Rangitata Diversion Race Management Limited

Klondyke Water Storage Facility Fish Screen Verification Management Plan

Revised May 2018

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1. Introduction

1.1 Background

The Rangitata Diversion Race (RDR) intake structure on the true left bank of the Rangitata River diverts water from the river into the RDR canal. There is no fish screening at the point of diversion, however within the RDR canal there is a fish deflection system (a bio-acoustic fish fence or BAFF) where fish are directed towards a bypass back to the river. This existing behavioural fish screen is located upstream of the point where water will be diverted from the canal to the proposed Lake Klondyke Water Storage Facility (Klondyke reservoir), and therefore fish will encounter it before entering the Klondyke reservoir. The BAFF system has been shown to have limited success at preventing fish from moving further down the RDR (Ryder 2015) and so RDRML are taking the opportunity to implement a new fish screen as part of the Klondyke Water Storage Facility development.

Several fish screens options have been considered along with several potential locations.

Up to early 2017, the preferred option for a replacement fish screen was a permeable rock bund overlying an array of infiltration galleries. This structure would be positioned immediately downstream of the existing RDR sand trap, and stretch across the entire RDR channel. A bypass channel would be situated immediately next to the downstream end of the rock bund to allow fish to return back to the Rangitata River.

Since the rock bund and infiltration gallery concept was developed, RDR management have consulted further with stakeholders and regulatory authorities around fish screening requirements for the RDR. In addition to this, a group including representatives from RDRML, Environment Canterbury, Fish & Game, Riley Consultants, Golder Associates Ltd., and Ryder Environmental travelled to the west coast of the United States in April 2017 to visit fish screen manufactures, inspect sites where fish screens have been installed and monitored for screening effectiveness, and discuss fish screening concepts with authorities and operators.

Based on feedback from stakeholders and Environment Canterbury, the recommendations within the 2007 Canterbury fish screening guidelines (Jamieson *et al*. 2007) and the findings from the recent visit to the US, RDRML and its advisors have developed an alternative fish screen proposal for the RDR based around a rotary cylinder screen system located upstream of the RDR sand trap, approximately 1,000 m downstream of the intake gates on the Rangitata River. Further information on the fish screen design can be found in Riley Consultants (2017), and summarised below in section 1.2.

1.2 Proposed fish screen – revised design concept

The concept for the revised RDR fish screen is shown in Figure 1. It consists of a concrete structure for the fish screens to be positioned at an acute angle to the flow in the canal. Water flowing along the channel will progressively enter through a series of cylindrical (rotary) screens, positioned along a concrete wall, and pass into the downstream race (the RDR). A proportion (between 3 and 5 cumecs) of the flow will continue along the entire length of the screen system and downstream towards a fish bypass entrance and back to the Rangitata River.

The design concept for the fish screen encourages very high flow velocities past the screens (the sweep velocity) towards the fish bypass entrance.

The screen material associated with the rotary cylinders will have openings of 2 mm. They may be constructed either of mesh or more likely wedge wire, and the latter will probably incorporate bushes to clean the screen. Water jets are often used for mesh systems. The screens will rotate periodically as required to keep them clean.

A vertical traveling screen may be added at the tail end of the screen array, in order to improve sweep velocities towards the fish bypass entrance.

It is likely that the bypass will be constructed as an open channel and the entrance will be open and designed to enable full channel flow from the invert up to water surface. The exit point to the river will be designed to restrict fish from entering back into the bypass.

1.3 Purpose of this management plan

The purpose of the Fish Screen Verification Management Plan (FSVMP) is to develop and implement a methodology that enables sufficient data to be collected to confirm that the fish screen is operating to meet the objectives and design specifications of ECan consent CRC182542 and condition 7.

1.3.1 Objectives

The objectives of FSVMP are as follows:

1. To confirm that the following key fish screen design specifications are required to be verified under this plan:

    (i) an average approach velocity across the screen of less than 0.12 m/s;

    (ii) an average sweep velocity past the fish screen to the associated fish bypass channel that must be significantly greater that the approach velocity.

2. To confirm that the fish screen does not injure or cause fish mortaiity, and that the fish bypass channel is effective in attracting and providing safe passage back to the Rangitata River.

3. To outline a framework for ensuring the fish screen is maintained and operated in a manner that ensures design specifications continue to be met throughout the life of the screen and bypass system.

