CENTRAL PLAINS

WATER

# Central Plains Water Limited

## Rakaia River Intake – Fish Barrier

December 17th 2013

**Prepared by**

| Name | Position on Project | Signature | Date |
|---|---|---|---|
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# Appendices


Appendix 1 – Water Permit No. CRC 137417 Conditions Relating to the Fish Barrier

# 1. Introduction

As requested in your email dated 30 October 2013, we have prepared a report assessing the potential fish screening ability of the proposed Central Plains Water Enhancement Scheme Rakaia River intake. The purpose of this report is to provide the necessary information to seek approval from the Canterbury Regional Council regarding the fish barrier design aspects of the proposed intake. Aspects of the scheme design have been discussed with CPWL staff in an iterative manner, and Greg Ryder accompanied representatives from CPWL, Department of Conservation, North Canterbury Fish & Game Council and the kayaking community to the intake site in November 2013.

# 2. Scheme Background

By way of background, the Central Plains Water Enhancement Scheme is a community irrigation scheme which will provide water to an area of 60,000 ha of the Canterbury Plains between the top of the Canterbury Plains to the west, State Highway 1 to the east and the Waimakariri and Rakaia Rivers. The scheme will reduce the reliance on deep wells and 'run of river' sources and at the same time increase the availability of water for irrigation across the command area.

The Waimakariri and Rakaia Rivers will be linked via a 56 km canal running around the toe of the foothills and water from the canal will be distributed to properties by a combination of pumping and gravity feed throughout the 60,000 ha by over 500 km of underground piping. The first stage of the scheme will comprise 20,000 ha between the Rakaia and Selwyn Rivers.

The key components of Stage 1 are:

- An intake and headworks at the Rakaia River to bring water into the headrace.
- A headrace alongside and traversing along the northern bank of the Rakaia River to the top of the main Rakaia terrace.
- A level headrace along the plains to convey water north and into the reticulation system.
- A piped reticulation system providing pressurised water to all shareholder properties in the scheme area.

The diversion point is to be located approximately 8 km downstream of the Rakaia Gorge Bridge. It will intercept a stable river braid in this at NZMG (E2406875, N5739474) and convey the water along the intake channel, through the intake gates, the sedimentation pond and fish barrier before entering the headrace.

The general layout of the intake works is shown in Figure 1.

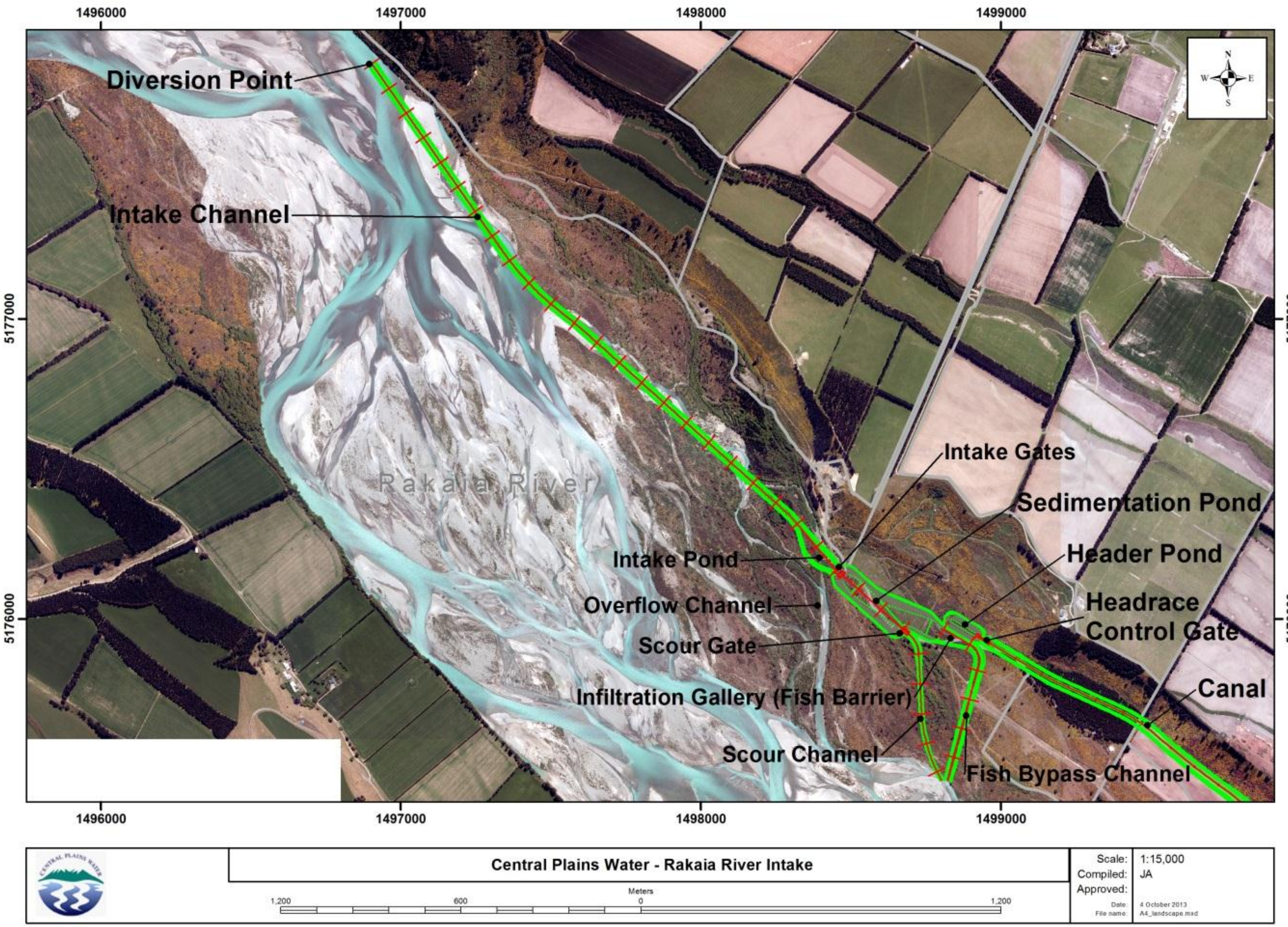


***Figure 1*** *General layout of Rakaia River intake and headworks.*

## 3. Fish Barrier Conditions

Conditions 6 to 11 of Water Permit No. CRC137417 specify requirements for the design, approval, installation and maintenance of a fish barrier at the intake, these conditions are presented in full in Appendix One.

