Department of Primary Industries
and Regional Development

Fishway Assessment and Monitoring Procedure

This document outlines the rationale, objectives, methodology and protocols for fishway assessment and monitoring.

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More information

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Cover image: A contractor measure water levels during wet commissioning of Seaham Weir vertical slot fishway. NSW DPIRD – Fisheries.

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1. Overview

To evaluate the effectiveness of constructed fishways and ensure compliance with the *Fisheries Management Act 1994* (FMA), DPIRD - Fisheries needs to ensure specific monitoring and reporting requirements are addressed. Part of this requirement is to demonstrate that newly constructed fish passage infrastructure is passing the full range of species and size classes as per the agreed fishway design criteria.

Fishways must meet the following Monitoring, Evaluation and Reporting (MER) requirements to ensure effective ongoing operation and compliance with s218 FMA. If this cannot be met there may be the need for future compliance and/or offset requirements.

2. Monitoring Objectives

2.1 Operational and Hydraulic Objectives

Operational questions that require assessment include:

- Is the fishway and weir / regulator being operated as per the Operation and Maintenance (O&M) Manual?
- Do fishway and weir hydraulics (e.g. head differentials, water velocity, and water turbulence) meet design criteria throughout the fishway?
- Are suitable attraction flows throughout the water column being provided to the fishway entrance and immediately downstream?

2.2 Biological Objectives

It's important to identify key biological questions related to fishway effectiveness, which include:

- What migratory native fish are present below the fishway?
- Are migratory native fish able to effectively locate and enter the fishway entrance(s)?
- Once in the fishway, are migratory native fish effectively ascending the fishway?
- Are migratory native fish effectively exiting the fishway?
- Is the fishway passing the target size range and species of native fish over the designed flow range?

3. Methodology

There are three types of fishway monitoring methods required to ensure effective ongoing operation and that ongoing compliance with s218 FMA is met. These include operational, hydraulic and biological monitoring, where activities within each methodology are implemented at different stages over the course of construction and the operation of a fishway. Construction monitoring is essential to ensure that a suitable fishway has been provided meeting s218 FMA obligations, whereas ongoing operational monitoring ensures that free fish passage is not obstructed and that necessary operational options are implemented when required. Figure 1 provides an overview of the monitoring requirements over the life of a fishway.

