

EXECUTIVE SUMMARY

Preface

The WRC has to date sponsored three projects dealing with fishways in South Africa. These are: a) Project K5/1270, dealing with flow measurement at natural controls as well as the provision of fishways; b) Project K5/1310 aimed at developing criteria for the design of fishways for South African rivers and estuaries; and c) a comprehensive study (Project K5/1409) focusing on facilitating the free passage of migratory aquatic biota in Southern African rivers.

Due to the obvious overlap it was decided by the steering committee that the end products of the three studies would be integrated to produce a document titled: *Guidelines for the planning, design and operation of fishways in South Africa*. The present report, which emanates from the first project (K5/1270), is the first edition of this guideline document.

Chapter 1. Introduction

There are a large number of both private and government instream structures (e.g. storage weirs, diversion weirs, flow gauging weirs, culverts and dams) that impede or totally block the migration of aquatic biota in South African rivers. In spite of the known negative impact of these structures on migratory fish and macrocrustaceans, to date only about 35 fishways have been built to facilitate fish movements over these barriers. Most of these fishways, however, are not effective in passing fish, as they are not designed for South African species or river conditions.

Recent legislation in terms of the Environment Conservation Act, 1989, the National Water Act, 1998, and National Environmental Management Act (Act 107 of 1998) stipulates that appropriate mitigation (such as fishway construction) is required if any proposed instream structure obstructs the natural migration of indigenous aquatic species. The main aim of the guidelines in this document is to ensure that when this legislation is enforced, the necessary information is available to allow successful and cost-effective fishways to be constructed.

The importance of a multidisciplinary approach to fishway planning and design cannot be over-emphasised. The reader should always bear in mind that the provision of a successful fishway requires the close collaboration of fish biologists, hydraulic and civil engineers.

Two excellent review reports on the provision and design of fishways on European rivers have recently been produced, namely Lariner, M, Travade F & Porcher J.P., (2002) and FAO/DVWK (2002). These reports stress the basic principles in fishway design and show many examples of fishway layout and placement at barriers. It is recommended that the present guideline document should be read in conjunction with these two reports.

Chapter 2. Summary of Protocols

The procedures or protocols used to assess the need for and provision of a fishway at any particular instream structure, are briefly outlined in this chapter. Six procedural steps or protocols are proposed, namely:

i) Necessity Protocol

This protocol assesses a range of criteria in order to determine the ecological need for a fishway and also the practical and financial feasibility of providing a successful and cost-effective fishway.

ii) *Priority Ranking Protocol*

Various criteria are assessed and scored in order to quantify the ecological impact of the barrier in question on migratory species present – i.e. determine the importance of providing a fishway at the barrier.

iii) *Design Protocol*

An outline is given of the appropriate information on migratory species found at the site that is required to assess the biological constraints on fishway design. These biological data are used, together with the hydrological and topographical data specific to the site and barrier operation and design, in order to determine the most suitable fishway type and design details appropriate for the specific site.

The fish swimming behaviour is used to help determine the appropriate fishway type, while the fishway dimensions and internal hydraulics are influenced by the size and swimming ability of the target species. Important aspects such as the correct placement of the fishway exit, and particularly the location of the fishway entrance and the need for auxiliary and attraction water to ensure that fish are attracted to and can find and enter the fishway, are also discussed.

iv) *Construction Protocol*

Procedures are required during the construction phase to make sure appropriate project planning is in place to oversee and audit the work at critical stages. This protocol is required to ensure design criteria are adhered to and no design changes are made without biological input. In addition, a final audit is required at completion, and in some instances, it is necessary to conduct hydraulic tests and to fine-tune the structure before commissioning.

v) *Monitoring Protocol*

It is important to devise and implement an appropriate monitoring protocol to assess the effectiveness of the fishway in passing the target species and to reveal any problem areas. Guidelines for such a protocol are given in the report. The monitoring program may reveal the necessity for “fine-tuning” the fishway structure, including minor structural changes to the fishway or river channel.

vi) *Operational Management Protocol*

This protocol is aimed at ensuring that the information from monitoring work is used to devise and implement an operational management strategy. Such a strategy should include regular maintenance and clearing of debris, as well as regulating water flow down the fishway to ensure the successful functioning of the fishway during periods of migration.

