Fish passage past the Lake Wairarapa control structure

Charles Mitchell & Associates
Biological Consultants
Te Manu Road
RD2
Rotorua

Published by
Department of Conservation
Head Office, PO Box 10-420,
Wellington, New Zealand

This report was commissioned by Wellington Conservancy

ISSN 1171-9834

Reference to material in this report should be cited thus:

Mitchell, C., 1995.
Fish passage past the Lake Wairarapa control structure.
Conservation Advisory Science Notes No. 126, Department of Conservation, Wellington.

Keywords: Lake Wairampa, floodgates, native fish, fish pass

Introduction

The outlet to Lake Wairarapa has been controlled by a set of 6 radial arm floodgates since the early 1970s. Water velocities through the outlet control structure are normally high, above the speeds at which most native fishes can swim for any significant period of time. At other times the floodgates are closed and there would obviously be no opportunity for fish to enter the lake.

Most native freshwater fishes are diadromous. That is, they must migrate to and from the sea to complete their life-cycles (McDowall 1990). Recognition of this fact resulted in a small fish pass structure being built through the hump upon which the floodgate sills rest. However, construction of the Lake Wairarapa control structure was followed by a marked decline in the fisheries values of the lake (Hicks 1990).

It has been long been a concern of the Department of Conservation that this structure is so clearly in abeyance of the Fish Pass Regulations (1984). Lake Wairarapa and the associated wetland complexes form a very significant portion of the swamp and coastal lake habitat remaining in the lower North Island. The lake once supported and retains the potential to support a wide range and abundance of fishes. Free passage to and from the sea is required for at least a greater portion of the time than is the case at present.

Fish Pass Design

The purpose of this brief report is to present design concepts which could lead to a successful fish pass being installed past the Lake Wairarapa control structure.

Based on the results of a fisheries survey (Hicks 1990) it became apparent that a fish pass suitable for the mix of species expected in Lake Wairarapa would have to cater for a range of behaviour patterns and swimming ability. The first subdivision is between fish which prefer to swim in the water column or at the water surface. This group includes the common whitebait and common smelt, grey mullet and yelloweyed mullet. The second and larger group are the fishes which orient to the bottom and which can rest against the bottom in areas of high water velocity. Flounder, elvers and the various bully species are some of these fishes.

There is one common concern for all the fishes which attempt to migrate into Lake Wairarapa. For much of the time water velocities through the control structure are too high for them to swim against. A successful fish pass should provide a continuous strip of slow flowing water within which these small, weak swimming fishes can swim as they make their way into the lake.

To achieve this goal it is only necessary to present the fish with a relatively small and discrete layer of slow flowing water. Hydraulic flume studies (Mitchell 1989) showed that native fishes are adept at selecting slow flowing zones to make upstream movement easier.

One layer of water which is always relatively slow flowing and which displays hydraulic behaviour quite different from the water column is the boundary layer. Any object in a water flow has a "skin" of water which moves more slowly than the surrounding flow. This "skin" of water increases rapidly in thickness as the roughness of the object increases. Diving observations in rapids show that small fish can find areas of quite slow flowing water between the stones, despite the very high velocity of the water above (C. Mitchell, pers obs.).

Lonnebjerg (1990) reported that a "natural-artificial" stream channel lined with rocks was successful in allowing a wide range of small fishes to move upstream.The fish were moving within the boundary layer and had an infinite range of water velocities to choose, both for swimming and to rest in. This design performed far better than apparently more sophisticated and greatly more expensive fish pass designs.

The fish pass design described here uses parallel lines of rocks to generate a boundary layer suitable for bottom swimming fish. Research in Japan has shown that closely spaced lines of rocks running parallel to the lines of flow in the water result in the best conditions for fish passage with this design (Nakamura 1994).

For the surface swimming fish a design is presented which again utilises the generation of a wide boundary layer with low flow eddies. Hydraulic flume testing showed that common whitebait readily responded to the eddies generated by ridged long-run roofing set on edge. It was found that a higher and narrower raised profile generated stronger eddies which allowed passage at greater flume water velocities. In contrast materials such as corrugated iron had a relatively "clean" hydraulic profile and gave fish no significant boundary layer for upstream passage (Mitchell & Boubee 1995).