To summarize, the main requirements of the conditions relating to the design and operation of the fish barrier are:

- The performance objectives of the barrier shall be to exclude all adult fish and at least 95% of juvenile salmonids that have entered the fish barrier area, and as far as reasonably practical, all excluded fish shall be returned safely to the mainstem of the Rakaia River downstream from the intake.
- The design plans for the fish barrier are to be certified by a suitably qualified engineer and a fisheries biologist and include details on the proposed location of the fish barrier, proposed fish barrier material and size, design sweep velocity, design approach velocity, and an effective by-pass structure and flow which returns fish to an actively flowing braid of the river.
- The fish barrier shall consist of an infiltration gallery, and be designed to prevent fish bypassing the barrier into the canal.
- The barrier shall be a bed of cobbles of minimum depth 1.5 m over the top of an intake pipe, and stone size in the top 0.3 m in the range of 50 mm to 100 mm diameter and in the lower 1.2 m in the range 100 to 200 mm in diameter.
- The velocity over the galleries (the sweep velocity) at any time shall be a minimum of 0.5 m/s.
- The velocity into the galleries (the approach velocity) shall be a maximum of 0.1 m/s.
- The ratio of the sweep velocity to approach velocity at any time shall be a minimum of 5.0.
- A fence will be installed between the fish barrier and the header pond to prevent native fish moving overland and into the header pond connected to the canal.
- An effective fish bypass system (formed in consultation with the North Canterbury Fish and Game Council and Department of Conservation) shall be maintained at all times that water is diverted into the scheme, to return fish to an active braid of the river as soon as is reasonably practicable.
- There shall be an effective operation, inspection and maintenance schedule.
- The design and operation of the fish barrier shall demonstrate best practice, and take into consideration regional or national guidelines in relation to fish barrier design, and/or any international guidelines that the certifiers consider relevant.
- The certifying report shall also specify any monitoring requirements, and any monitoring program shall be conducted for the first five years of operation and establish the effectiveness of the barrier in achieving the performance objectives (first bullet point above).

## 4. Fish Barrier Location and Approach

The proposed fish barrier consists of four infiltration galleries located downstream of the sedimentation pond and directly adjacent to the irrigation canal header pond (Figures 1 and 3). Fish will approach the fish barrier after having travelled from the diversion point in the river, through the intake channel to the intake pond and intake gates located at the entrance to the sedimentation pond, and through the sedimentation pond itself.

The intake pond and also the entrance to an overflow channel leading to the river will be located immediately upstream of the sedimentation pond and intake gates to allow kayakers that have entered the intake channel to continue downstream. To prevent kayakers entering the gates a bar screen or ‘trash rack’ (Figure 2) will also be located immediately upstream. The spacing of the trash rack bars will be sufficiently large (150 mm bar spacing) to allow adult fish to pass through the bars and not become impinged (trapped on the bars by the force of the water passing through). The recommended maximum bar spacing for excluding adult eels and salmonids from an intake is approximately 25-30 mm, at least five times smaller than the trash rack bar spacing, and therefore the risk of impingement is considered low. Also, the water velocity in the intake pond will be less than 0.5 m/s, and the velocity at the approach to the trash rack will be less than 1.0 m/s when at full take.  These velocities are much less than the burst swimming speeds of adult salmon (3.3 - 6.8 m/s, Bjorn and Reiser 1991[1]), adult trout (1.9 - 3.9m/s, Bjorn and Reiser 1991) and adult eels (>1.5 m/s, European eel, Solomon and Beach 20042).

The water velocity at approach will therefore be sufficiently low to enable large fish to orientate themselves to avoid impingement. The bars of the trash rack will be smooth, with no sharp edges that may damage fish if they do contact the bars briefly. Some fish may also enter the overflow channel, which is an existing braid that will provide passage back to a main braid of the river some 600 m downstream.

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[1] Bjornn, T. C. and Reiser, D. W. 1991. Habitat requirements of salmonids in streams. In. Meehan, W.R. (Ed.). Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19: 41-82.

[2] Solomon, D.J. & Beach, M.H. (2004) Manual for the provision of upstream migration facilities for Eel and Elver. *Science Report SC020075/SR2.* Environment Agency, Bristol, England, pp. 63.

