FISH SCREEN CONCEPT
TOTARA VALLEY- OPIHI RIVER
OPUHA WATER LIMITED & MINISTRY FOR PRIMARY INDUSTRY

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TOTARA VALLEY INTAKE - OPIHI RIVER
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1.0 Introduction

In 2019 Irrigation New Zealand (on behalf of the Fish Screen Technical Working Group), received a grant from the Sustainable Farming Fund (now Sustainable Food and Fibre) to further research fish screen design criteria. The research ultimately aims to provide clear and simple guidance on fish screen requirements.

For the current stage of this project three locations with screens that are not compliant with current fish screen standards were chosen. The sites were also selected to provide a variety of existing fish screen types and river intake conditions. This report investigates options for achieving a compliant fish screen at the existing Totara Valley scheme intake on the Opihi River.

This document includes details of the fish screening design requirements and various options of location and screen type for this intake. This is an initial assessment to enable the MPI project and Opuha Water to consider which of these options for the location and screen type to consider further.

Included in this report is a suggested approach to the selection of the best location for a fish screen at a site and selection of screen types. The following stages in the development of a solution for this site including detailed design could lead to changes to meet all the requirements for a fish screen. The tables in Appendix A are drafts that have been developed with the Fish Screen Working Group which include the issues to consider in selection of the location for a fish screen and some general parameters for different fish screen types.

2.0 Background

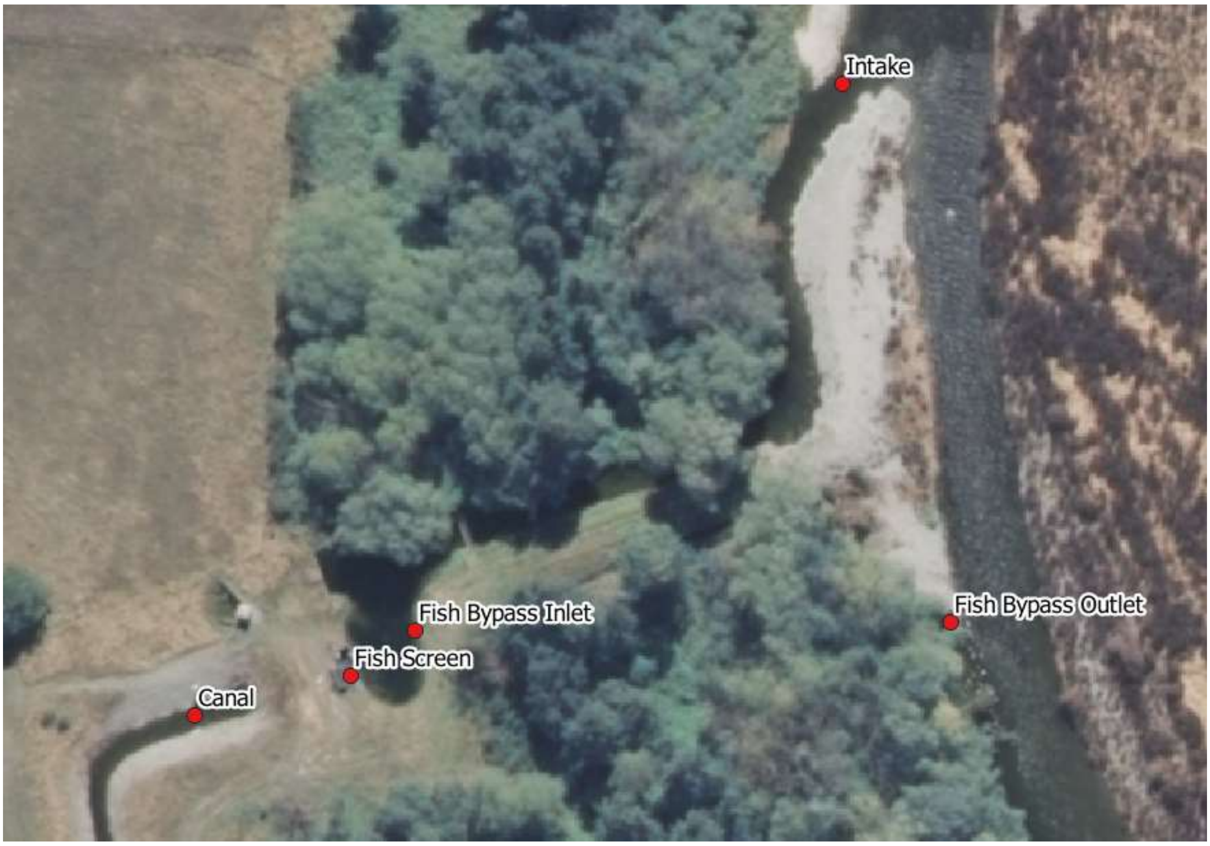
The Totara Valley Irrigation Scheme supplies water from the Opihi River to farms just south of the Opihi River and Opuha River confluence, covering approximately 1766 hectares along the southern side of the Opihi River. The scheme has been in operation for more than 20-years. The current maximum consented take from the Opihi River is 1.1m^3/s.