Details

Entrance design is a critical feature of fish passes. Unless fish can easily find the fish pass entrance then it will fail. In this design the fish pass entrances are beside the sides of the control structure. When high water velocities are encountered, the instinctive response of fish migrating upstream is to swim to the sides. Here they may be able to progress further upstream by exploiting any boundary layer flow-discontinuities. The sides of the approaches to the Lake Wairarapa Control structure are lined with grades of stones of increasing size (Figs 1 & 2). It can therefore be expected that fish will easily move through this area to accumulate against the concrete sides of the control structure, in the lee of the main flow through the gates. This is where the entrances of the fish pass are planned to be placed (Fig 2).

The fish pass designs presented here have been prepared so that they are relatively easy and economical to construct. The design for bottom swimming fishes can be built on site or in a yard. If the yard option is chosen then the space between adjacent slabs will have to be slightly greater so that each section can be folded up concertina-fashion for transport to the site. The boxing for each slab is intended to be reused (Fig 4).

There may be problems with obtaining sufficient quantities of stones of the relatively precise size and dimensions required. Although river-sourced stones are likely to be harder and more robust, it is considered that the irregularities of quarry rock will generate more turbulence and thus a deeper boundary layer. Quarry rock would thus be more effective for the fish pass. Andesite or basalt would be the preferred type of rock.

Placing the slabs will first require a bottom inspection by a diver to check whether there are boulders or debris on the floor of the control structure. It is considered that two light cranes, one living at each end of the fish pass section, would then be necessary to lower each fish pass section into place on either side of the flood gate sill. Final movement of the sections so that they rest against the concrete "hump" that the flood gate seals rest in (Fig 3), will require co-ordination with the diver.

One concern is whether flow over the sill would be sufficient to lift the concrete slabs and sweep them away. Should the upstream one be moved there is the risk that it could foul the flood gate, with expensive consequences. Therefore the end slabs are enlarged and angled so that flow will tend to keep them in place. In addition the mass of these slabs at around 4. 5 cubic metres of concrete, plus the mass of the other linked slabs should be sufficient to hold them in place. Stones averaging 34 kg have been used to make the scour pads on either side of the structure (Fig 2). Apparently these stones have remained in place over the years.

The rather elaborate end slabs serve a further purpose. They carry the boundary layer as close as possible to the slot in the flood gate sill. Turbulence generated from the end slabs should flow across the 0.5 m (or preferably less) space at the top of the "hump". The aim of fish pass is to present a continuum of opportunity over an obstacle. It must be recognised that the clearance needed for the flood gates is a weak point in this design which must be closed as much as possible.

The fish pass for surface swimming fish appears much less complex and costly. It should be possible to buy the profiled metal already cut to length from the factory. But fixing the material in place, beneath the normal water surface, could be labour intensive and hence expensive. It is necessary to attach metal to very high quality concrete in a zone where there will be great turbulence and periodic impacts from drifting debris. In addition the problem of corrosion must be recognised. After the initial fixing it should be possible to reattach lengths of the metal profile to the fastenings whenever required. Something like stainless steel dynabolts would need to be specified for this reason.

Cost Estimates

At this stage it is not considered possible to provide accurate estimates of the cost of constructing and installing these fish pass structures. After acceptance of the concepts presented here are gained from the Wairarapa Regional Council then accurate costings are obviously required. This is really the province of the engineers. The engineers are also responsible for the safety and maintenance of the control structure and any fish pass facility that may be constructed. But I imagine that it could cost in the vicinity of $30 000 - $50 000 to build and install the fish passage facilities along both banks of the control structure.

Acknowledgements

I would like to thank S. Blakemore and I. Heslop of the Wairarapa Regional Council for their assistance with this project.