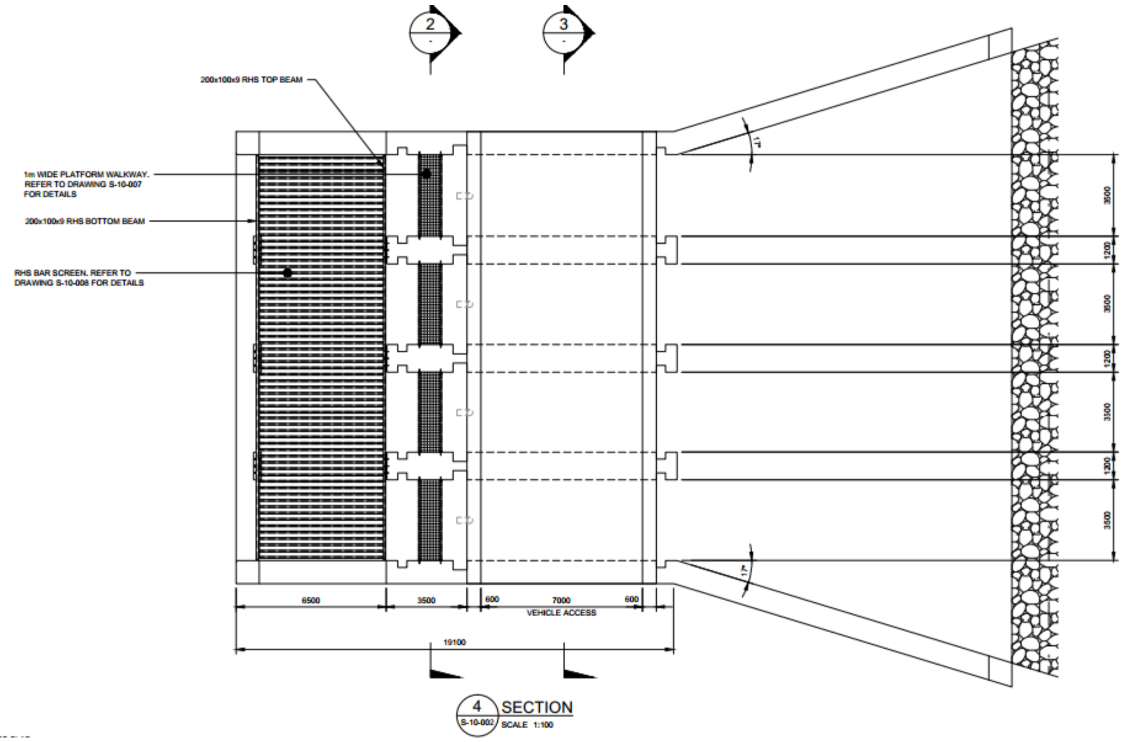


***Figure 2*** *Intake gate with bar screen.*

The undershot intake gates at the entry to the sedimentation pond will be designed to minimise any disorientation and/or damage to fish as they pass through the gates and into the pond. As such, the control structure will consist of four gates, each with an open aperture size of 2.5 m (height) x 3.5 m (width) and no obstructions below the gate. The maximum water velocity through the gates will be less than 1 m/s under most flow conditions and the design of the discharge to the sedimentation pond will be graded to dissipate energy and water velocity rapidly. The gates will be fully open except in flood conditions (flows above approximately 300 $m^3/s$, which occur about 10% of the time), when they will be partially closed to minimize the amount of sedimentation entering the sedimentation pond.

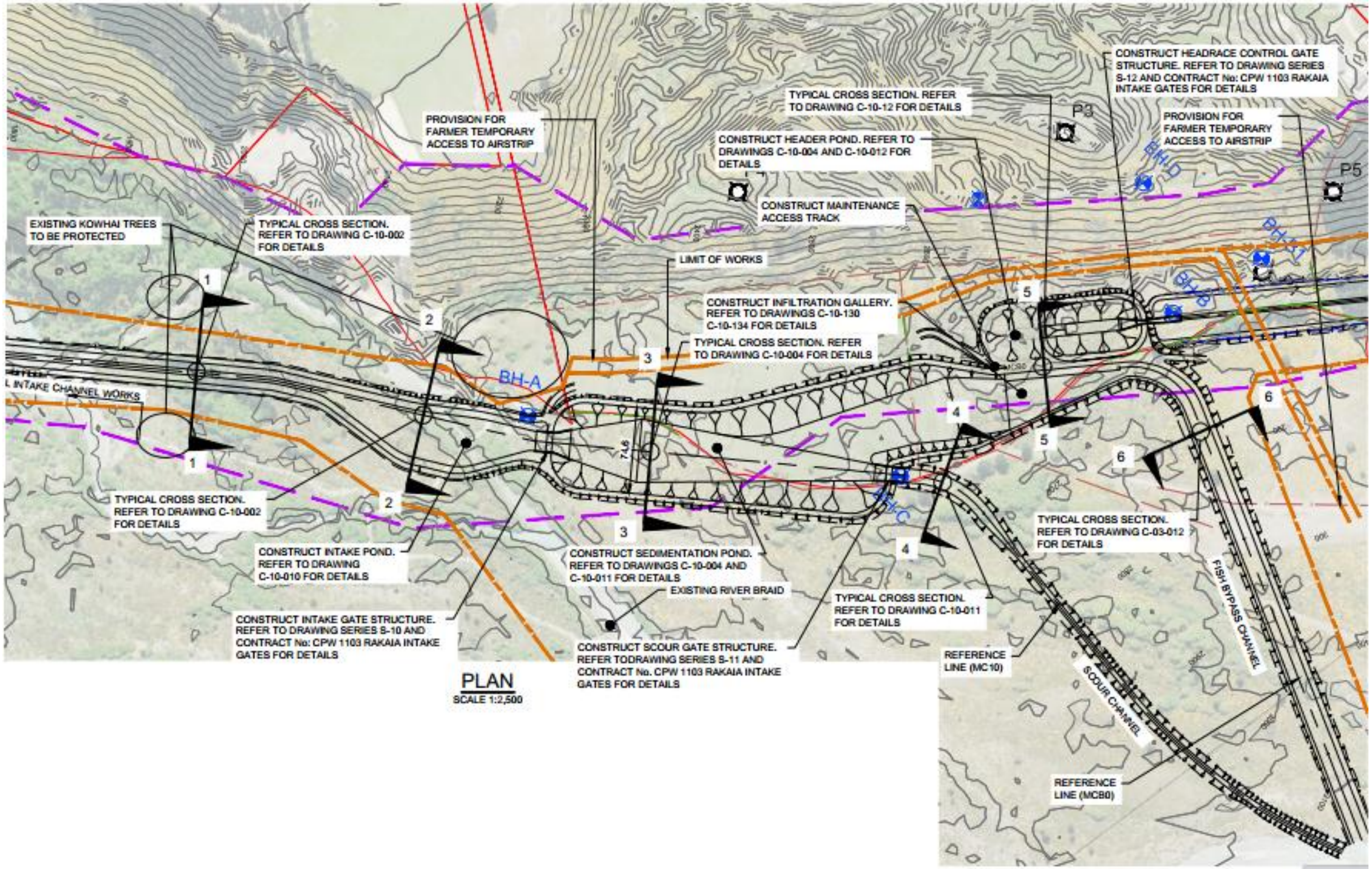


***Figure 3*** *Layout plan of intake structures.*

## 5. Fish Barrier Material and Size

Fish will approach the four infiltration galleries from the sedimentation pond. An infiltration gallery will consist of loosely packed cobbles, which allows water to move through and enter mesh intake pipes buried below the surface of the gallery, while providing a barrier to fish movement. From each of the four galleries the water will then flow into a central culvert to the irrigation race header pond, located adjacent to the galleries (Figures 1 and 3).