Totara Valley has an existing fish screen which has been in place for approximately 10 years. The fish screen is located approximately 65m from the river intake. There is no control structure on the intake and water flows through the intake into a pond area where the current Andar fish screen is located. The Andar fish screen is a flat screen with chain-link brush cleaning system, that is located at the head of the pond. The screen is approximately 2m in width and 4m in length (refer to Photo 1). The fish bypass is a small diameter pipe that runs out of the pond into a wide and 1m deep channel that flows back to the Opihi River (refer to Photoset 1).

Figure 1 shows the layout of the Totara Valley Fish Screen. Key points include:

1. Existing Fish Screen and Debris Screen are approximately 65m from river intake.
2. The bypass is approximately the same distance from the screen back to the Opihi River.

Figure 1: Current configuration of Totara Valley Irrigation Intake



3.0 Review of Existing Intake and Fish Screen

An engineer from RILEY visited the site with 2 Fish & Game officers and two of the Opuha staff on 31 January 2020 as part of the selection of suitable fish screens for the study. When we arrived at the site we found the screen was not operating and believed to be due to a tree branch getting caught and the chain being broken that operates the cleaner. The screen is an ANDAR screen which was originally designed as a Didymo debris screen but have been installed in a number of locations as a fish screen.

In 2010 a detailed assessment of the fish screen was undertaken as part of a study into 6 screens in Canterbury. In 2018 Environment Canterbury (ECan) undertook a compliance monitoring inspection. These inspections of the fish screen considered the seven criteria within the NIWA Guidelines[1] as a basis of the assessment. The findings from the 2010 study and inspection by ECan found the following key issues with the screen:

[1] Jamieson, D., Bonnett, M., Jellyman, D., & Unwin, M. (2005). Fish Screening: good practice guidelines for Canterbury. NIWA, Auckland, 70pp.

- The approach velocity is estimated to be a little greater than 0.12m/s (Estimated as 0.15m/s)
- There is not perceivable sweep velocity at the screen
- The bypass is not considered effective as is a small pipe and has a very low flow in comparison to the take. The entrance to the bypass is not considered suitable for a number of fish species as it is a culvert and the location in a pond does not attract fish. In the trial undertaken no Salmon and a very small number of trout were captured in the bypass.
- The brush cleaning system results in a fish being caught and lifted out of the water with debris.
- The seals around the bottom of the screen had gaps and thought the likely route for the large number of fish in the trial getting past the screen into the race downstream.