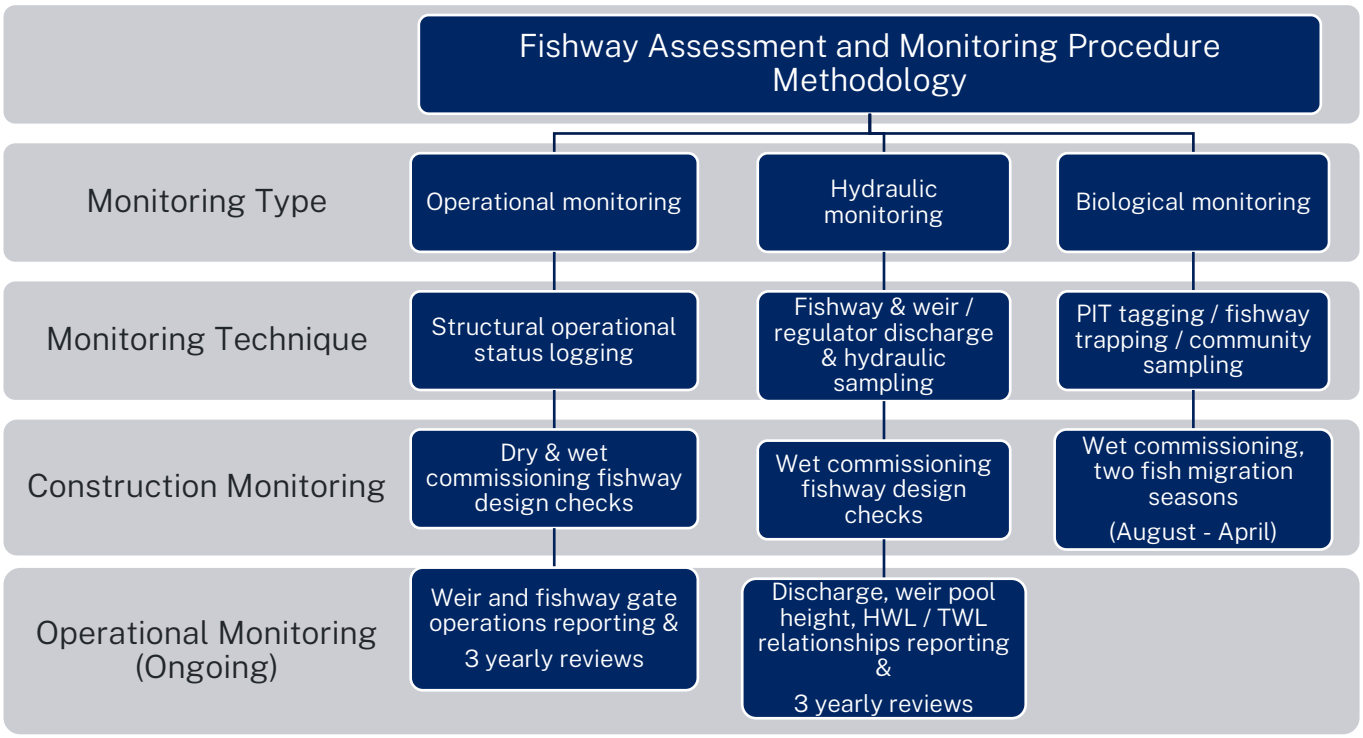

Figure 1: Fishway assessment and monitoring procedure methodology.

3.1 Operational Monitoring

Key design criteria and realised conditions that are fundamental to fishway operation are shown in the following tables.

Variable	Reporting Period	Data requirement	Benefit
Weir Gate Operations	Bi-annual reporting of daily data	Complete logs on weir gate settings (m AHD) and HWL / TWL water levels (m AHD) relative to discharge	Understand the operation of weir gates to maximise fishway attraction relative to discharge
Fishway Gate Operation	Bi-annual reporting of daily data	Complete logs on fishway gate operations (timing of fully open / closed gates)	Ensure the correct operations of fishway entrance and exit gates with respect to weir pool and tail water levels (m AHD)
Fishway Design	Commissioning with repeated review every three (3) years	Measurements of physical fishway dimensions e.g. pool cell size and invert levels, baffle / slot angle, slot widths, fishway slope	Ensure that fishway design specifications are within specified design tolerances

Table 1: Fishway operational monitoring criteria, timing and benefits.

Note: that following a fishway drown out event a full operational monitoring assessment will be required to identify any issues directly after a flood.

3.2 Hydraulic Monitoring

Every fishway is designed to possess specific hydraulic characteristics, if these differ from the designed parameters, fish passage success will be reduced or prevented.

Variable	Reporting Period	Data requirement	Benefit
Fishway Flow Variables	Commissioning with repeated review every three (3) years	Measurement of flow velocities and head differences within each slot and pool and across the entire fishway structure	Understand fishway hydraulic conditions and ensure they are within specified design ranges
Attraction Flow Fishway	Commissioning with repeated review every three (3) years	Visual footage of attraction flow conditions throughout the water column (where possible) and immediately downstream of the weir / fishway relative to flow discharge across the rest of the weir	Ensure that necessary attraction flow is present and to maximise fishway attraction by ensuring excessive turbulence, velocities, and/or eddies / recirculating flows are not present at the entrance
Site Hydrology Fishway Design	Bi-annual reporting of daily data	Weir discharge (ML/D), headwater and tailwater stream gauging	Understand if specific sight hydrology requirements (e.g. weir discharge) and/or HWL / TWL targets have been met relative to weir / fishway operation

Table 2: Fishway hydraulic monitoring criteria, timing and benefits.

