Managing Fish Passage in the Hikurangi Swamp Land Drainage and Flood Protection Scheme

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ABSTRACT (200 WORDS MAXIMUM)

Hikurangi Swamp Scheme is a land drainage and flood protection scheme managed by Whangarei District Council, providing protection to 5,600 ha of low-lying pastoral farmland within a catchment of 55,000 ha. The scheme was progressively implemented over the last century with major stopbanks and pump stations being installed in the 1970's, and has extensively modified what was one of the largest wetlands in the southern hemisphere. This has resulted in major impacts on the eel fishery which is of significant cultural and historic importance for local landlocked iwi as well as a commercial source.

Significant barriers exist to both upstream elver passage and downstream migrant passage, with evidence of eel mortality through deoxygenation of impounded waters and pump stations. Whangarei District Council is examining mitigative measures for improving fish passage and habitat by implementing or trialling a range of options. These include electric barriers, modified gravity discharges and screen sizing, and (in conjunction with NIWA) a tag and release programme to determine mortality rates through pump stations.

This paper gives an overview of the scheme operation and proposed fishery enhancement measures, its' role within the wider catchment and the often conflicting issues arising between environmental and economic drivers.

KEYWORDS

Fish passage, eels, flood protection, land drainage, cultural impact

PRESENTER PROFILE

Conal Summers has been in the role of Stormwater Asset Engineer for Whangarei District Council since 2008, and is responsible for Asset & Project Management for both the urban stormwater network and the Hikurangi Swamp Flood Protection and Land Drainage Scheme.

1 INTRODUCTION

The Hikurangi Swamp Scheme (the Scheme) is a flood protection and land drainage scheme lying to the north west of Whangarei which receives water from a catchment of 55,000 Ha, draining to 5600 Ha of lowland farms. The scheme consists of drainage networks, 64 km of stopbanks and 7 pump stations.

The scheme protects pastoral land from flooding and removes floodwaters from pastoral lands to reduce pasture loss. The Scheme is owned and managed by Whangarei District Council (WDC) and funded through a targeted rate system.

Through a recent resource consent process, the impacts of the scheme on fisheries (particularly the eel fishery) were highlighted and as a result mitigative measures are underway within the scheme and the wider catchment. This paper details the issues and options for mitigation.

2 SCHEME DESCRIPTION

2.1 CATCHMENT DESCRIPTION

The Hikurangi Swamp is located within Whangarei District, approximately 20km north of Whangarei CBD. The three main tributaries entering the head of the scheme are the Waiotu River, Waiariki Stream and Whakapara River, draining an area of 321 km^2. These tributaries join at the northern end of the swamp (below State Highway 1) to form the Wairua River. Other tributaries from catchments totalling 148 km^2 join the Wairua River in the main swamp which has an area of 5670 ha, so that at the outlet of the swamp in the south west the total catchment is 528 km^2 with a straight line length of the swamp of 8.8 km and river length of 23.3km.

Below the swamp, the Wairua River flows for 6 kilometres through a narrow valley with limestone rock outcrops and further downstream over a basaltic lava flow before cascading down the Mangere Rapids (Moores et al, 1968). The river runs for another 16 km before reaching the Wairua (Omiru) Falls, at which point partial diversion through the "run of river" Wairua power station occurs, then to the confluence with the Mangakahia River to form the Northern Wairoa River at Tangiteroria. Relative locations of features are shown in Figure 1.

Prior to modification through drainage and construction of the scheme, the Hikurangi Swamp was one of the largest wetlands in the southern hemisphere.

2.2 SCHEME HISTORY

Initial drainage of the Hikurangi Swamp was undertaken by the lands & Survey Department and commenced in 1919, continuing until the 1930's. This resulted in an extensive drainage network being established which reduced flood frequency. Lack of maintenance of the drainage networks over the following 2 decades impacted on their performance, and in 1953 Whangarei County Council took over responsibility for their management. Drains were reinstated fully by 1962 at which time the newly formed Northland Catchment Commission took over management (Moores et al, 1968)

The Northland Catchment Commission examined options for improved protection of the low lying swamp farmlands and the current scheme was constructed between 1969 and 1977.