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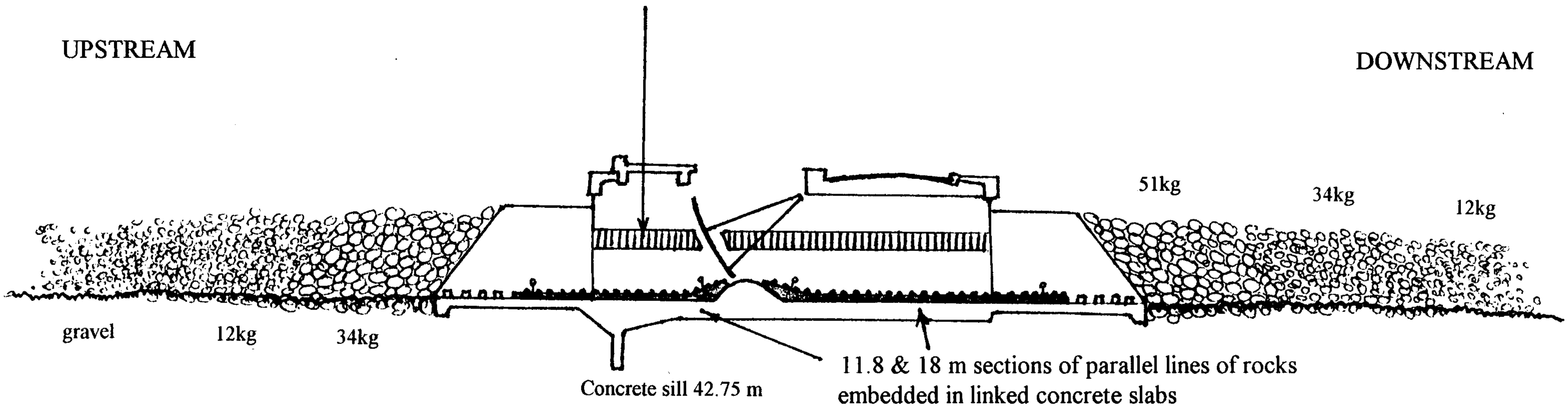
A. Passage for surface swimming fish. 24.4 m long panel of boundary layer generating material fixed at normal water level



B. Passage for bottom oriented fish.

Fig 1. Section through Lake Wairarapa control structure showing fish passage facilities.