1.3.2 Verification Working Group

The final details of the FSVMP will be developed through consultation with a Verification Working Group (VWG), to be initiated by the consent holder (RDRML) and to include invited representatives from Environment Canterbury, Ngai Tahu, Central South Island Fish & Game and the salmon angling community.

1.3.3 Terminology

'Safe passage' can be defined as fish that are passed back to the river with screen structure-induced injury and mortality rates less than agreed (Nordlund 2012). In North America, agreed injury and mortality rates are usually 2-5% for juvenile fish (Nordlund 2012), which are most prone to damage. For a passage facility designed using NMFS (National Marine Fisheries Service) criteria, which are largely reflected in the proposed RDR fish screen design concept, injury and mortality are rare (Nordlund 2012).

Figure 1. *Schematic layout of revised RDR fish screen and bypass channel (redrawn from Riley 2017).*

2. Methodology

2.1 Field measurements

2.1.1 Stage 1: Hydraulic testing: approach and sweep velocities

The approach velocity (Figure 2) is to be measured no less than 7.5 cm (3 inches) in front of the screen face or at the edge of the boundary layer at the screen face, in the manner described below (hydraulic testing methods). Data derived from this testing is to be used to confirm that the average approach velocity across the screen face is ≤ 0.12 m/s.

The predicted sweep velocity for the proposed screen design is approximately 1.0 m/s at a peak canal flow of 42.2 m^3/s (Riley Consultants 2017), or approximately 8 times greater than the approach velocity. The sweep velocity (Figure 2) past the fish screen to the associated fish bypass channel is also to be measured. The sweep velocity is to be significantly greater than the approach velocity, and average approximately 8 times the average approach velocity.

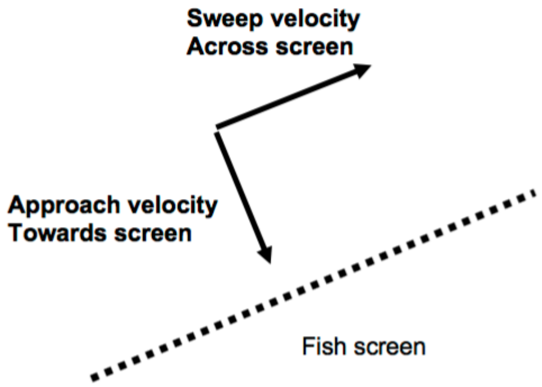

Figure 2. *Sweep velocity and approach velocity in relation to screen position (from Jamieson* et al. *2007).*

Water velocities at the screen will be measured using an Acoustic Doppler Velocimeter (ADV), Acoustic Doppler Current Profiler (ADCP) or other suitable devices (see Bureau of Reclamation 2009). An ADV measures velocity at a specific point whereas ADCP data on water velocities in the canal will be collected along a series of transects running perpendicular to the screen system and spanning the length of the screen at regular intervals.

Hydraulic testing methods shall include the following components:

- velocity measurements are to include at least 16 test points around the face of each rotary screen;
- test points are to be evenly spaced;
- approach velocity testing is to be no greater than 3 inches away from the screen face;
- the gross spacing grid of the entire screen is to be tested, and if results meet the

approach velocity threshold, spot check smaller grids can be undertaken. If criteria is met, the assumption is that entire screen has consistent velocity;

- testing conditions are to include as close as possible to the maximum design flow, the median design flow and the minimum design flow (i.e., RDR maximum, median and minimum abstraction rates, and maximum and minimum bypass flows);
- for point velocity testing, the velocimeter must be held at a consistent distance from screen, and the probe must be correctly aligned so axes accurately reflect screen velocities (e.g., see Figure 3);
- testing equipment must not interfere with water flow in the vicinity of the probe.