2.3 SCHEME DESIGN

The design intent of the scheme was twofold: To prevent the main river from inundating farmlands in events up to a 5 year ARI, and to prevent loss of pasture by removing internal catchment water within 3 days (through pumping) during the same design event. Recent modelling has shown that the performance is currently closer to a 3.5 year ARI. Physical works undertaken included the following:

1. Channel reconstruction of the Wairua, Whakapara and Waiotu rivers (straightening and removal of oxbows)

2. Construction of Control banks on the Wairua, Whakapara and Waiotu rivers to constrain event storm flows in the main channel

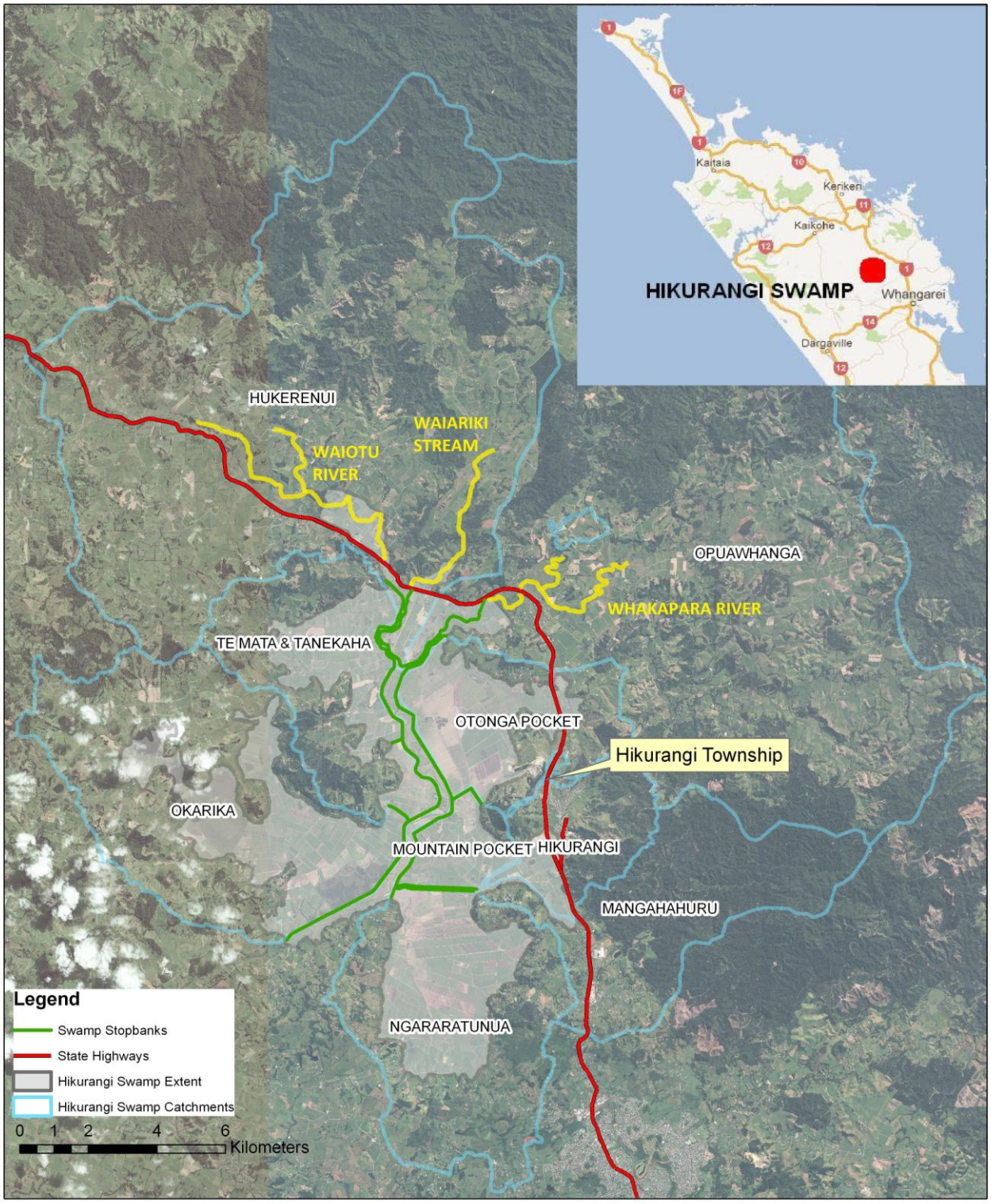
3. Division of the swamp into 7 "pockets" through construction of stopbanks, each pocket having its own pumping station.