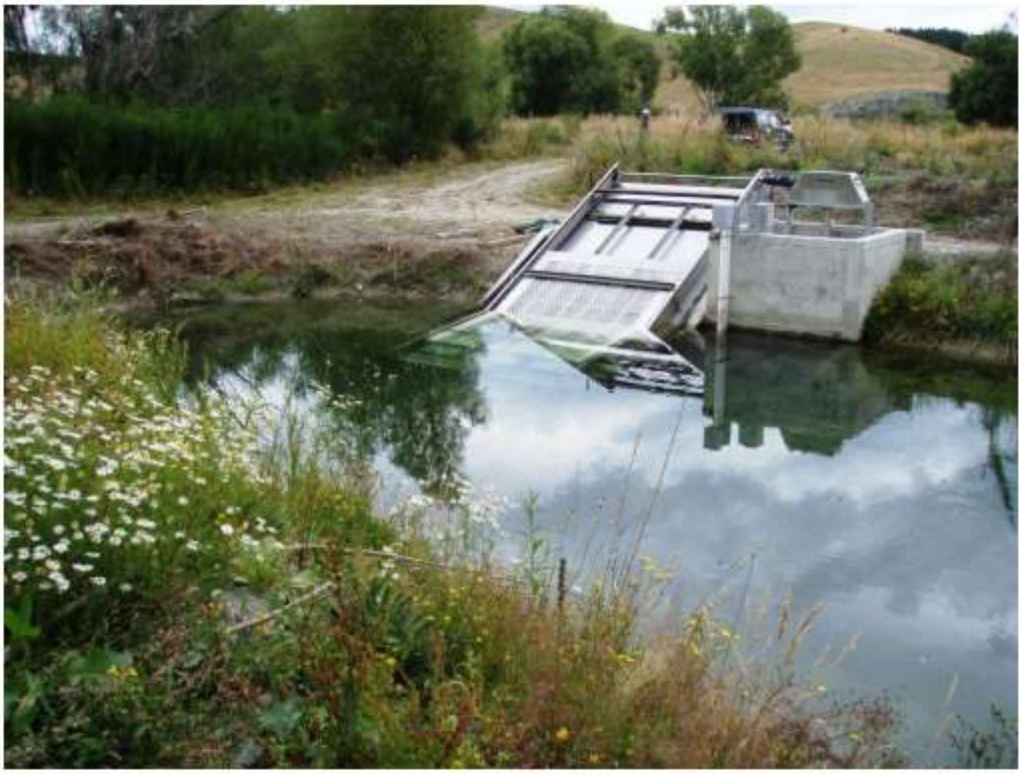
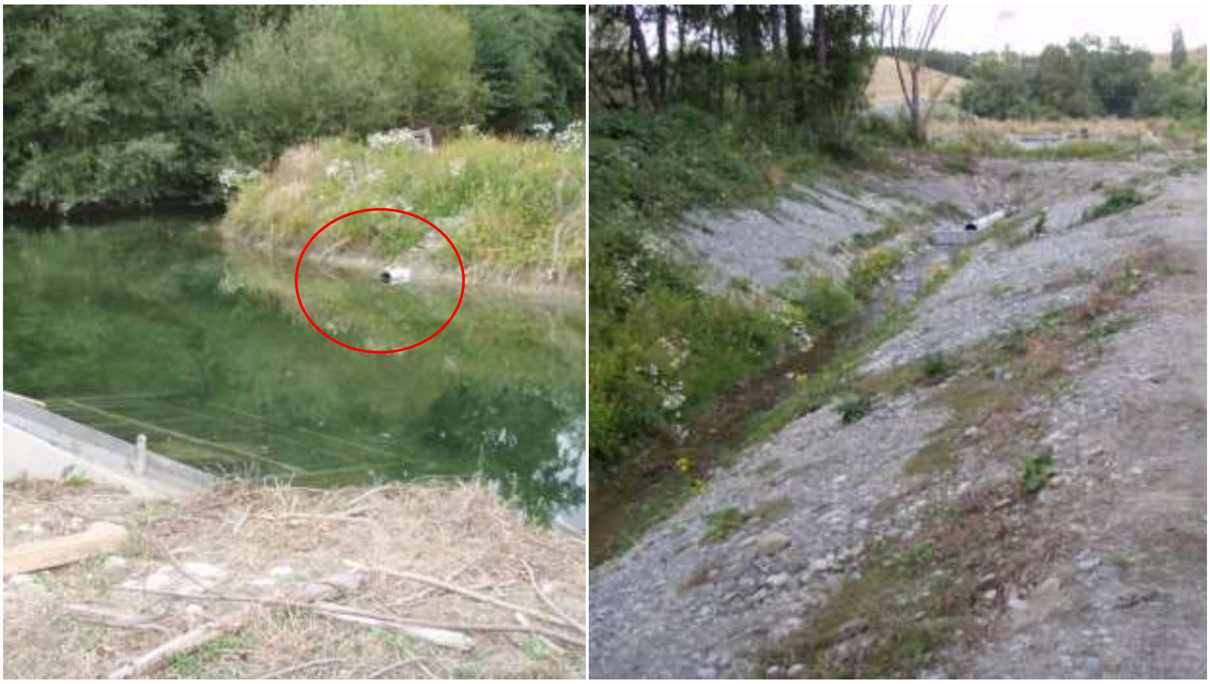


Photo 1: Totara Valley Fish Screen

From our initial observations at site it is our opinion that there are no feasible modifications to the current screen that would achieve the requirements in the guidelines. Therefore, it is recommended a new fish screen is constructed.



