a)

Road-waterway crossing	Road-waterway crossing group	Waterway and fish habitat location Fish movement corridor class	Comment and rationale
Chainage 83 865 5 x 3600 x 1200 box culvert	Group 4 – small multi-cell box culvert 600 – 1200 high	Flood channels and minor lagoons c Murray Flats south of Lagoon Creek Class A	Prominent waterway with substantial flow on Murray Flats

6 FISH PASSAGE PROVISIONS AT ROAD-WATERWAY CROSSINGS

in the road corridor studies to assess the suitability of waterway structure designs proposed on the basis of drainage, utility and other objectives. Integrated design for multipurpose requirements can best be achieved in the project concept phase by examining options for waterway structure configurations that meet all design requirements. More detailed examination of options in the preliminary design phase will allow confirmation of design proposals.

In some instances, the road corridor scale assessment of fish passage requirements may identify alternative waterway drainage structure proposals to those identified in the initial drainage design for the structures. This may lead to a change of structure type or configuration from that initially proposed, such as consideration of a bridge crossing in lieu of a culvert, or other mitigation or remediation measures such as an additional culvert cell or lowered culvert invert.

Grouping of waterway structures for the road corridor in terms of type and size of drainage structure, fish movement corridor class, and fish passage goals and design objectives will assist in standardizing design provisions and in defining overall requirements for fish passage for the project. In order to assist with integrated design provisions, this grouping should also identify structure sites with special requirements such as terrestrial fauna passage or road underpass.

For example, in terms of fish passage options for the priority box culvert waterway crossings in the Bruce Highway Corduroy Creek to Tully road project, the envelope of hydraulic conditions for the culverts indicted that the corner “L” baffle fishway design within the box culvert cell would provide a suitable fish passage design solution for all crossings. Where terrestrial fauna passage across the road corridor was provided towards the southern end of the road, the location and configuration of the culvert crossing (Chainage 82 920) was adopted in the road corridor scale studies to allow integrated ures.13oward

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