4. Construction of designated spillways at each pocket to control spills for events larger than design into the pockets. The apportionment of flows was established by examining known, significant floods (prior to scheme inception) and calculating the volume of water lying within the theoretical pocket boundaries, based on existing topography (Blackburn, 2010).

A map of the scheme showing the flooding and control bank extents is shown in Figure 2.

Figure 1: Catchment Features

Figure 2: Scheme Location, Catchments, Stopbanks & Flood Extents



2.4 SCHEME MANAGEMENT AND RESOURCE CONSENT

Following local government amalgamation in 1989 management of the scheme moved from the Northland Catchment Commission to Whangarei District Council. The funding of the scheme is through 2 targeted rates, one for the drainage district (related to the network of drains pre- scheme) and the other related to the scheme as described in 2.3.

Whangarei District Council applied to Northland Regional Council for resource consent for the Scheme in 2004. As a result of submissions related to the scheme hydraulic model and the resulting proposed spillway amendments further refinement of the hydraulic model was undertaken over the following years. Consequently the consent was re-notified to original submitters, and consent was granted in May 2010.

Conditions of consent required a number of management plans related to Scheme management, Riparian and Oxbow restoration management, and fishery management. The primary focus of fishery management is on the eel fishery due to its cultural significance, although measures taken will improve fish passage for all species.

3 EEL FISHERY MANAGEMENT

3.1 CULTURAL FISHERY

The Hikurangi Swamp has long been a traditional source of eel (tuna) for local iwi. As part of the WDC resource consent process for the Scheme, a Cultural Effects Assessment Report was prepared in conjunction with Ngati Hau. This report clearly demonstrated the importance of the traditional tuna fishery to Ngati Hau. An excerpt from the report (Chetham & Shortland, 2010) is reproduced below:

"Effects on fish and fishing were of enormous importance to Nga Hapu o Te Reponui and this concern is multi-facetted. Of prime importance is the ability of the hau kainga and ahi kaa to be able to fish for the needs of their whanau and manuhiri. It is widely acknowledged that fish stocks, both in terms of numbers and diversity of species, have been heavily depleted over time and any additional impacts that may affect stock recovery will have significant effect on the wellbeing of tangata whenua."

The significance of tuna to local iwi is exemplified through historical photos (Photo 1) and their prominence at local marae (Photo 2).

Photo 1: Eel drying rack (courtesy Dick Shepherd)

WDC was largely unaware of these issues until the report and has since developed an ongoing relationship with Ngati Hau to examine the fishery issues within the scheme. WDC, NIWA and Ngati Hau initially undertook a number of field trips and meetings/workshops to examine the issues and evaluate mitigative measures in place both nationally and internationally.