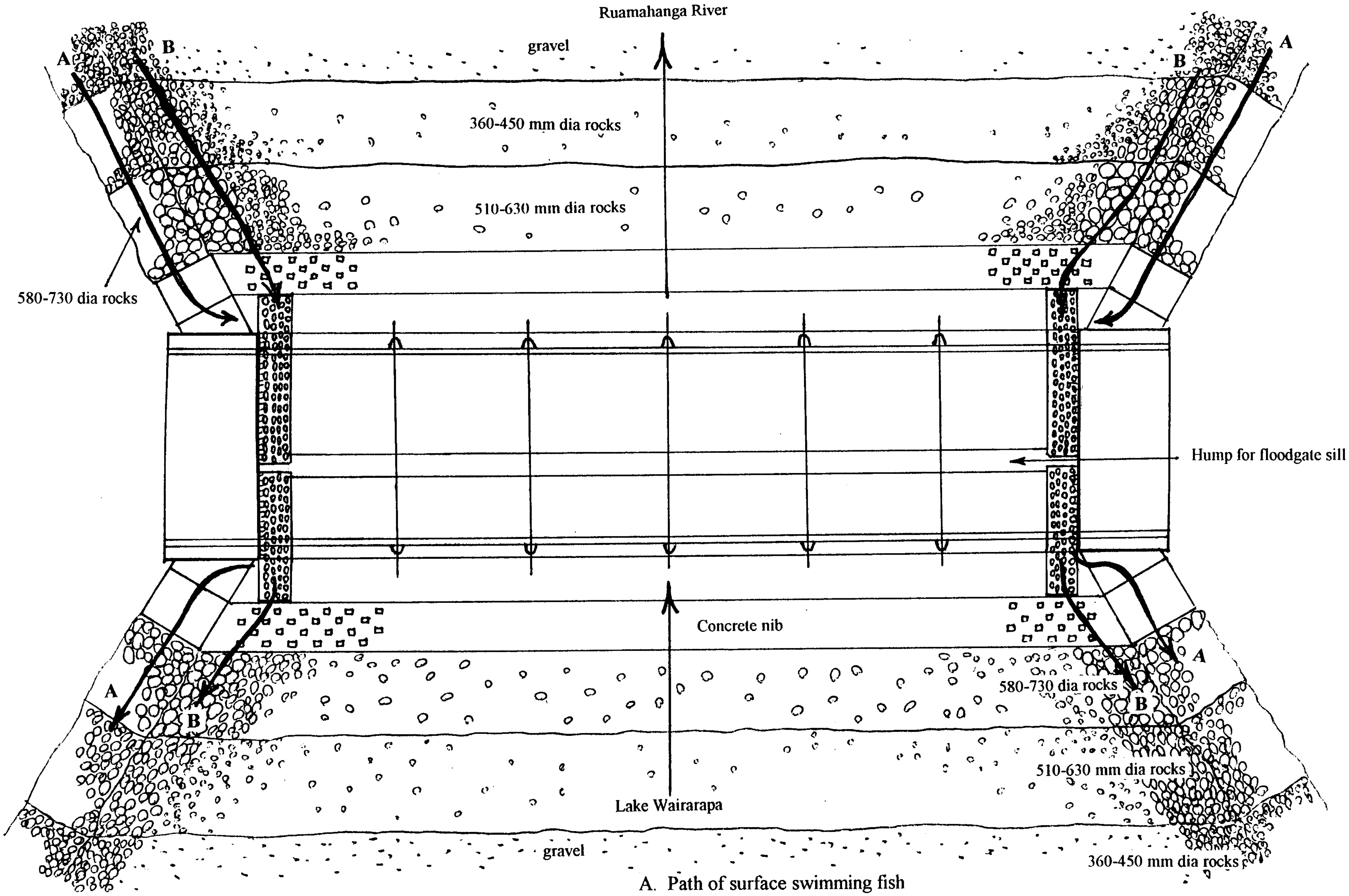


Fig 2. Plan of Lake Wairarapa Control Structure

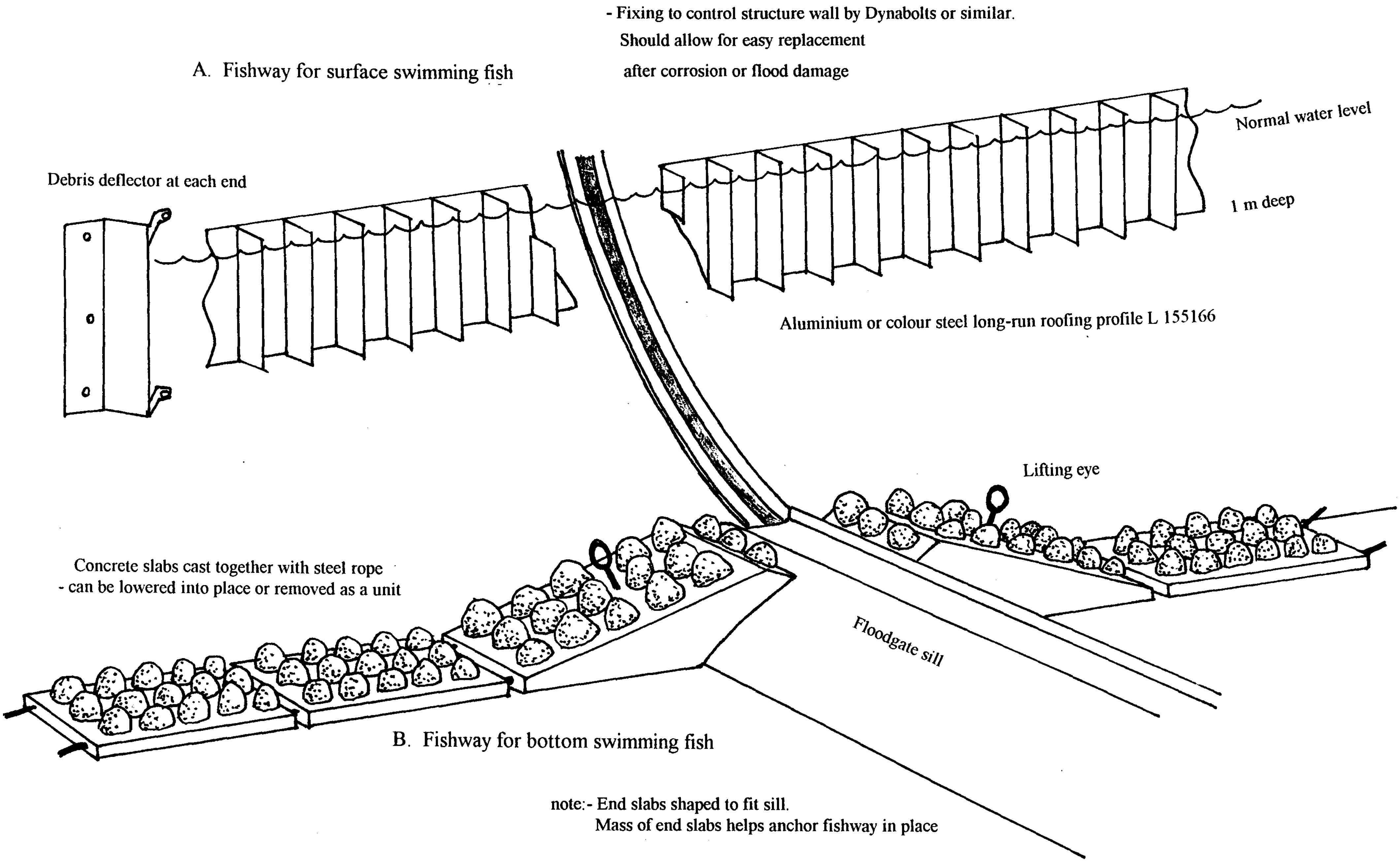


Fig 3. Lake Wairarapa Control Structure
- Provision for fish passage past floodgate sill