Note: that following a fishway drown out event a full operational monitoring assessment will be required to identify any issues directly after a flood.

3.3 Biological Monitoring

Assessing the fish present in and around the fishway will provide an understanding of whether the fishway is operating to its design specifications or if there is an issue present that may be preventing fish passage.

Methodology	Reporting Period	Advantages	Limitations
Trapping	Over two (2) fish migration seasons across designed flow ranges	Assesses full size range and composition of migrating species able and unable to approach and ascend the fishway Provides information on small-bodied fish (<100 mm)	Trap avoidance behaviours Escapement bias Limited information on fishway approach and ascent performance and behaviour Limited data sampling opportunities and higher labour costs
PIT Tagging	Over a minimum of two (2) fish migration seasons across designed flow ranges	Provides 24 hr data logging Allows fish migration to be correlated with environmental variables such as flow Fish are tagged for life (multiple recordings) and can be monitored between multiple fishway sites Antenna arrays can provide information on fishway approach and ascent performance and behaviour	Cannot be used in small-bodied fish (<100 mm) Sample size can be fish size / species limited with ACEC implications

Table 3: Fishway biological monitoring criteria, timing and benefits.

Note: that if clear evidence arises that a fishway is not passing the full range of native species and size classes, the structure will be assessed for design and operational options to improve performance. Following any refurbishment activities at the fishway or weir, biological monitoring will be required for an additional two (2) migration seasons.

4. Fishway Performance Criteria

4.1 Fishway Commissioning Criteria

Fishway Review Assessment Guidelines will help to identify specific metrics that are outside design specifications during dry and wet commissioning phases. Dry commissioning will ensure that all dimensions of the fishway meet the construction design and are within acceptable tolerances. Wet commissioning will ensure that specific fishway hydraulic variables are within design criteria ranges

including: total headloss, baffle/cell headloss, flow velocities (e.g. at slot *vena contracta* and within pools), turbulence and fishway entrance attraction conditions.

4.2 Fishway and Weir Operation and Hydraulic Criteria

Performance criteria for fishway and weir operations will be assessed against requirements detailed within the approved O&M manual. Compliance with operation specifications will be governed by the following:

- Is the fishway and weir / regulator being operated and maintained as per the O&M manual with respect to prevailing headwater and tailwater conditions and associated flow discharge.
- Do head differentials and water velocity meet design criteria throughout the fishway?
- Are suitable attraction flows being provided to the fishway entrance relative to flows being discharged by the weir?

4.3 Fishway Trapping Criteria

Fishway trapping is undertaken to describe the migratory fish community ascending and/or descending the fishway. Trapping enables comparison of the abundance, size distribution and species composition of fish entering the fishway with fish reaching the exit. A detailed assessment of fishway performance will be determined against the fishway design criteria relative to size class and species. This is achieved by identifying statistically important differences in the abundance, species composition and size of fish collected at the entrance and the exit.

4.4 PIT Tagging Criteria

1. **Fishway approach (%):** This metric is the number of PIT tagged native fish that approach the fishway as a percentage of total PIT tagged fish at the location prior to monitoring. It indicates the effectiveness of the fishway and weir gate operations in attracting fish to the fishway entrance. An estimated approach rate with upper 95% confidence limit (UCL) less than 25 % will require further assessment. Where possible, the assessment will investigate inter- and intra-species patterns relative to age class and migration timing. The fishway and weir O&M procedures will need to be reviewed to ensure suitable attraction flows are being provided to the fishway entrance. Water Infrastructure NSW and DPIRD - Fisheries will discuss the findings of operational assessments prior to the start of the next fish monitoring season.
2. **Fishway passage efficiency:** This metric is the number of PIT tagged native fish that exit the fishway as a percentage of fish approaching the entrance. A passage efficiency with UCL less than 60 % per native fish species requires further assessment.
3. **Fishway ascent time:** This metric is the average time taken for fish to ascend from the fishway entrance to the exit and will be inspected across fish species and size classes. A functioning fishway should permit native fish species to ascend the fishway within a median time of 8 hours to correspond with a twelve hour daylight period. Research has demonstrated that certain native fish avoid darkened channels and may abandon a fishway attempt if light levels decrease (Mallen-Cooper 1999; Stuart and Mallen-Cooper 1999). Additionally, a functioning fishway must

show no biologically relevant positive or negative association between ascent time and body size because that would indicate a specific size class is struggling to ascend the fishway.