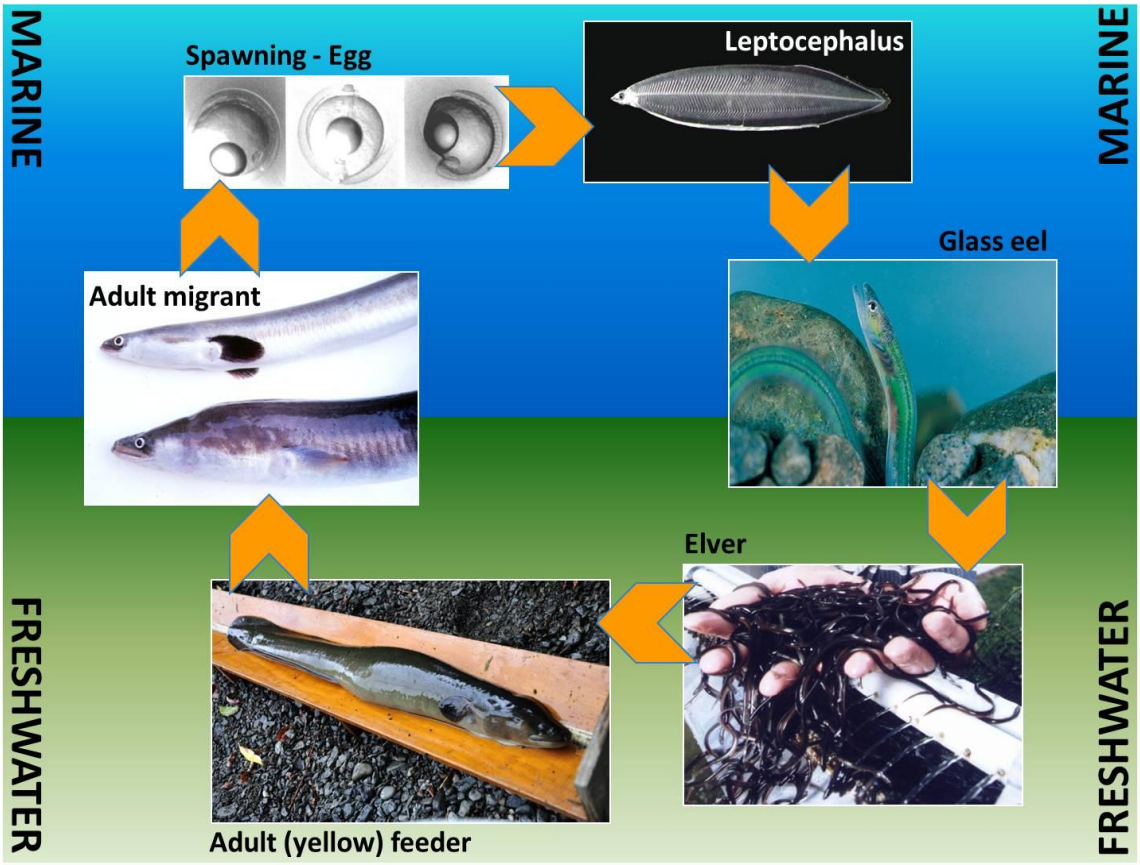
Photo 2: Carvings at Akerama Marae

As a result of the catchment wide nature of this issue, the stakeholders involved have expanded well beyond the physical scheme boundaries and now include Northpower, multiple iwi groups, NIWA, local landowners and farmers, and school groups. The continued engagement and support of local iwi is critical to progressing fishery management both within the scheme and across the greater catchment.

3.2 EEL LIFECYCLE

In order to complete their lifecycle, freshwater eels must move between freshwater and the sea (known as a diadromy), spending extended periods in marine, estuarine, and freshwater habitats. The eel has a unique and complex life cycle (Figure 3). Breeding occurs in the marine environment, following an extended adult growth stage in freshwater (40-60 years), and a long migration from their freshwater habitat to spawn in the Pacific Ocean near Tonga (Williams & Boubée, 2012).

Figure 3: Eel Lifecycle (reproduced Courtesy of NIWA)



Upstream migration relates to movement of juvenile eels (elvers) from the sea to the inland waterways where they will remain until returning to sea to spawn as Tuna Heke (downstream migrants). Based on records obtained at the Wairua Power Station in summer 2011/12 the upstream migration appears to begin around September-October and runs until approximately March. Movement of elvers at the schemes control structure may, however, only begin around November.

3.3 SCHEME IMPACTS ON THE NATURAL FISHERY

Within the Hikurangi Swamp Scheme, the pump stations and stopbanks present barriers to both upstream and downstream migration to tributaries within the swamp scheme "pockets" but do not impact on migration within the main channel or to tributaries above State Highway 1.

3.3.1 UPSTREAM BARRIERS

Within the scheme, the primary barriers to movement from the main Wairua River channel to tributaries are at the pump stations. Each station has a gravity flapgate which is designed to prevent flows from the main river channel entering the pockets during elevated river levels. Elvers must pass through these gates to access the upstream tributaries. Elver movement is impeded due to two separate issues at the gate:

VELOCITY BARRIER

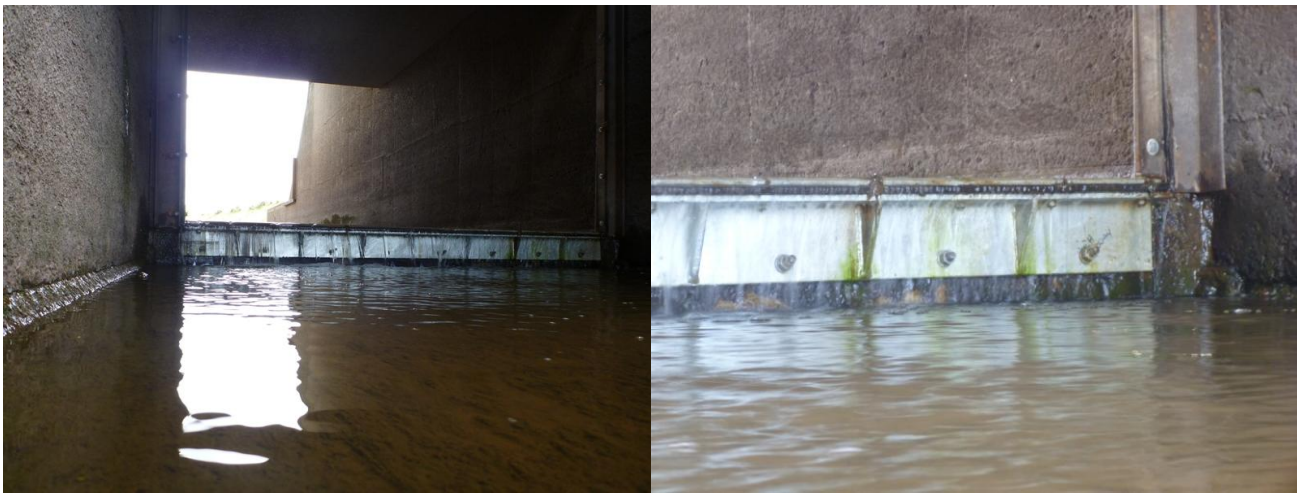
Outside of flood events the gates are kept minimally open, allowing passage of pocket water into the main channel. The aperture size is such that water velocities are increased to a point where elver passage is difficult (Photo 3). Opening the gates is possible operationally but leads to the potential for human error; with major consequences in terms of internal catchments being inundated by river water should the gate not be closed.

Photo 3: Looking down on to gravity flapgate

PHYSICAL BARRIER

The invert of the gravity flapgate is above the invert of the outlet channel (Photo 4), and at low flows it is difficult for elvers to climb over the gate frame. The gate frame is constructed of angle iron and thus has a horizontal overhang which is difficult for elvers to transition.

Photo 4: Looking upstream to gravity flapgates & overhang



3.3.2 **DOWNSTREAM BARRIERS**

Downstream migration is impeded in 2 ways:

- Eel mortality through entrainment in scheme pumps
- Impediments to migrant movement into the main river channel during periods of oxygen depletion in the pocket areas following significant storm events (where the river has spilled into the pockets).

The extent of, and exact factors that lead to, mortality are unknown. In the case of extreme storm events where waters are impounded for several days and extensive oxygen depletion occurs, eels mortality may occur across large areas of the catchment but may not be evident until water is drawn down to the pump stations and eel carcases are destroyed through the pumping process. Video evidence exists showing significant numbers of chopped mature eels downstream of a pump station. It is difficult to ascertain whether eels passing through the pumps were dead or alive prior to entrainment.

Factors such as seasonality, size of storm, and time of migration by eels to the stations from within the pocket catchments all impact on mortality throughout the scheme. It is probable that some mortality due to oxygen depletion would have occurred in the natural (pre-developed) state of the swamp area following extreme storm events and it is difficult to quantify the effect of the scheme on the extent of mortality through this mechanism. However, the presence of the stopbanks effectively hinders passage of fish species into the main river channel where a more oxygenated environment exists.

3.3.3 **HABITAT DEGRADATION**

Swamp and wetland drainage, waterways re-alignment, decrease in extent and frequency of flooding (during which eels feed extensively on land invertebrates), loss of natural riparian cover and increased nutrient loadings have all contributed to a significant loss of fish habitat within the entire catchment.

3.4 WIDER CATCHMENT IMPACTS ON THE FISHERY

There are 2 other areas that have impacted on the natural fishery within the wider catchment, commercial fishing and the Wairua power station.

3.4.1 COMMERCIAL FISHING

The extent and impact of past and present commercial fishing within the scheme and wider catchment has not been documented. The Ministry of Fisheries manages the eel fishery under a Quota Management System. The Hikurangi Swamp is part of the Northland quota management area but this is geographically large and specific catch locations and numbers are not recorded. In the 1970's significant commercial harvesting was undertaken and a processing plant was operated in Hikurangi, exporting to Europe. Anecdotally, commercial presence and catches have decreased markedly over the last decade or so.

3.4.2 WAIRUA POWER STATION

The most significant natural barrier to upstream migration within the catchment (but outside the Scheme area) is the Wairua/Omiru falls. Since the construction of the Wairua power Station in 1917, significant flows have been diverted through the headrace (just above the falls) to the penstocks, at times reducing the base flows by up to 90%. Given the historical abundance of eels within the scheme area, it appears that in its natural state the falls did not severely impede elver recruitment.