Photoset 1: Fish Bypass pipe inlet (left) and Fish Bypass pipe outlet into channel (right)

4.0 Basis for Design of Fish Screen

In Canterbury the recommended approach in the design of a fish screen is the NIWA Guidelines reference in Section 3.0 and Canterbury Land and Water Regional Plan (CLWRP)[2] Schedule 2. In most recent consents this is often used as the basis for consent conditions related to fish screening.

4.1 NIWA Design Guidelines

The NIWA guidelines outline seven design criteria for fish screens as follows:

1. Location.
2. Approach (through screen) velocity.
3. Sweep velocity.
4. Fish bypass at screen.
5. Fish bypass connectivity to river.
6. Screen materials and mesh size.
7. Operations and maintenance.

These design criteria need to be demonstrated in determining the fish screen location and fish screen type. The other considerations in the selection relate to operational actions (i.e. automated screen cleaning) and ease of operation/maintenance, construction costs, operating costs, and ongoing compliance monitoring risks and costs. Under 5. Fish bypass connectuivity to the screen, consideration of whether to allow upstream fish passage also needs to be considered which influences the overall placement and design of the bypass.

[2] Canterbury Land and Water Regional Plan. Schedule 2 Fish Screen Standards and Guidelines. (December 2016).

ECan is involved within the “Fish Screen Working Party (FSWP)” which is considering recommendations for fish screen requirements in Canterbury. The approach in general being discussed is as follows:

- If a fish screen meets the seven design criteria outlined in the NIWA guidelines/Schedule 2, then the design would be considered compliant and would only require verification that it meets the design criteria. Generally no ongoing monitoring of the screen effectiveness would be required.
- If a fish screen does not meet all of the seven criteria, then the criteria not being compliant would need to be described and mitigations to address such none compliance described. Such a screen may be required to prove its effectiveness for all fish species and ongoing effectiveness monitoring may be required.

Attempts to perove the effectiveness of fish screens has been attempted through live fish trials, but this process is problematic and proves difficult to achieve definitive results for river intakes. The uncertainty in these trials appears to be very high and introduces a significant risk to the consent holder where plan objectives and consent conditions require monitoring to demonstrate screen effectiveness to an absolute standard (i.e. LWRP Schedule 2). Therefore an approach based on absolute design criteria is more easily measured/audited and is the recommended approach.

4.2 Design Philosophy for Velocity

The NIWA Guidelines as discussed above have seven key criteria and two relate to the velocity of flow into/through the screen (approach) and across the screen (sweep). A common discussion is whether these criteria need to be met on average or in all parts of the screen. It is recommended that any new screen should aim to not only meet the average velocity requirements but that it shows design considerations to aim for equal distribution of velocity across the screen surface.

The main two means of achieving the approach/through screen velocity is by:

1.0 Increasing the total screen area and screen open area ratio to achieve the design velocity criteria

2.0 Reducing the average velocity by providing a baffle behind the screen to control the distribution of flow. A baffle is often a plate with a variety of openings. The size and density of the openings enables the distribution of flow to be more uniform. The design of a baffle is very complex and requires some research and development depending on the shape of the screen, the flows and velocities being designed. A number of the screens available on the market have baffles within their design.

5.0 Fish Screen Location

5.1 General Process in the Selection of the Fish Screen Location

The selection of the most suitable location for the fish screen needs to take account of a variety of factors. Appendix A includes a table that details the different factors in this selection process and the questions that need to be considered in the assessment. The following is a list of the key elements that need to be considered in assessing the best location for a fish screen for a site.

- River intake conditions.
- Potential to combine river intakes and fish screens.
- Flood water levels and protection of infrastructure.
- Fish bypass location, length and connection back to river.
- Upstream fish passage in the fish bypass.
- Control of flows for the fish screen and bypass.
- Management of debris.
- River user and operator safety.
- Operation and maintenance.
- Monitoring of the intake and fish screen.