4. **Fishway ascent pattern:** This is the assessment of how native fish ascend the fishway and is dependent upon multiple PIT antennae within the fishway in addition to antennae located at the fishway entrance and exit. Assessment of fishway ascent patterns will utilise data visualization tools to show whether individuals undertook a simple ascent (i.e. passed quickly from the entrance to the exit) or a complex ascent (e.g. repeated ascents and descents of the fishway including failed ascents). It is not possible for a standard assessment to be completed across all sites due to variations between fishway PIT system setups. This assessment is qualitative, with the primary aim to detect potential issues with fishway passage (e.g. multiple delayed or discontinued ascents). The number of failed ascents and number of fish that registered a failed fishway ascent subsequently ascending the fishway may be used to help quantify the fishway ascent pattern.

5. Fishway Assessment Protocols

5.1 Operation and Maintenance (O&M) Manual

Individual fishways will each have an O&M manual that clearly articulates how the respective fishway and associated weir / regulator gates are to be maintained and operated over the full design hydrological flow range and the life of the structure to achieve suitable fishway hydraulic conditions.

O&M manuals are to be developed during the fishway design phase that detail fishway and weir gate operation protocols to optimise fishway performance. These operational protocols will be integrated into water delivery programming where possible and should ensure appropriate governance arrangements are in place that allow for continual review, consultation and revisions/improvements where possible. Fishway O&M manuals are to be completed and submitted prior to, or with, project approval documentation (e.g. Review of Environmental Factors (REF) or Environmental Impact Statement (EIS)) for DPIRD - Fisheries to review and comment on regarding suitability.

5.2 Fishway Commissioning

DPIRD - Fisheries have developed Fishway Review Assessment Guidelines (Appendix B) to aid with the dry and wet commissioning assessment. This enables DPIRD - Fisheries staff to collect fishway variables based on a particular fishway design type.

Fishway commissioning monitoring should occur prior to the departure of the fishway construction contractor to ensure that any identified faults and/or modifications can be rectified in a timely manner and to avoid site re-establishment costs.

At fishway commissioning, an assessment of fishway dimensions and internal hydrodynamics throughout the fishway is completed and a report will be produced within one (1) week of fishway commissioning or at another time mutually agreed between DPIRD - Fisheries and the asset owner / project manager.

Where metrics are recorded outside of design specifications, actions will be implemented by the asset owner / project manager to address the identified issue within 6 months of the report findings. Follow up commissioning will be required when any design specification issues have been rectified.

5.3 Operational Assessment

Operational assessment including measurements for the physical fishway dimensions are required during the commissioning phase and repeated every three (3) years or following a drown out event. Requirements for operational reporting include complete logs on weir gate settings, HWL / TWL relative to discharge, and complete logs on fishway gate operations. Compliance reporting on operations plans is required bi-annually to ensure necessary operation to maximise fish passage and that required adjustments are made.

5.4 Fishway Biological Assessment – Fishway Trapping

Fishway trapping is required to understand fishway performance against the design criteria, FMA s218 compliance and fish population changes as a result of the construction of a fishway. Key trapping requirements and considerations include:

1. Fishway trap lifting mechanisms (permanent or mobile) are to be considered and identified during the detailed design phase.
2. Fishway trap construction to be made from 3 mm perforated stainless steel mesh. Cone dimensions and angle to be identified during the detailed design phase. Fishway traps are

preferred to fit against the fishway slots rather than within a fishway cell to avoid trap avoidance of migrating fish.