Chapter 3. Biological Background to Necessity Protocol

The various criteria used to assess whether a fishway is required, or can feasibly be constructed at a particular barrier, are discussed in this chapter. These criteria include:

- Natural absence of indigenous migratory species due to a) natural bio-geographical reasons, b) absence of suitable habitat upstream of barrier due to its location at the top of the catchment, or due to habitat destruction by man, and c) the presence of both natural or man-made instream barriers close to the site.
- The particular design or height of the instream barrier may preclude the possibility of providing a fishway. This could be due to anticipated high mortalities of downstream migrants and excessively high fishway costs due to the length of fishway required.

v. *Auxiliary and Attraction Water*

Auxiliary water is additional water that is provided within the fishway to increase water volume and velocity and the entrance, while Attraction water is external to the fishway and is used to attract fish to the general area of the fishway entrance. The provision of either auxiliary or attraction water (or both) is particularly important in large, wide rivers where fish could have difficulty finding the fishway entrance.

vi. *Sediment and Debris*

Many South African rivers carry both large sediment and debris loads during floods. The deposition of sediment in pools and the blocking of normal flow through a fishway by debris, can change the internal hydraulics and make the fishway impassable. Careful design and location of the fishway to prevent sediment deposition and provision of debris deflectors can reduce the impact, but regular maintenance and cleaning is a prerequisite for successful fishway functioning in the long-term.

vii. *Topographical Considerations*

The topographical characteristics of the river channel and river banks at the site can influence both the potential fishway type and design details. The presence of enough space and suitable bedrock material and gradients will determine whether a natural-type rock-ramp fishway could be built. Suitable bedrock below the barrier may allow the construction of low walls or "pre-barrages", which improve the drown-out properties of the barrier and facilitate fish passage at higher flows.

viii. *Cost of Fishways*

Fishway construction costs can vary tremendously depending on factors such as the site characteristics, presence of suitable bedrock material and accessibility and whether the fishway is incorporated into the original design or retrofitted.

Chapter 7. Design Guidelines

The hydraulic design of fishways is illustrated by means of a few design examples. These examples describe the basic hydraulic theory and design criteria and illustrate the advantages and disadvantages of various types of fishways. The use of hydrological data in the design process is also illustrated.

From the examples used it is clear that it is often possible to design relatively cheap pool and weir type fishways for small fish migrating in small rivers with long periods of low flow in which the water level at the barrier remains relatively constant. In larger rivers where large variations in water levels occur, vertical slot fishways are the preferred option. Combinations of a pool and weir fishway and a vertical slot fishway by providing a sloping sill in the slot seems to hold a lot of promise for South African conditions.

Chapter 8. Monitoring and Operational Management

The importance of conducting carefully designed fishway monitoring programmes is discussed in this chapter, and recommendations are made regarding how such monitoring programs should be structured to ensure that all relevant information is captured.

The monitoring protocol should assess the effectiveness of the fishway in passing the target species. This will enable any minor structural changes to be made and to fine-tune the operational management, if necessary. Recommendations are made regarding fishing gear and fishing effort to be employed, as well as the abiotic and biotic data that should be collected.

The monitoring protocol can be summarised as follows:

- a). Capture fish at upper end of fishway (i.e. successfully negotiated fishway) over a set period (12 or 24 hours) and determine numbers, species and size composition.
- b). Capture all fish entering fishway over comparative time periods and compare data with that in a) above.
- c). Determine fishway use over a range of discharges and correlate the measured fish passage through fishway with the changes in the hydraulic parameters.
- d). Carefully observe the fishway in operation for any problems such as debris blockages, accumulation of migrants at bottlenecks within the fishway due to high turbulence at critical pints, presence of migrants below the barrier unable to find the fishway entrance, etc.
- e). Analyse data and make necessary changes to the fishway design and/or fine-tune operational management and maintenance programme of the fishway.