The following sections provide for an assessment of the intake location for the Totara Valley fish screen with consideration of the factors listed above.

5.2 Assessment of locations for Totara Valley fish screen

We have considered the following potential locations for a new fish screen:

1. At the current location
2. At the intake in the river.
3. Along the race between the intake and existing fish screen location.

The fish bypass is an important component of an effective screen and needs to provide a link back to a river channel. The location and route back to the river is only indicated in the following figures as general concept. Once a preferred option(s) is selected, during a detailed design phase the location and geometry of the bypass will need to be investigated further. The design of the fish bypass will also include a means to control flows in the bypass and consideration of the fish passage downstream in the bypass and a means to avoid upstream fish passage from the river.

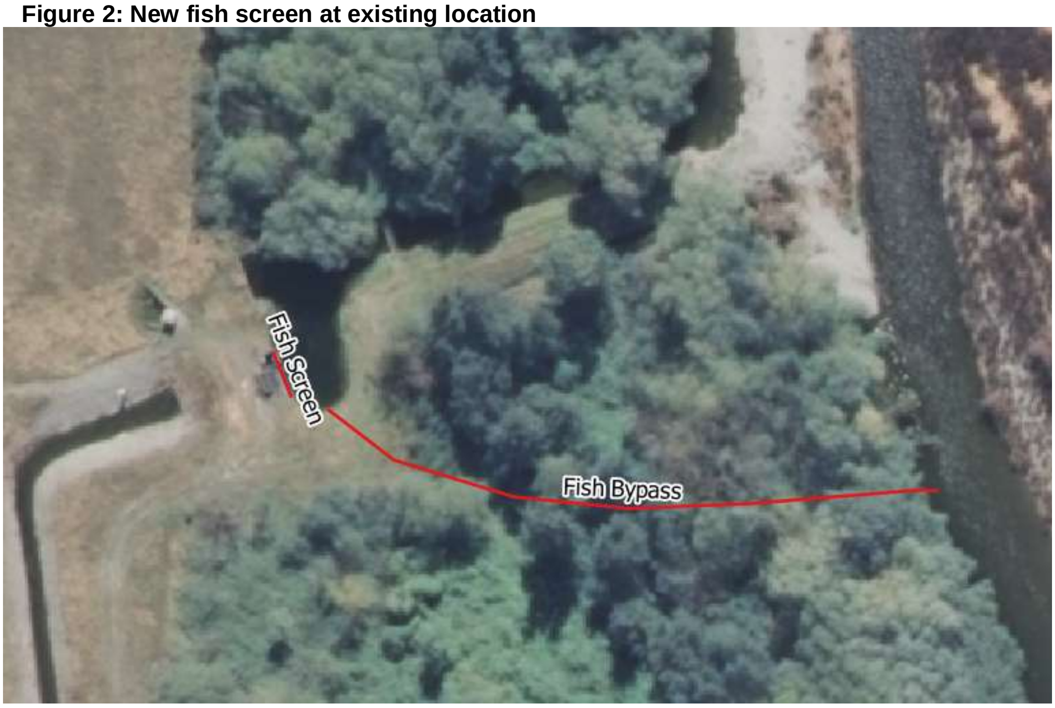
In addition to fish screening there are issues relating to debris/sediment management, flood protection of infrastructure, safety of operators and river users and flow control. It is important to note that these issues should not be considered in isolation and an integrated option may also be more cost effective.

For the screen options at current location and further upstream on intake channel the water level difference between the intake and the outlet of the bypass would need to be assessed to confirm what water head is available for the design. If there is not sufficient water head then to achieve the required sweep velocity and velocity in the bypass the bypass may need to be realigned to return further downstream.

5.3 At the current location

A fish screen could be constructed at the existing fish screen location. The advantages of this location is that it is close to existing infrastructure, though it is likely that the current Andar screen would need to be replaced with a screen system that would meet the NIWA guidelines. There would also need to be a debris screen installed up stream as well as work done to improve the fish bypass so that the recommended approach and sweep velocities were achieved (See Figure 2).