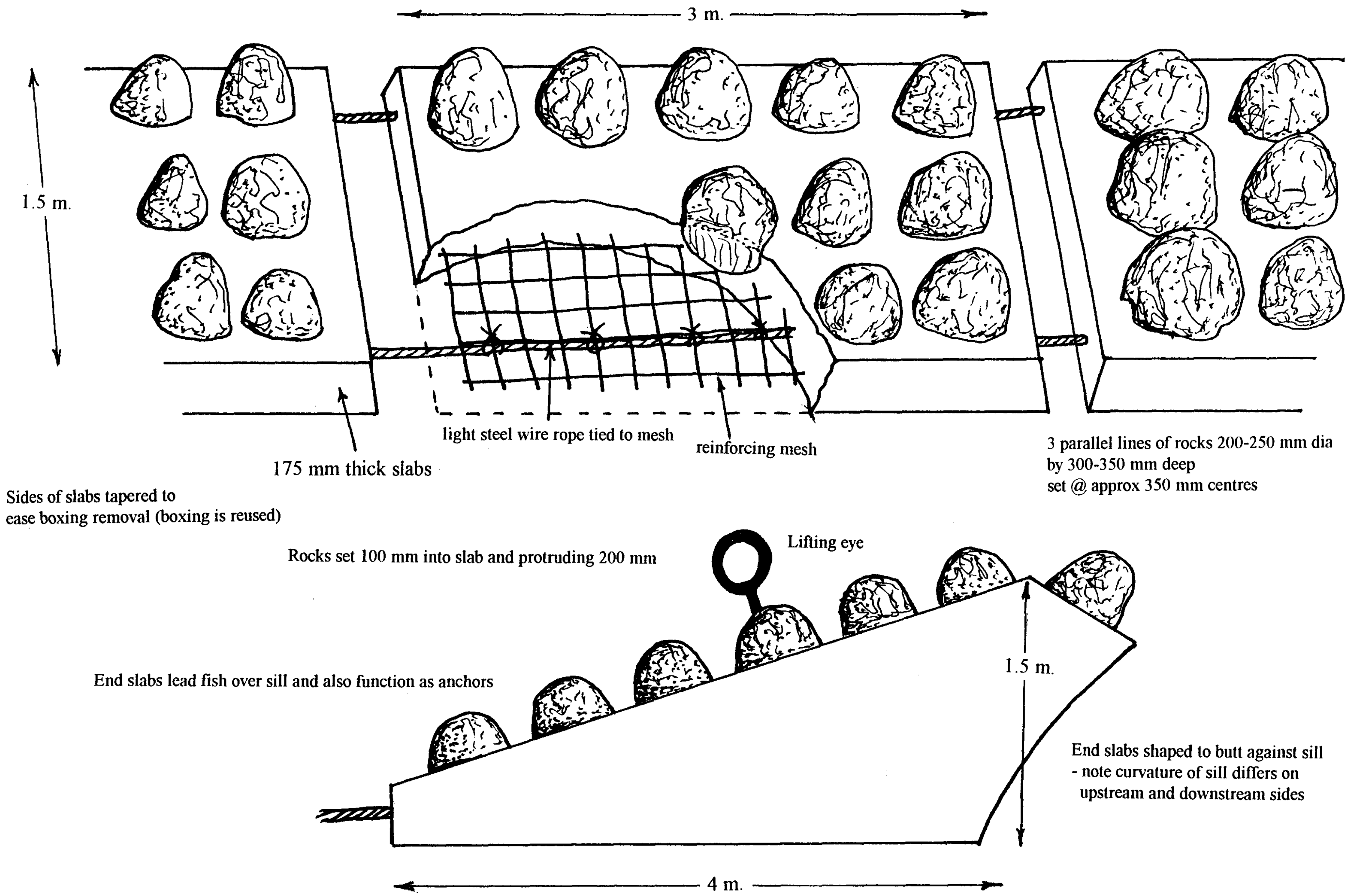


Fig 4 Lake Wairarapa Control Structure
- Details of concrete slabs for fishway for bottom swimming fish