3. Fishway trapping will be initiated at new fishways at the start of the migration season (August-April inclusive). If fishway commissioning is not completed by mid-September, sampling will be delayed until the following migration season (i.e August-April inclusive).
4. Fishway trapping will be required for a minimum of two (2) full migration seasons. Monthly sampling efforts of replicate trapping samples should be carried out for one week each month for five months of the migration season (ideally September-January).
5. Monthly sampling consists of paired 24 hr replicates of trapping at the fishway exit and the entrance.
6. When fishway trapping is conducted solitary to other sampling methodologies, four (4) fyke nets are to be set approximately 100 m downstream of the fishway entrance to provide an independent sample of upstream migrating fish unrelated to the fishway trap.

5.5 Fishway Biological Assessment – PIT Tagging

1. A minimum of a three-antenna array at each fishway PIT site is recommended with the locations identified during the detailed design phase. An antenna at the entrance, 1st baffle and exit of the fishway is a minimum requirement. Additional antenna's will be determined by the number of exit and entrance gates on the fishway. A third-party contractor will need to be engaged to install the PIT system during fishway construction in line with asset owner Technical Specifications.
2. PIT sampling should be initiated at new fishways at the start of the migration season (August – April inclusive). If fishway commissioning, including PIT system installation, is not completed by mid-September, PIT sampling at that site will need to be delayed until the following migration season (i.e. August – April inclusive).
3. Fish will be PIT tagged once a month over five (5) months during the fish migration season (August – March with preference of September – January) at each fishway identified for PIT tagging. Fish are to be electrofished, tagged, and released as close to the weir as possible to improve chances of tagging migratory fish over sedentary species.
4. Each weekly tagging effort should aim to tag a minimum of 200 specimens from a range of species.
5. Fishways will be sampled for two (2) complete migration seasons except where a PIT system is offline for greater than 2 months from September – January inclusive, in which case sampling will occur across a third migration season. In the occurrence of an offline PIT system, PIT sampling will cease until the PIT system returns to a fully operational status.
6. PIT reader system maintenance is to be undertaken by a third-party contractor when required. The PIT system should be checked for operational status during the winter months leading up to the start of the fish migration season to ensure successful operation.
7. Once monitoring has ceased at a fishway, the asset owner should discuss with DPIRD - Fisheries to determine the fate of the PIT system equipment. PIT system operation and maintenance may be used as part of a system wide research program in conjunction with other sites within proximity.

5.6 Fishway Biological Assessment Duration

Fishway biological monitoring will occur for a minimum of two (2) full fish migration seasons. Further biological monitoring beyond the two (2) years will be required under the following scenarios:

a. The five (5) monthly monitoring (e.g. trapping and / or PIT monitoring) trips are unable to be completed between August – March.

b. The PIT monitoring system is offline for greater than one (1) month from September – January inclusive. PIT tagouts will cease when a PIT system is offline.

c. Clear evidence arises that the fishway is not passing the full range of native species and size classes over the prescribed flow range as per the design criteria. Metrics used to assess fishway functionality are presented in Section 4.3 and 4.4. A lack of suitable numbers of tagged native fish and/or variable flows cannot be used as justification to void the monitoring program, and discussions with DPIRD - Fisheries is recommended if conditions affect implementation of monitoring.

d. If a fishway is deemed ineffective, the structure will be assessed by DPIRD - Fisheries, Water Infrastructure NSW and the asset owner for design and operational options to improve performance. Following any refurbishment activities at the fishway and/or weir, the fishway will be sampled for an additional two (2) migration season. If modifications to the fishway are not completed prior to mid-September, PIT monitoring will be delayed until the following fish migration season unless agreed to in writing by DPIRD - Fisheries.

6. Fishway Maintenance

Regular maintenance of a fishway is vital to ensure it continues to operate according to its design specifications.