3.5 MITIGATIVE MEASURES

This section outlines the mitigative measures implemented or proposed to be undertaken by Whangarei District Council within the Hikurangi Swamp scheme in relation to the barriers and issues identified in Section 3.3. Many of these measures are being trialled currently with implementation planned over the following 6 – 12 months.

3.5.1 UPSTREAM BARRIERS

VELOCITY BARRIERS

WDC is currently trialling a mechanism to hold the flapgates open in the larger pump stations. These gates already have a retaining bracket for keeping flapgates up safely to facilitate maintenance (Photo 5), and a loop of industrial grade rubber, or chain and spring, is attached to the bracket and to the counterweight frame on the flapgate(Photo 5). The tension is then adjusted to open the gate sufficiently to reduce velocities whilst still allowing the rising river head to effectively close the gate during a storm event.

Photo 5: Tensioning strip to keep gate partially open

PHYSICAL BARRIERS

In order to remove the physical barrier presented by the flapgate frame overhang, WDC is increasing the water level downstream of the gate through installation of a bund using half-pipes in the gravity channel several metres downstream of the gate (Photo 6). This will elevate the water levels 50-100m above the gate invert at all flows. As elvers are able to pass vertical and inclined surfaces (but not horizontal overhangs) the use of half pipes will not present any impediment to their passage.

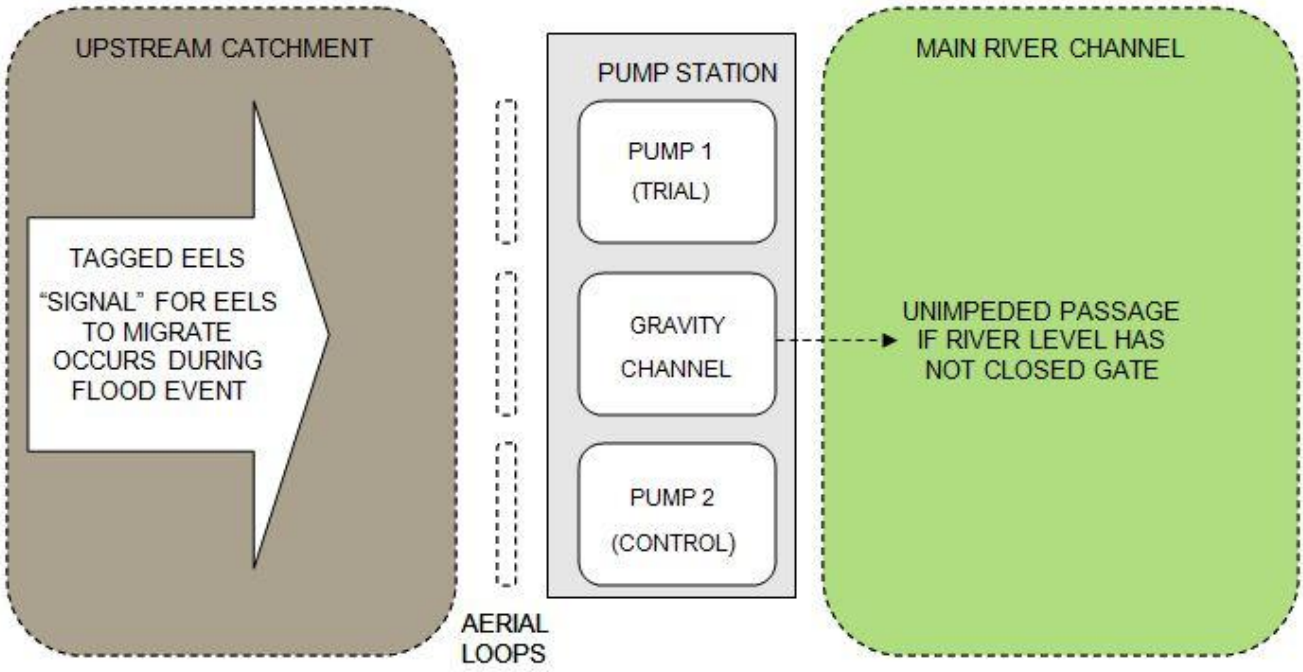
Photo 6: Proposed downstream bund

3.5.2 **DOWNSTREAM BARRIERS**

WDC in conjunction with NIWA is installing a trial site at a single pump station to validate mitigative measures to reduce the incidence of eels being entrained in the pumps. If the trial is successful the measures will be implemented across the whole scheme. This will also provide valuable research information to assist in management of eel fisheries nationally and internationally.