Figure 2: New fish screen at existing location



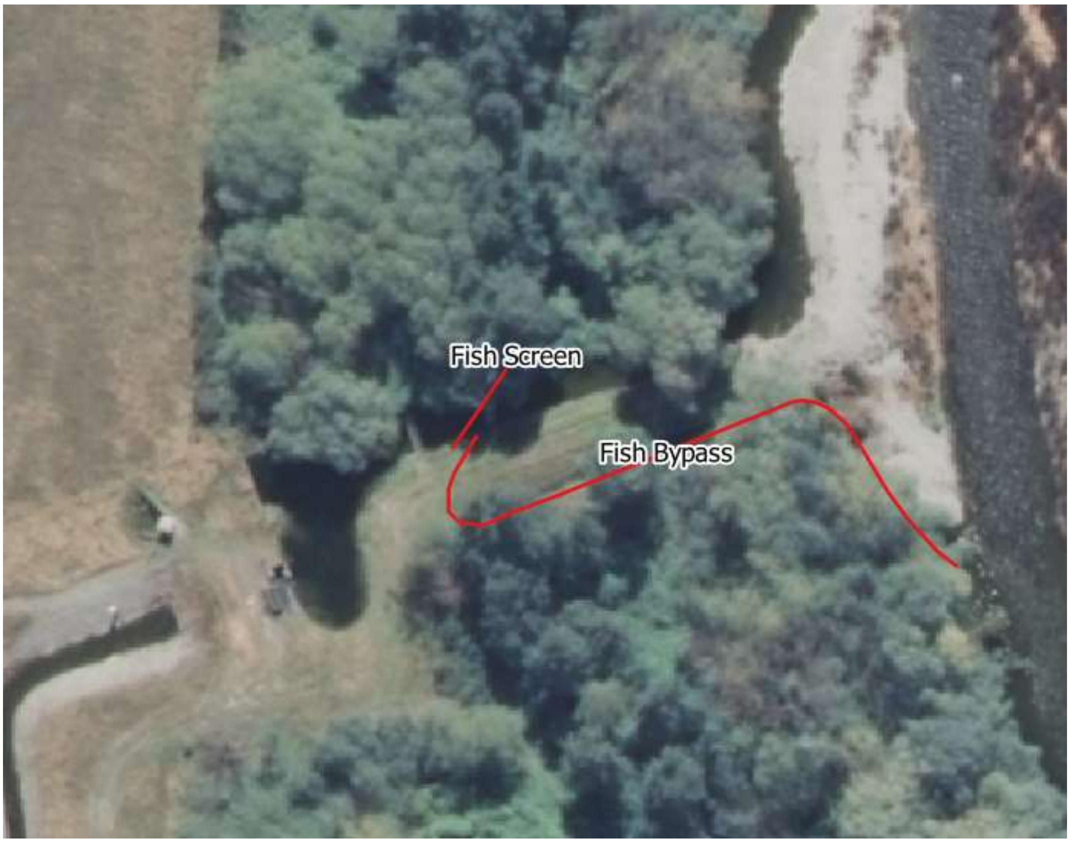
5.4 At the River Intake

At this location, the screens would be exposed to the river and the debris it conveys. There is also the issue of changes in the river braids which all suggest that this would be a difficult location to locate the fish screen at. The benefits of a fish screen at this location is that it does not require a fish bypass as the fish would remain in the river. The issues relating to construction and ongoing operation would suggest this is unlikely to be a feasible option.

5.5 Between the Intake and Current Fish Screen Location

At this location, the fish screen would be far better protected from the river and the debris it carries though it may still be necessary to have a debris screen located upstream of the fish screen. The advantage of this location is that it is likely that the existing fish bypass can be incorporated into the design. Figure 3 shows the location of the fish screen and bypass

Figure 3: Between Intake and existing fish screen



6.0 Fish Screen Type

There are several different types of fish screen that have been considered. The NIWA guidelines include a summary of several different types of screens.
Appendix A includes a table with the various parameters for a fish screen to be considered in the selection of a suitable screen. The screens considered as potentially appropriate for the Totara Valley intake based on the flows, previous trials on physical screens, results from recent testing of screens, and the design of recent fish screens are:

- Rotary cylinder screen (automatic cleaning) with an electric motor.
- Rotary cylinder screen (automatic cleaning) with a hydraulic turbine.
- Cone Screen
- Fixed flat screen.
- Travelling flat screen.
- Other Screen options