As required by condition 8. e. iii. the infiltration gallery will be constructed to have a minimum 1.5 m depth of cobbles over the top of the intake pipes, with cobble size in the top 0.3 m of the gallery in the range of 50 mm to 100 mm diameter and in the lower 1.2 m of the gallery in the range 100 to 200 mm in diameter.

## 6. Fish Barrier Sweep and Approach Velocities

Conditions 8. e. iv., v., and vi. require that the sweep velocity over the infiltration galleries at any time shall be a minimum of 0.5 m/s, the approach velocity shall be a maximum of 0.1 m/s, and the ratio of the sweep velocity to approach velocity at any time shall be a minimum of 5.0. These conditions are relevant to the achievement of the performance objectives (Conditions 7. a. and b.) to exclude all adult fish and at least 95% of juvenile salmonids that have entered the fish barrier area, with the intention of the conditions to ensure that fish are swept past the galleries and are not drawn in through the cobbles.

The approach and sweep velocity (and their ratio) will vary depending on the intake flow. Table 1 shows how estimated velocities vary for each infiltration gallery at intake flows of 1, 5, 10, 15, 20 and 32 $m^3$/s. Based on the design specifications, approach velocities at all intake flows are estimated to be 0.05 m/s or less (Table 1), which is lower than the maximum of 0.1 m/s required by Condition 8. e. v.. The ratio of the approach and sweep velocities (minimum 15, Table 1) also exceeds the Condition 8. e. vi. requirement of a minimum of 5.0. Both of these conditions are therefore fulfilled for all four galleries at all intake flows. Condition 8. e. iv. requires a minimum sweep velocity of 0.5 m/s over the fish barrier. Table 1 shows that this condition is met for all galleries at intake flows of 5 $m^3$/s and higher. For three of the four galleries (depending on the bypass flow configuration, i.e., gate or channel constriction control), this condition is not always met at intake flows below 5 $m^3$/s (minimum sweep velocity 0.28 m/s). However, given that the approach velocity is very low at these lower intake flows (less than 0.01 m/s) we consider the risk of fish being drawn into the galleries to be minimal. Therefore although Condition 8. e. iv. is not met for all galleries at intake flows below 5 $m^3$/s, in our opinion the sweep velocity will still be sufficient to achieve the performance objectives (Conditions 7. a. and b.) of excluding all adult fish and at least 95% of juvenile salmonids.

We also note that the '*Fish screening: good practice guidelines for Canterbury*' (Table 2 of Jamieson *et al.* 2007)[3] recommends that the approach velocity should not exceed 0.12 m/s and that the sweep

[3] Jamieson, D., Bonnett, M., Jellyman, D., and Unwin, M. 2007. Fish screening: good practice guidelines for Canterbury. Prepared for the Fish Screen Working Party by NIWA. NIWA Client Report: CHC2007-092, October 2007.

velocity should be greater than the approach velocity. These recommendations are met for all galleries at all intake flows (Table 1).

***Table 1*** *Infiltration gallery approach and sweep velocities and ratios at different intake flows. Yellow highlighting indicates when Conditions 8. e. iv., v., and vi. are not met. Source: Riley Consultants (2013[4]).*

**Channel Control**

| Sweep Velocity (m/s) | Approach Velocity m/s) | Ratio |
|---|---|---|
| 0.64 | 0.044 | 15 |
| 0.66 | 0.032 | 21 |
| 0.64 | 0.026 | 25 |
| 0.63 | 0.018 | 35 |
| 0.59 | 0.01 | 59 |
| 0.52 | 0.002 | 260 |

| Sweep Velocity (m/s) | Approach Velocity m/s) | Ratio |
|---|---|---|
| 0.8 | 0.05 | 16 |
| 0.77 | 0.036 | 21 |
| 0.72 | 0.028 | 26 |
| 0.66 | 0.02 | 33 |
| 0.55 | 0.01 | 55 |
| 0.37 | 0.002 | 185 |

| Sweep Velocity (m/s) | Approach Velocity m/s) | Ratio |
|---|---|---|
| 0.95 | 0.048 | 20 |
| 0.88 | 0.034 | 26 |
| 0.8 | 0.026 | 31 |
| 0.71 | 0.02 | 36 |
| 0.54 | 0.01 | 54 |
| 0.3 | 0.002 | 150 |

| Sweep Velocity (m/s) | Approach Velocity m/s) | Ratio |
|---|---|---|
| 1.17 | 0.05 | 23 |
| 1.06 | 0.034 | 31 |
| 0.95 | 0.026 | 37 |
| 0.82 | 0.02 | 41 |
| 0.6 | 0.01 | 60 |
| 0.28 | 0.002 | 140 |

## 7. Fish Fence

As required by condition 8. e. vii. a fence will be installed between the fish barrier and the header pond to prevent native fish moving overland and into the irrigation supply channel. The consent conditions do not specify which native fish species that are to be excluded with this fence, however it is presumed that the intention is to prevent eels crossing overland into the irrigation channel during wet periods. Eels are known to sometimes travel overland through moist vegetation at night in order to move between waterbodies. To discourage eels from moving overland the area of ground between the fish barrier and the irrigation channel will be gravelled to provide a well-drained surface that will not retain moisture, and a low fence overlaid with wind break/shade cloth (or a similar small sized mesh that eels will not be able to push through) will be constructed between the fish barrier

[4] Riley Consultants. 2013. Central Plains Water Rakaia River Intake Fish Screen Preliminary Design. Prepared for URS.

and the header pond. The fish barrier will be separated from the header pond by an embankment approximately 10 m wide with sloping sides (Figure 4). The fence will be constructed at the top of the true right embankment slope and running parallel to the true left side of the fish barrier area. The fence will be at least 1 m high to ensure eels are not able to launch themselves over the top, although it is expected that the 10 m wide gravel embankment (which will also be used for vehicle and stock access) will not be an attractive route to eels for overland travel anyway.