Figure 4 is a representation of what occurs at Mountain pump station when eels within the "pocket" (the upstream catchment bounded by stopbanks and pump station) look to migrate downstream. The eels are thought to be driven to migrate during a significant rain event, at which time the main river level will be rising and (depending on the event size) pump stations will be operating. Mountain pump station is being used for the trials due to having two identical pump bays and ease of access.

Figure 4: Representation of Migrant Eel Movement through Pump Station



The approach involves catching mature eels (with the permission and assistance of local iwi) and attaching a RFID (Radio Frequency Identification) transmitter to them, followed by release upstream of the pump station. Each pump bay and the central gravity gate are fitted with an aerial loop which activates the RFID transmitter and logs the information when the eels pass through.

One pump bay will be used as a control with no alterations and the other will be used for the trial measures (detailed below). Monitoring the gravity gate will allow collection of data on the number of eels able to migrate through the gravity flapgates before the river level rises sufficiently to close the doors.

TRIAL 1

This involves setting up a pulsed DC electrical field across one intake screen. This is achieved by installation of 3 copper strips on the pump bays:

- before the intake screen (upstream)
- at the intake screen

- behind the intake screen

with application of the DC field on the strips in a negative-positive-negative arrangement, leaving the gravity gate and other intake screen unmodified. Voltage of 3-12 volts is applied with a pulse frequency of 1.5 hertz, as NIWA have shown this to be an effective deterrent in pilot scale trials and limited field trials. The installation is underway and will be operational for the 2013 migrant season (approximately May- August).

TRIAL 2

This involves reduction of one intake screen size to 20mm from the current spacing of 50mm. Due to the presence of aquatic weeds within the scheme some pockets have significant problems during a storm event with blinding of intake screens and a subsequent operational impact, the extent of any screen modifications on operational resources needs to be determined.

FISH FRIENDLY PUMPS

It is acknowledged that the current pumps will cause mortality if eels are entrained in them. WDC has previously investigated use of Archimedes Screw pumps which are more fish friendly, but for a number of reasons (including cost, inability to access during storm events, and operational aspects) these were not deemed feasible for implementation within the Scheme.

3.5.3 HABITAT DEGRADATION

WDC has prepared a riparian and oxbow management plan as required by the Scheme resource consent, which identifies areas where significant waterway modifications occurred. Restoration of the oxbow loops through riparian planting and installation of earth bunds to increase water levels will provide additional habitat for tuna and other fish species within the main channel catchment. Photo 7 shows the extent of channel straightening and the remnant oxbows.

Photo 7: Aerial of main channel showing old oxbow loops

3.5.4 **FISHERY POPULATION SURVEYS**

Electric fishing and trapping of waterways within the swamp area was undertaken during March 2013 in order to provide data for a baseline population estimate of species present and numbers. Results of this are currently unavailable.

3.5.5 **WIDER CATCHMENT MEASURES**

Northpower installed a prototype trap and transfer mechanism at Wairua power station in 2011/12 consisting of an elver ladder and holding tank (Photo8). This was monitored daily by local iwi representatives and any elvers were transferred to upstream waterways within the catchment. An estimated 3 million elvers were transferred in the first year. For the 2012/13 year, a more permanent installation was undertaken and a dedicated vehicle with aerated holding tanks was supplied by Northpower. This site has also played a valuable role in engagement with the local community, with visits from schools, farmers, and community groups.

Photo 8: Elver capture at Wairua Power Station

4 CONCLUSIONS

The Hikurangi Swamp Scheme has introduced significant barriers to eel passage through construction of spillways, pump stations and habitat degradation, resulting in damage to a food resource of significant cultural value to local iwi. Many improvements to enhance fish passage are relatively simple and low cost in installation, although measuring effects off these improvements may not be evident for many years due to both the size of the catchment and the lifecycle of the eel.

Dependent on the outcome of trials, measures will be implemented across the Hikurangi Swamp Scheme over the next 6- 12 months.

ACKNOWLEDGEMENTS

I would like to acknowledge Dr Jacques Boubée of NIWA for his tireless enthusiasm and ability to engage all stakeholders in fishery management issues. I would also like to acknowledge Te Raa Nehua and Allan Halliday of Ngati hau for showing me the importance of the eel fishery to their cultural wellbeing.

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