6.1 Rotary Cylinder Fish Screen

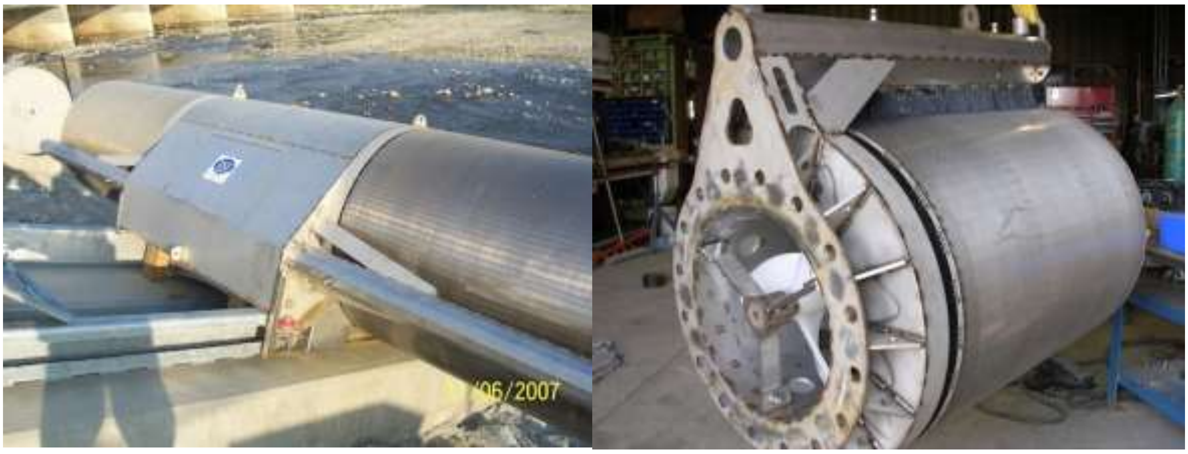
A common type of fish screen introduced to New Zealand in the 1980s is the Rotary Drum Screen. The performance of these screens has been a concern over many years as there are a number of problems observed with the screens previously installed which include:

- Fish accumulating around the front of the screen, which are at risk from predators as well as the risk from the moving screen.
- Rubber seals wearing out and leaving openings for fish to get through.
- High approach velocities and often no sweep velocity as the screens located within a concrete chute and the screen at right angles to the inflow.
- Screens being blocked, and during maintenance being lifted out of the water leaving an unscreened intake.
- Poorly designed fish bypass geometry or no fish bypass.

Previous studies have been undertaken by NIWA to assess the effectiveness of various types of fish screens in New Zealand irrigation systems. One irrigation system assessed in this study employed a rotary screen (Mead Intake) as a fish screen. The results of that study found the screen performed poorly for a number of the problems listed above as well as having 5mm mesh size which a number of the smaller fish were able to pass through.

A group including representatives from Rangitata Diversion Race Management Ltd, RILEY, Ryder Consulting Ltd, Fish & Game North Canterbury and ECan travelled to California and Washington State in April 2017 to visit fish screen manufacturers and sites where fish screens have been installed. A number of cylinder screens were observed, which along with vertical travel screens, appear to be the preferred screen type being installed in those two States. These screens were very different than common rotary screens constructed in New Zealand. These screens are rotated by a motor and have either bush cleaning system or water jets to facilitate cleaning from within the screen. Figure 4 shows an example of a design for an installation in the United States of these cylinder screens (Intake Screens Inc.).

Figure 4: Cylinder Screens Design in United States (Intake Screens, Inc.)



The screens in Figure 5 would be installed at an angle to the flow. The first one is a "T" shape and has electric motor to rotate occasionally when required for cleaning and usually on a timer. The second screen is driven by a propeller and continuously rotates. The screens can be installed on rails so that they can be retrieved for maintenance. The alternative would be to dewater the race to undertake any maintenance work which may be a better option for CIL.

The screen with an electric motor can operate over a full range of flows and only rotates as required. The screen with a propeller requires a minimum of approximately 40% of the full flow to operate and rotates continuously. The operating range can be extended by using more than one screen or having different sizes.