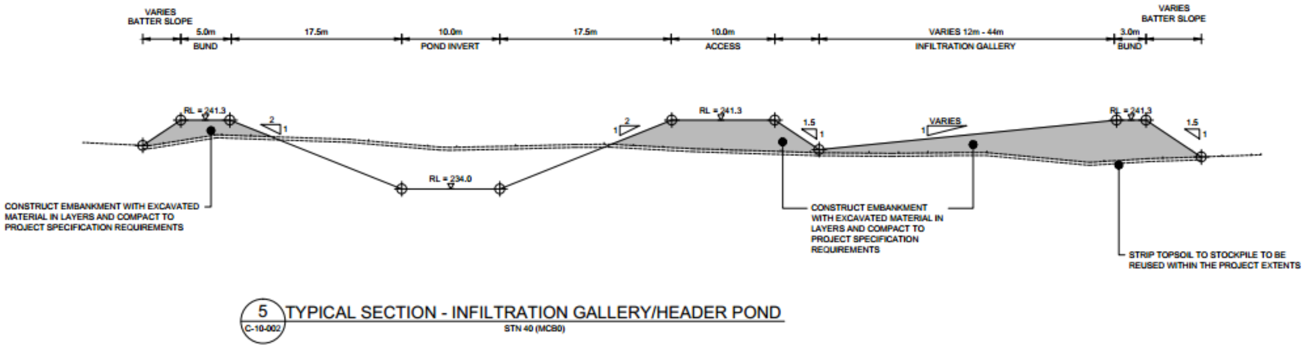


***Figure 4*** *Typical cross section of the infiltration gallery/header pond.*

## 8. Fish bypass

An effective fish bypass system (formed in consultation with the North Canterbury Fish and Game Council and Department of Conservation) is to be maintained at all times that water is diverted into the scheme, to return fish to an active braid of the river as soon as is reasonably practicable (Conditions 7. c., 8. e. viii. and 8. e. ix.).

The fish bypass channel will be located directly downstream of the fish barrier (Figures 1 and 3), therefore providing a direct route for fish moving past the fish barrier to enter back into the Rakaia River and continue their downstream migration. The channel should be engineered to ensure that there are no sharp surfaces or tight corners with high water velocities, which may cause damage to small fish. The flow in the bypass channel will range from 0.5-4 $m^3$/s under normal flow conditions (similar to that in minor braids of the Rakaia River mainstem) and will have a natural, 'V-shaped' channel to ensure that there is sufficient water depth in the channel for fish passage at a range of flows (Figure 5). The channel will be constructed by excavation and will have a substrate of gravels and cobbles, which will provide cover for small fish as they move downstream. The channel should be engineered to ensure that there are no large pools to provide cover for larger fish (adult salmonids and eels), which will discourage them from becoming resident in the channel to prey on smaller fish.

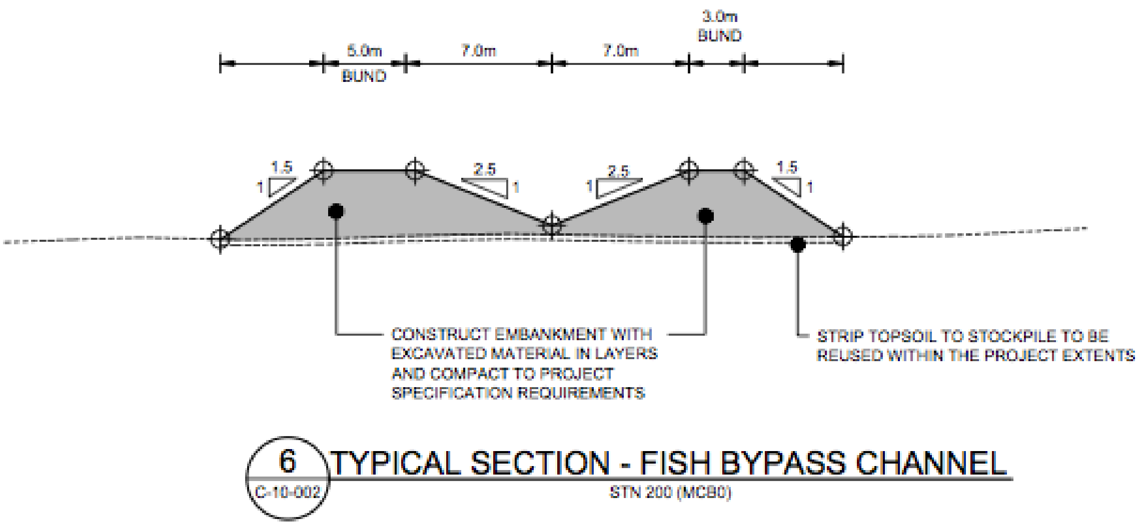


***Figure 5*** *Typical cross section of the fish bypass channel.*

## 9. Upstream migrants

Upstream migrating fish in the Rakaia River may be attracted to discharges from the CPW intake. The consent conditions for the Fish Barrier (Appendix One) do not make specific reference to ensuring that safe passage is provided for upstream migrants, however the wording of Condition 7 "… *to ensure the adverse effects on all fishery components are no more than minor* …" could be interpreted as requiring consideration of the fate of upstream migrants.