Protocol	Frequency	Details
Fishway operational inspection	Minimum twice per year: (1) July or August (2) January	Follow the '*Checklist for Fishway Maintenance*' (Appendix A of the O&M Manual - contact DPIRD – Fisheries for a copy) To ensure fishway is operational for the peak fish migration period
Post flood fishway operational inspection	Following fishway drown out flow events (flow to be determined)	Follow '*Checklist for Fishway Maintenance*' (Appendix A of the O&M Manual - contact DPIRD – Fisheries for a copy) High flows that drown out the fishway which may result in subsequent damage and reduced operational effectiveness
Debris / sediment management	Following each fishway operational inspection, as per defined criteria	Debris can collect within the fishway or trash rack and partially or fully block fish passage
Vegetation management	Following each operational inspection, as required	Over time trees can grow in or adjacent the fishway and cause damage. Trimming is preferred to complete removal to prevent further fishway damage
Fishway re-survey	Three (3) yearly	Ensures continued effective fishway operation. Undertaken in conjunction with DPIRD - Fisheries using their *Fishway Assessment Form* (contact DPIRD – Fisheries for a copy)

Table 4: Fishway maintenance requirements and timing.

6.1 Fishway operational inspection

It is important to check the fishway functionality in May or June prior to the start of the spring fish migration season so that any maintenance issues identified can be rectified before early September. Similarly, an inspection should occur in early summer (e.g. December / January) to ensure optimum fishway operation for the remainder of the fish migration season (e.g. to March / April), including potential downstream migration.

Ideally, the *Checklist for Fishway Maintenance* (Appendix A of the O&M Manual) should be completed during a period of low flow. If the Checklist identifies a significant issue requiring remediation, a follow-up maintenance plan will be developed in consultation with the DPIRD - Fisheries Fish Passage Manager.

The completed *Checklist for Fishway Maintenance* form should be forwarded to the NSW DPIRD - Fisheries Fish Passage Manager for their records.

6.2 Post flood fishway operational inspection

Routine inspections should occur following high flows that drown out the fishway which may result in subsequent damage and reduced operational effectiveness.

Ideally, the *Checklist for Fishway Maintenance* should be completed after flows have receded following a high flow event. If the Checklist identifies a significant issue requiring remediation, a follow-up maintenance plan will be developed in consultation with the DPIRD - Fisheries Fish Passage Manager.

The completed Checklist should be forwarded to the NSW DPIRD - Fisheries Fish Passage Manager for their records.

6.3 Debris / sediment management

Debris such as logs, limbs, twigs, leaves, rubbish, etc. can collect within the fishway or trash rack which can partially or fully block fish passage effectiveness.

As such, all debris should be removed from the fishway at the time of inspection where possible, with rubbish being disposed of appropriately. Natural material such as small limbs, leaves, etc. can be placed on the adjacent bank > 2 m away from the fishway. Large limbs and logs should be removed from the fishway, being careful not to damage the structure, and inserted in the immediate downstream pool where possible. Large machinery may be required to lift larger woody debris. Consultation with DPIRD - Fisheries is required under s199 FM Act for dredging and reclamation (i.e. removal of woody debris, rocks or any materials from water land).

Sediment Management – High flows can deposit sediment (silt, sand, gravel, etc.) within the fishway, thereby reducing pool depth and flow discharge. Each pool should be measured during routine fishway operational inspections. Where it is highlighted that a pool has infilled with sediment, fill material within the respective pool should be promptly removed. Care must be taken not to damage the fishway during sediment management activities. Removal and disposal of instream fill material should follow best practice Blue Book recommendations.

6.4 Vegetation management

All trees are to be trimmed / removed if growing within 2 meters of any part of the fishway. Trees are to be trimmed in preference to removal except for situations where the tree roots may be detrimental to the fishway.

Large machinery may be required to lift larger woody debris. Smaller limbs and vegetation are to be removed from the site and disposed of appropriately. Aquatic weeds should be removed from the fishway. Consultation with DPIRD - Fisheries is required under s199 FM Act for dredging and reclamation (i.e. removal of woody debris, rocks or any materials from water land).