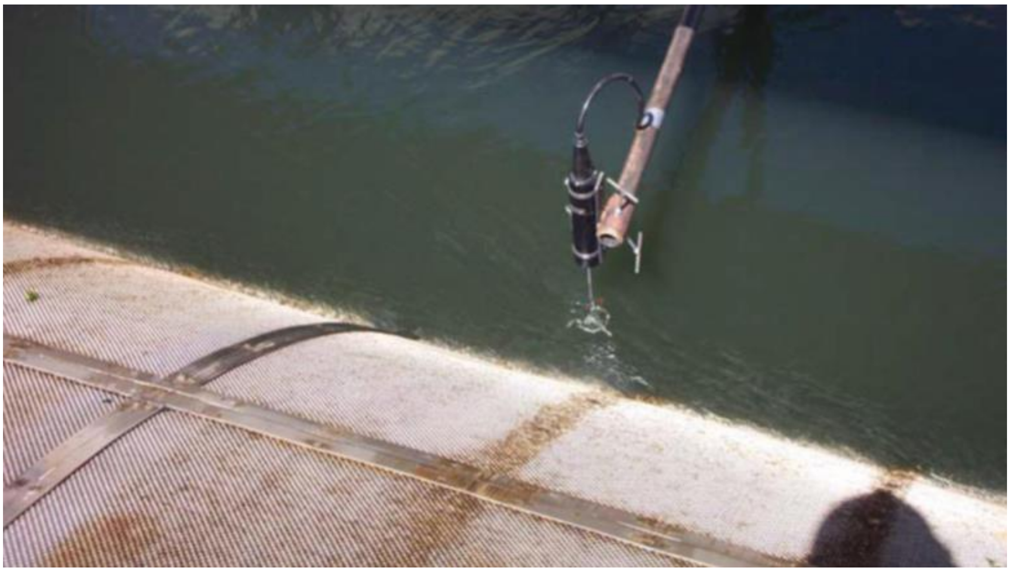

Figure 3. *Example of an ADV velocimeter on a rigid, fixed attachment, measuring point approach velocity in front of a mesh rotary screen.*

A velocity profile of the water column within the fish screen channel and in the area towards and immediately in front of the entrance to the bypass channel is also to be obtained. This information is to be used to augment information on sweep velocities across the face of the screen.

2.1.2 Stage 2: Bypass testing

(i) Confirming bypass effectiveness

Stage 2 of the plan requires the consent holder to develop and implement a monitoring plan for assessing the effectiveness of the bypass at attracting fish and providing safe passage back to the Rangitata River.

The monitoring plan is to be implemented within 12 months of commissioning the fish screen and repeated annually thereafter for at least three years. The plan is to confirm what field methodologies will be undertaken to assess bypass effectiveness. The monitoring plan is to include methods for capturing fish in the bypass and inspecting their external features for damage (e.g., Richardson 1998, also see below). The bypass channel should be designed to allow the insertion of effective fish trapping nets and for the conveyance of captured fish to facilities for further assessment. For comparative purposes, the plan is likely to require fish to be captured in the RDR canal prior to reaching fish screen infrastructure.

In addition to the above, inspections of the bypass are to be undertaken to ensure that it meets the general requirements identified in the fish screening good practice guidelines for Canterbury (Jamieson *et al.* 2007), including:

- The entrance to the bypass is easily located by fish.
- That the flow velocity draws fish into the bypass entrance and there is sufficient flow into and through the bypass to prevent fish returning.
- That the interior of the bypass poses no risks to fish travelling through it, for example, extreme bends, obstacles, rough surfaces, hydraulic jumps and free-falls are absent or pose no risk.
- The outfall where the water and fish from the bypass re-joins the main flow of the Rangitata River also poses no risk to the fish (generally this means the fish should not be exposed to an excessive free fall, or impact onto hard surfaces and/or shallow water).
- To confirm that the bypass outfall should returns fish to active water and generally avoids returning fish to the river in such a way as to expose the fish to predation from other (larger) fish or from birds.

(ii) Testing to assess fish health

Fish health assessment is based primarily on a visual examination of scales and fins for damage that might have been caused by the screen or other obstructions. Injuries for which fish are inspected for include:

- “Excessive” descaling (which can be considered a “presumed mortality”);
- Scattered or general scale loss;
- Patterns of scale loss (scrapes, patches indicating abrasive direct contact);
- Split or frayed fins;
- Bruises, cuts or skin abrasions;
- Eye injuries including corneal abrasions, internal haemorrhages and ruptured lenses.

Specific criteria for “excessive descaling” have evolved for more than a decade in North America. As a guide, a fish can be considered “descaled” and an “assumed mortality” if visual observations find the per cent scale loss on each side of the body is >20% (total possible maximum of >40%).

In order to determine whether descaling and other injuries are due to the fish screen and bypass system, trials are to be undertaken for the first three years of operation using hatchery raised Chinook salmon fry (<50mm). Fish are to be held in a cage immediately upstream of the screen structure for an agreed period of time to acclimatise prior to release. A sub-sample of fish shall be inspected prior to release and any injuries as described above shall be recorded.