Upstream migrating fish in the vicinity of discharges from the CPW intake could include adult trout and salmon, adult lamprey, elvers, and juvenile bluegill bully, koaro and torrentfish (Table 2). The peak upstream migration period of adult trout and lamprey is predicted to be from June to September and therefore will most likely be outside the period of operation of the CPW intake. The upstream migration periods of adult salmon, elvers, and juvenile bluegill bully, koaro and torrentfish may however overlap with operation of the intake (Table 2).

***Table 2*** *Upstream migration periods of migratory fish species likely to be found in the Rakaia River in the vicinity of the CPW intake. Adapted from Environment Waikato (2007) and McDowall (1995), with information on salmonid migrations from Hopkins and Unwin (1987) and Dungey (2011). '++' indicates peak periods for migration activity and '+' the range.*

| Species | Summer | | | Autumn | | | Winter | | | Spring | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | D | J | F | M | A | M | J | J | A | S | O | N |
| Bluegill bully (juvenile) | ++ | | | | | | | | | | | ++ |
| Brown trout (adult) | | | | | | | + | + | + | | | |
| Chinook salmon (adult) | | + | ++ | ++ | ++ | + | | | | | | |
| Koaro (juvenile) | | | | | | | | | | ++ | ++ | + |
| Lamprey (adult) | | | | | | | ++ | ++ | ++ | ++ | | |
| Longfin eels (juvenile) | ++ | ++ | ++ | ++ | ++ | | | | | | + | ++ |
| Shortfin eels (juvenile) | ++ | ++ | ++ | ++ | ++ | | | | | | | + |
| Torrentfish (juvenile) | ++ | ++ | ++ | | | | | | | | | ++ |

These species may be attracted to the outflow from the CPW fish bypass, which will range from 0.5 to 4 $m^3/s$ under normal flow conditions. This flow is relatively small in comparison to the flow in the Rakaia River mainstem, however it is possible that fish may be attracted to these small inputs entering the mainstem on the true left of the river.

Evidence for the potential attraction of adult salmon is provided through the observation that salmon enter the tailrace of the Highbank Hydroelectric Power Scheme (maximum discharge approximately 25 $m^3/s$), which is located on the opposite side of the Rakaia River from the proposed CPW intake structure. Unwin and Glova (1999)[5] examined the relationship between the Highbank HEPS discharge and the number of salmon that were recovered from the tailrace channel during salvage operations. Salmon salvage operations proved necessary as it was found that upstream migrating fish that entered the tailrace channel did not return back downstream and seek an alternative upstream route when they reached the 'dead end' of the HEPS tailrace, but remained in place apparently waiting for conditions to improve to continue their upstream migration (Hardy 1986 cited in Unwin and Glova 1999) (a screen and bypass has since been installed so fish salvages are no longer required). From their analysis of 18 years of data, Unwin and Glova (1999) concluded that there was a clear relationship between the number of salmon salvaged from the tailrace and the volume and timing of flows. From the available data Unwin and Glova (1999) developed an equation to predict the number of salmon that would require salvage for a given discharge from the Highbank HEPS tailrace during February to April (the peak period of upstream migration). They found that the relationship was exponential and the number of fish requiring salvage increases rapidly as discharge increases, with the salvage required approximately doubling for each 3 $m^3/s$ increase in mean discharge (between February and April). Unwin and Glova (1999) went on to characterize the potential impact of salmon entrainment to the tailrace based on the following guidelines (Table 3):

***Table 3*** *Unwin and Glova (1999) guidelines for the impact of salmon entrainment to the Highbank HEPS tailrace.*

| Mean daily discharge, Feb to April ($m^3/s$) | Number of fish salvaged | Magnitude of impact |
|---|---|---|
| < 10 | <100 | Minor |
| 10 to 20 | 100 to 1000 | Depends on size of salmon run |
| ≥ 20 | >1000 | Major |

Based on these guidelines the number of salmon entering the discharge from the CPW intake structure fish pass (flow range 0.5 to 4 $m^3/s$ under normal flow conditions) would be approximately 10 to 13 fish, which is less than 100 fish and therefore of minor impact to the fishery.

The impact on other fish species that may enter the bypass channel is also anticipated to be minor as habitat will be present for these species within the bypass channel and if they encounter an upstream obstacle that they cannot pass they will be able to safely return downstream to the main

[5] Unwin, M. J. and G. J. Glova. 1999. The impact of discharges from the Highbank tailrace on the Rakaia River salmon fishery. Report prepared by NIWA for Beca Carter Hollings and Ferner Ltd., on behalf of TrustPower. October 1999.

river (and seek an alternate route upstream). These fish will therefore not be lost from the system.

Even if some adult salmon do enter the bypass channel it is expected that they will be able to move safely up through the intake structure to continue their upstream migration. Minimum channel water depths of 0.24 – 0.30 m are recommended to allow upstream passage for adult salmon (Thompson 1972[6], Bjornn and Reiser 1991, ODFW 1997[7]). Salmon are able to move upstream in shallower water depths, however they may suffer condition loss if this is required over a prolonged distance (Mosley 1982[8]). The bypass channel will be designed to have sufficient water depth (0.24-0.30 m) to allow upstream salmon passage. Maximum average water velocities in the bypass channel will also be 1.2 m/s to allow upstream salmon passage. Recommended average water velocities for salmon passing upstream through culverts 60-90 m long are 0.9 m/s (Table 4), however as upstream migrants will not be restricted to a culvert, but will be moving through a channel with natural substrate, there will be a range of water velocities present, including slower velocities on the margins of the channel, and opportunities for fish to rest.

***Table 4*** *Average water velocity standard for salmon passage through culverts (from ODFW 2004 in Hudson and Harkness 2010)[9].*

| Culvert length (m) | Average water velocity (m/s) |
|---|---|
| <20 | 1.8 |
| 20 - 30 | 1.5 |
| 30 - 60 | 1.2 |
| 60 - 90 | 0.9 |

Water velocities through the undershot control gates will also not exceed the maximum burst swimming speed of adult salmon (3.3-6.8 m/s) and upstream passage for adult salmon will therefore be possible throughout the CPW intake structure.