6.2 Cone Screens

These screens are similar in design and concept to the cylinder screens but are designed to sit on the invert of a channel and have main advantage of being suitable for shallow channel water depths. They include the same brush cleaning system and baffle to distribute the flow evenly across the surface.

Figure 5: Cylinder Screens for Cohuna and Trangie Nevertire Irrigation (AWMA, Australia)

6.3 Travelling Flat Screens

Travelling screens are mechanical screens installed vertically. The screens operate by rotating around a drum at the top and bottom of the screen with the motors above the water. The screens are self-cleaning through air or water jets at the top of the screen. Like the rotary cylinder screen, they are widely used in the United States and considered just as effective. Figure 6 shows an example of a screen from Hydrolox and located at Fall River in the United States.

Travelling screens require a longer length of screen in comparison to rotary screens but are more suited for narrow channels.

Figure 6: Example of Travelling Screen (Fall River, Hydolox Screen)

6.4 Other Screen Options

Other screen options have been identified by the Technical Group and are noted in the Decision Tables (see appendix A)

6.5 Screen Selection

Appendix A includes a table with some of the common issues associated with various screen types and this needs to be considered in selecting a suitable option. The selection of the preferred screen type will depend on the following:

- Location and geometry of the location.
- Depth of water and available head loss through screen.
- Intake flow and available flow for the bypass
- Issues of flow control.
- Electricity at site (or alternatives)
- Sediment/debris management.

The screens will need to be constructed at an angle to the flow to achieve sweep velocity.

Given the type of screen selected for the differing water depths, the length of the screen will differ. For a flat screen, if we assume a 1m water depth the screen would need to be 9.2m long and similarly, 1.5m water depth would require a 6.1m long screen. For a cylinder screen, if we assume a 1m water depth, the screen would be 7.3m long with a maximum cylinder size of 0.4m diameter. Similarly, for 1.5m water depth, the screen would be 3.2m long with a maximum cylinder size of 0.9m diameter. For the cylinder screen this would allow for a 0.3m water depth both above and below the screen.

7.0 Construction Issues

The construction of a fish screen for Totara Valley, unless located at the river intake, should be relatively straight forward. The construction could be undertaken outside normal irrigation period and the scheme shut down. A screen at the intake would require management of water from the river.

The screen could be constructed on a concrete wall or using embankments with the screens on the ends of a pipe through the embankment. Figure 7 shows a variety of different options for construction of a cylinder screen including at the end of a pipe through an embankment, on an embankment slope with pipe through embankment or on a concrete wall.

Figure 7: Cylinder screen construction types

7.1 Construction Costs

When a preferred location and screen type is selected then a cost estimate can be undertaken. The cost of the construction of a new mechanical fish screen including all of the civil works is typically in the order of \$100,000 to \$400,000 per 1 m^3/s.

8.0 Discussion and Preferred Fish Screen Location and Type

The initial assessment of the location of a fish screen by the FSWG has concluded that the best location is the current location of the fish screen. The geometry needs to be modified to provide for better velocities at the screen and an improved fish bypass.

It is likely that the water depths will be relatively shallow and limited head loss available at this site. A flat screen, cylinder or cone screen may be suitable for this site.

9.0 Next Steps

The main purpose of the fish screen concept report is to consider options for the location of a fish screen including consideration of the bypass and possible screen types. The order of this process is to first agree on the best location for the fish screen which requires consideration of the fish screen requirements, existing infrastructure and all aspects of the intakes design. Once a location or locations are selected then a more detailed assessment of the hydraulic conditions at that location and confirmation of most suitable screen type can be progressed. This assessment may require a topographical survey if LiDAR is not available or suitable which may be due to vegetation around the intake and fish screen location. A survey of the channels from the intake to the fish screen and downstream and proposed fish bypass will also need to be undertaken.

10.0 Limitation

This report has been prepared solely for the benefit of MPI, Irrigation New Zealand and Opuha Water Ltd as our client with respect to the brief. The reliance by other parties on the information or opinions contained in the report shall, without our prior review and agreement in writing, be at such parties' sole risk.

The hydraulic analyses and recommendations contained in this report are based on our understanding and interpretation of the available information. The recommendations are therefore subject to the accuracy and completeness of the information available at the time of the study. Should any further information become available, the analyses and findings of this report should be reviewed accordingly.