Following release, fish are to be trapped in the bypass channel using methods that minimises any damage to fish once trapped. Trapped fish shall then be inspected for injuries in the same manner undertaken for the pre-release inspection.

(iii) Bypass outfall inspections

The following components are to be included as a part of routine bypass inspections:

- check to ensure there are no predator holding areas (e.g., eddies that larger fish and shags could exploit) around the outlet of the bypass to the river (annually: 31 March, 1 September and following flood events >222 m^3/s at the Klondyke recorder);
- check every week to ensure there is no obstructions around the bypass outfall due the like of debris or gravel deposits.

2.2 Timing

A summary of the timing for specific inspections and monitoring requirements is presented in Table 1 below.

Table 1. *Summary of fish screen monitoring requirements.*

Timing	Component	Comment
	Stage 1	
At the detailed design stage	• undertake **CFD** (Computational Fluid Dynamic) modelling and any other appropriate modelling techniques to refine the screens to ensure that the approach velocities are consistent and less than 0.12m/s for all of the screen area	Pre construction check to confirm the design will meet this critical fish screening guideline.
Within 1 month of commissioning the fish screen	• confirm approach velocity (see s2.1.1) • confirm sweep velocity (see s2.1.1) • check bypass channel including confluence with the Rangitata River is fit for purpose (see s2.1.2) • confirm bar gap/mesh size	Checks to ensure the fish screen has been built to design specifications.
Prior to 1 September each year for the first five years of operation	• check upstream faces of screens are free of debris and significant algae, plant and fine sediment material • check seals around screens are tight and sufficient to exclude fish • check bypass channel including	Checks to ensure the fish screen is being maintained to design specifications. 1 September has been adopted because it is prior to the commencement of the irrigation season and prior to the

Timing	Component	Comment
	confluence with the Rangitata River is fit for purpose • verify cleaning system works properly • verify that all areas of the screen are being cleaned correctly; • verify that screen cleaning works effectively under worst case conditions.	commencement of salmon smolt run.
At least weekly every year of operation and following Rangitata River flood events >140 m^3/s	• check upstream faces of screens are free of debris and significant algae, plant and fine sediment material and the screen face is not damaged • check that cleaning system works properly • check that all areas of the screen are being cleaned correctly;	Best practice to ensure screen face is clear of fouling material that may affect performance. Also, a greater risk of debris and sediment material being deposited due to higher river flow events create a hazard for damaging the screen.
Immediately following Rangitata River flood events >222 m^3/s	• check bypass channel confluence with the Rangitata River is fit for purpose and suitable for returning fish to the river • check to ensure there are no predator holding areas around the outlet of the bypass to the river (also annually: 31 March and 1 September)	Flows > 222 m^3/s are equivalent to FRE3 events and potentially sufficient to disturb the bed of the river. So appropriate to check physical condition of the bypass confluence to confirm safe passage to the river is provided for.
Stage 2		
Within 12 months of commissioning the fish screen	• confirm fish are being attracted to the fish bypass entrance and safe passage is provided back to the Rangitata River • confirm that fish in the Rangitata River are not able to enter the fishbypass and swim or climb up it • confirm the travel time for salmon smolt moving past the screen face to the bypass	To confirm the condition of consent relating to safe fish passage back to the Rangitata River is being met.

3. Reporting

The first report is to be completed no later than 2 months following the first 12 months of commissioning the fish screen. Further reports are to be completed within two months following each year for the next four years, and within two months following any monitoring events related to major fish screen maintenance. The reports shall assess whether the fish screen is operating to the design specifications and include:

- detailed methodologies used to assess velocity profiles;
- field data on approach and sweep velocities including flow and other relevant conditions at the time of survey;
- detailed methodologies used to assess the efficiency of the fish bypass channel including assessments of the general criteria identified by Jamieson *et al.* (2007) and listed above;
- information on Rangitata River flows, RDR flows and fish screen bypass flows for one month prior to and during fish screen and bypass monitoring;
- records of fish screen maintenance and other inspections and monitoring summarised in Table 1;
- any recommendations for improving the fish screen verification methodology.

If it is found that any changes to the operation of the fish screen are needed so as to meet all the fish screening good practice guidelines for Canterbury, recommendations are to be made within the report as to the changes that are required.

4. References

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