The potential for upstream migrant fish to be attracted to water flushing from the sedimentation pond has also been considered. It is anticipated that sediment flushing will occur on average approximately monthly, with up to 70 $m^3/s$ being discharged over a short period (of about one hour). We do not consider that this flushing flow will be attractive to upstream migrating fish due to its short duration, high velocity and the turbid nature of the sediment laden water. The effect of not providing an alternative pathway for fish at the upstream end of the flushing/scour channel will therefore be less than minor. However, we also recommend that this channel be inspected for

[6] Thompson, K. E. 1972. Determining streamflows for fish life. Proceedings of the instream flow requirements workshop, Pacific Northwest River Basins Commission, Portland, Oregon: 31-50.

[7] ODFW. 1997. Guidelines and criteria for stream-road crossings. Oregon Department of Fish and Wildlife. 7 pages.

[8] Mosley, M. P. 1982. Critical depths for passage in braided rivers, Canterbury, New Zealand. New Zealand Journal of Marine and Freshwater Research, 16: 351-357.

[9] Hudson, H. and Harkness, M. 2010. Assessment of fish passage in the Hutt River gorge in response to reduced flows. Prepared for Greater Wellington Water by Environmental Management Associates, October 2010.

stranded fish during the adult salmon migration season once the scheme is commissioned to confirm that fish are not attracted to these discharges.

## 10. Fish barrier operation, inspection and maintenance schedule

Condition 8. e. x. requires that there shall be an effective operation, inspection and maintenance schedule for the fish barrier.

Maintenance of the fish barrier will include the removal of sediments in and around the infiltration galleries to ensure their effective functioning. The frequency of maintenance will be directly related to the quality of water that exits the sedimentation pond.

The trash rack at the entrance of the sedimentation pond will be inspected regularly and cleaned as necessary to remove debris and ensure its correct functioning. During cleaning any instances of fish impinging on the rack will be recorded.

The bypass channel will be inspected at the beginning of each irrigation season to ensure that a continuous flow (sufficient for downstream fish passage) is provided along the entire length of the channel and connecting to an active braid of the Rakaia River. After each major fresh or flood in the river (that occurs during operation of the intake) the confluence of the bypass channel with the Rakaia River will be inspected to ensure that an adequate connection for fish passage is still present. Excavation will be used to maintain the bypass channel.

## 11. Fish barrier monitoring

Conditions 8. d. iii. and 9. require that the certifying report shall also specify any monitoring requirements, and any monitoring program shall be conducted for the first five years of operation using appropriate practices to establish the effectiveness of the barrier in achieving the performance objectives (Condition 7) and the effect on juvenile native fish.

In order to confirm that the fish barrier is meeting the performance objectives it is recommended that verification of approach and sweep velocities at the fish barrier be undertaken once the fish barrier is operating. Verification of these velocities will provide confidence that the fish barrier is capable of excluding fish, however monitoring should ideally be able to demonstrate this by confirming that all adult fish and at least 95% of juvenile salmonids are prevented from entering the header pond and therefore the irrigation supply canal.

As infiltration galleries are still a relatively new technology for providing fish barriers there has not yet been extensive monitoring to confirm their effectiveness at excluding fish. As their use becomes more widespread monitoring techniques are evolving. Monitoring of galleries constructed to date has included the release of frozen peas and corn (as a model of juvenile fish) in front of the gallery, or the holding of dyed juvenile hatchery salmon in traps on top of the gallery, with monitoring to see if any passed through the gallery to the header pond. We understand that a joint investigation by Irrigation New Zealand, Fish & Game and DOC has found that a Rakaia River gallery intake had a very good test result for released and re-trapped live fish. A final report on this study was not available at the time of writing.

Given the likely development in monitoring methods that will occur prior to the operation of the intake, it is recommended that the exact details of the fish barrier monitoring plan be developed prior to the first monitoring occasion (i.e. with the first year of operation), in consultation with the North Canterbury Fish and Game Council and Department of Conservation (as required by Condition 8. d. iii.). However, to assist with any future monitoring, it is recommended that during construction of the intake structure attachment points for rigid fish traps be included in both the fish bypass channel and the header pond immediately downstream of the fish barrier.

## 12. Other monitoring and reporting

Monitoring of the fish bypass channel is recommended once the scheme is commissioned to confirm if upstream migrant adult salmon are entering. If significant numbers of salmon are found in the channel, and this is deemed to be having a more than minor impact on the fishery, mitigation may be considered to exclude salmon. Recommended mitigation could include excavation and engineering of the connection point between the bypass channel and the main river to create a wide confluence, with shallow water depths that discourage adult salmon from entering the channel.

Inspection of the flushing/scour channel is also recommended on at least three occasions immediately following a sediment flushing event to confirm that adult salmon are not attracted to the discharge and therefore becoming stranded in the channel once the flow recedes. If significant numbers of adult salmon are found in the channel, and this is deemed to be having a more than minor impact on the fishery, mitigation may be necessary. This could include engineering of a barrier at the downstream end of the channel to exclude salmon.

In fulfilment of Condition 11, any fish barrier shutdowns will be recorded and reported to the North Canterbury Fish and Game Council and Department of Conservation as soon as practicable, and records of screen failure will be forwarded to Canterbury Regional Council by 31 May each year, or as requested.

## 13. Conclusion

We consider that the design specifications of the fish barrier generally satisfy Conditions 6 to 11 of Water Permit No. CRC137417, and will be adequate to achieve the performance objectives. Final confirmation that the performance objectives have been met can only be made via an appropriately designed and implemented monitoring programme once the intake and associated fish passage structures have been built and are operating.