6.5 Fishway re-survey

Fishway hydraulic and design parameters (e.g. headloss, pool depth) are to be recorded via a detailed survey every three (3) years and compared against original design criteria. The survey is to be undertaken in conjunction with DPIRD - Fisheries using their *Fishway Assessment Form* (Appendix B of the O&M Manual), which can be arranged by contacting the DPIRD - Fisheries Fish Passage Manager at fish.passage@dpi.nsw.gov.au.

If the fishway survey identifies elements outside of design specifications, the DPIRD - Fisheries Fish Passage Manager should be consulted. The Maintenance Permit under part 7 of the *Fisheries Management Act 1994* does not authorise alteration works to the fishway other than routine debris, sediment, and vegetation maintenance outlined in this document. Instead, fishway alterations will require a separate permit and consultation from DPIRD - Fisheries.

7. Monitoring Governance

There are many activities that will enable the successful implementation of a fishway monitoring project that need to be completed across specific timeframes.

7.1 Fishway Operation and Maintenance Manual

The fishway O&M manual is developed in consultation with DPIRD - Fisheries and the Asset Owner / project manager. Fishway O&M manuals are to be completed and submitted prior to or with project approval documentation (e.g. an REF or EIS) for DPIRD - Fisheries to review and comment on regarding suitability.

7.2 Monitoring capital

Operational and biological monitoring capital may include weir pool/tailwater sensors, PIT tag systems, fishway traps and gantries. The design and construction of monitoring capital should be undertaken in consultation with DPIRD - Fisheries and specialist contractors.

The Asset Owner is responsible for the equipment and any associated maintenance.

7.3 Fishway Commissioning

Fishway commissioning should be completed in conjunction with DPIRD - Fisheries.

Dry commissioning (held at various hold points during and following construction) and a wet commissioning (following construction) will be required and provides the opportunity to address any issues that may have arisen during construction.

A dry commissioning is a check of all as-built components to ensure they meet design specifications.

Wet commissioning is the observation and measurement of the internal fishway hydraulics at different flow volumes to ensure they meet design specifications.

7.4 Fishway Construction Handover

The Asset Owner should obtain all necessary construction certification from the construction contractor. Any faults identified in the commissioning must be rectified by the contractor.

The Asset Owner should also inspect and approve the as-built documentation, operations and maintenance manual, and the required inspections.

7.5 Operational Monitoring and Reporting

Operational monitoring and reporting is the responsibility of the construction contractor until DPIRD - Fisheries have agreed that the fishway is functional and meets FMA s218 requirements. Following approval from DPIRD – Fisheries, the ongoing responsibilities are transferred to the Asset Owner.

7.6 Biological Monitoring and Reporting

Biological monitoring and reporting should be undertaken to help DPIRD - Fisheries ensure that the fishway performance criteria have been met as per criteria listed in Section 4. A specialist third-party consultant may be required to undertake these activities.

7.7 Permits and Animal Ethics

Fisheries Management Act 1994, Section 37 Permits and Animal Care and Ethics approvals will be the responsibility of the entity undertaking the biological monitoring components.

7.8 Data acquisition

The responsibility of specific operational and biological monitoring data will fall upon the collecting organisation to provide for sufficient reporting. These responsibilities include data management plans, data organisation, quality control and assurance, and data storage.

8. References

Mallen-Cooper, M. (1999). Developing fishways for non-salmonid fishes: a case study from the Murray River in Australia. Pp. 173-195. *In* M. Odeh (Ed.). Innovations in Fish Passage Technology (American Fisheries Society, 1999).

Stuart, I.G. and Mallen-Cooper, M. (1999). An assessment of the effectiveness of a vertical-slot fishway for non-salmonid fish at a tidal barrier on a large tropical/subtropical river. *Regulated Rivers: Research & Management*, 15(6), 575-590.