**Ryder Consulting Limited**

Greg Ryder, BSc(Hons), PhD.
*Director/Environmental Scientist*

**Riley Consultants Limited**

Paul Morgan, CPEng.
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# APPENDIX ONE:

**Water permit No. CRC137417 conditions relating to the Fish Barrier**

"6 *<u>Fish Barrier</u>*

*a. The consent holder shall install and maintain a fish barrier ("Fish Barrier ") on the intake works.*

*b. The Fish Barrier shall be installed prior to the abstraction of water authorised by this consent.*

*7 The Fish Barrier shall be designed to ensure the adverse effects on all fishery components are no more than minor using design principles of fish exclusion as approved by Canterbury Regional Council. In particular, the Fish Barrier design shall achieve the following performance objectives:*

- *a. exclude all adult fish; and*
- *b. exclude at least 95% of juvenile salmonids that have entered the Fish Barrier area; and*
- *c. as far as reasonably practical all excluded fish shall be returned safely to the main stem of the Rakaia River downstream from the intake.*

*8 Fish Barrier approval process*

- *a. Prior to the taking of water pursuant to this consent, the consent holder shall install the Fish Barrier across the intake designed in accordance with the certified plans approved by a person duly authorised by the Canterbury Regional Council.*
- *b. The Fish Barrier shall achieve the performance objectives of Condition 7 and for the purposes of this condition this shall be achieved by installing, operating and maintaining the Fish Barrier in accordance with the certified design plans referred to in Condition 8.d..*
- *c. The design plans for the Fish Barrier shall be certified by:*
  - *i. a suitably qualified engineer with experience in the design and operation of fish barriers; and*
  - *ii. a fisheries biologist with knowledge of salmonid and native fisheries ("the Fish Barrier Certifiers").*
- *d. Prior to the commencement of construction of the Fish Barrier, the consent holder shall provide to the Canterbury Regional Council, Attention: RMA Compliance and Enforcement Manager:*
  - *i. the certified design plans including the proposed location of the Fish Barrier, proposed Fish Barrier material and size, design sweep velocity, design approach velocity, and an effective by-pass structure and flow which returns fish to an actively flowing braid of the river; and*
  - *ii. a report from the Fish Barrier Certifiers which certifies the design and operation of the Fish Barrier:*
    - *a. demonstrate best practice in achievement of Condition 8.b.; and*
    - *b. take into consideration regional or national guidelines in relation to fish barrier design and/or any international guidelines that the Fish Barrier Certifiers consider relevant.*
  - *iii. The report required in condition 8.d.ii. shall also specify any monitoring requirements for the Fish Barrier. The consent holder shall consult with North Canterbury Fish and Game Council and Department of Conservation in preparation of this monitoring programme.*
- *e.*
  - *i. the Fish Barrier shall consist of an infiltration gallery that generally conforms with concept sketches 10836-20, 10836-21, 10836-22 and 10836-03, provided by Riley Consultants, February 2011, or equivalent as agreed by Canterbury Regional Council;*
  - *ii. the Fish Barrier shall be designed to prevent fish bypassing the Fish Barrier into the canal;*
  - *iii. the Fish Barrier shall be a bed of cobbles of minimum depth of 1.5 metre over the top of an intake pipe, and stone size in the top 0.3 m in the range of 50 mm to 100 mm diameter, and in the lower 1.2 m in the range 100 to 200 mm diameter;*
  - *iv. the velocity over the galleries (the 'sweep velocity') at any time shall be a minimum of 0.5 m/s;*
  - *v. the velocity into the galleries (the 'approach velocity') shall be a maximum of 0.10 m/s;*
  - *vi. the ratio of sweep velocity to approach velocity at any time shall be a minimum of 5.0;*

vii. *a fence between the Fish Barrier and the irrigation supply channel to prevent native fish moving overland from the Fish Barrier to the irrigation supply channel;*

viii. *an effective bypass system shall be maintained at all times that water is diverted into the scheme, to ensure unrestricted passage is maintained to and from an active braid of the river;*

ix. *the bypass channel shall be formed in consultation with North Canterbury Fish and Game Council and Department of Conservation to ensure effective return of fish to an active braid of the river as soon as is reasonably practicable; and*

x. *there shall be an effective operation, inspection and maintenance schedule.*

f. *A person duly authorised by the Canterbury Regional Council shall give written notice to the consent holder stating whether or not it approves of the certified design plans within 20 working days of receipt of the plans and the Fish Barrier Certifiers' report referred to in Condition 8.d. and such approval shall not be unreasonably withheld.*

g. *The consent holder shall, prior to commissioning, provide a certificate from a suitably qualified person confirming that construction of the Fish Barrier has occurred in accordance with the certified design plans approved in accordance with Condition 8.f..*

*9 Any monitoring program required in condition 8.d.iii. shall be subject to the approval of a person duly authorised by the Canterbury Regional Council and shall be conducted for the first five years of operation of the Fish Barrier using appropriate practices, to establish the effectiveness of the Fish Barrier in achieving the performance objectives specified in condition 7 and the effect on juvenile native fish.*

*10 In the event that the Barrier is shown to be not fully effective in achieving the performance objectives in condition 7 the consent holder shall immediately commission a report.*

a. *This report shall be prepared by a fisheries biologist/s with knowledge of salmonid and native fisheries and shall address the consequences of non compliance on the fisheries of the river and, if appropriate, shall recommend mitigations. Such recommendations may include improvements to fish exclusion and/or enhancements to fish populations such as fishery habitat improvements or other actions considered appropriate by the author/s.*

b. *The report shall be prepared in consultation with North Canterbury Fish and Game Council and Department of Conservation and shall be delivered by the consent holder as soon as reasonably practicable but in any event no later than 6 months of confirmation of non compliance to the Canterbury Regional Council, Attention: RMA Compliance and Enforcement Manager.*

c. *Within 20 working days of receipt of the report a person duly authorised by the Canterbury Regional Council shall give written notice to the consent holder stating what action it requires, if any, in response to the report and recommendations.*

*11 The incidence of Fish Barrier shutdowns shall be recorded and reported to the North Canterbury Fish and Game Council and Department of Conservation as soon as practicable. Records of screen failure shall be forwarded to Canterbury Regional Council by 31 May each year, or as requested.*"