Prioritisation for restoration of out-flow stream habitat of coastal wetlands on the west coast of the Manawatu-Wanganui region

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Executive Summary

- The extensive sand dunes of the west coast of the Horizons Regional Council area contain many wetlands and lakes. A Horizons Regional Council wetland inventory has identified a number of these as being of high ecological value.
- Previous assessments have concentrated on the wetlands/lakes themselves with no consideration of the condition of their outlet streams that link them to the ocean. This linkage is important for many native fish species which must have free access to the ocean to complete their lifecycles.
- Horizons Regional Council wishes to choose some coastal lake/wetland outlet streams to undergo restoration of the riparian zone and fish passage. It is envisaged that the results of this restoration will be used to increase public awareness of the benefits of stream restoration and to promote further work in the region.
- This study investigated the current in-stream and riparian condition and severity of fish barriers in a number of coastal lake/wetland outlet streams. The aim was to select those streams that would benefit most from restoration.
- The in-stream and riparian condition of outlet streams were similar among the sites surveyed. Streams typically had a sandy substratum, no overhead shade, very sluggish water movement, were choked by macrophytes and had low habitat diversity. Riparian vegetation was usually long pasture grasses and/or exotic trees.
- A number of in-stream structures (culverts, weirs) were assessed with most of these not being barriers to fish passage. However, some structures, especially lake level weirs were identified as being barriers to the free movement of fish.

- A composite habitat quality score taking into account in-stream and riparian habitat condition, flow permanence and source lake/wetland quality was calculated to determine which outlet streams were most likely to benefit from riparian restoration. To rate the severity of fish barriers, a cumulative barrier severity score was calculated to rank the streams in terms of fish passage.
- Riparian restoration would be better targeted at the outlet streams of the higher quality source lakes/wetlands. We recommend Waiwiri Stream (Lake Papaitonga), Hokio Stream (Lake Horowhenua) and the Omanuka-Pukepuke Lagoon outlet (the section downstream of Pukepuke Lagoon only) as sites where riparian restoration would be most advantageous.
- Restoration of fish passage is likely to be most beneficial in those outlet streams that have the greatest amount of quality habitat above any potential barriers. We recommend Waiwiri Stream (Lake Papaitonga) and the Omanuka-Pukepuke Lagoon outlet (the section downstream of Pukepuke Lagoon only) as being of the highest priority for fish passage restoration. The lake level weir of Lake Horowhenua (Hokio Stream) should also be modified to allow the year-round passage of fish.
- Any restoration efforts must have realistic, defined and measurable goals. To show the effectiveness of any restoration, a monitoring scheme needs to be designed with an adequate period of pre-restoration data collection.

1. Introduction

1.1 Rationale and aim

Horizons completed and subsequently revised an inventory of wetland areas within the Manawatu-Wanganui region and have prioritised these wetlands based on a series of characteristics (Horizons 2005, Lambie 2008). This inventory included many coastal wetlands and lakes, but not a comprehensive assessment of their outlet streams and connectivity to the ocean. Horizons recognise that to maintain and potentially enhance the population of some key aquatic fish species (e.g. eels, inanga, giant kokopu) it is necessary to gather information on the habitat condition and potential barriers to fish movement that may be present in such outlet streams. In late 2008, Horizons Regional Council successfully obtained a FoRST Envirolink grant for the "Prioritisation for restoration of out-flow stream habitat of coastal wetlands on the west coast of the Manawatu-Wanganui Region". The aim of this report is to provide advice on how to prioritise stream habitat to maximise environmental outcomes of riparian restoration works and installation of fish passage. To ensure that restoration funds are spent in the appropriate areas with the maximum environmental benefit, this report aims to prioritise sites for restoration works and identify areas where the required restoration works are reasonably simple and have a high potential for success.

1.2 Wetland systems in the Manawatu-Wanganui region

In the Manawatu-Wanganui region around 97% of the original wetland habitat has been lost since human settlement, predominantly through the development of farmland (Maseyk 2007). What remains often exists as small isolated patches in a matrix of farm and forestry land. These "wetlands" comprise a range of habitats including estuaries, lakes and swamp forest and have a number of values. The types of wetland areas in the Manawatu-Wanganui region and their values are outlined in Lambie (2008). Lambie (2008) which is an update of a previous wetland inventory and prioritisation project (Horizons 2005), assigns priority to regional wetlands based on biological diversity, size, representativeness, contribution to remaining area and the presence of rare or threatened species. This inventory was focussed on the wetlands themselves and did not include an assessment of outflow streams or connections to the ocean.

1.3 Coastal lakes and wetlands

The extensive sand dunes of the west coast of the Horizons region contain dozens of wetlands and lakes, many of which have been assessed as being of high priority (Horizons 2005, Lambie 2008). The condition of existing coastal lake and wetland systems is threatened by coastal land development, especially intensification of farming but also coastal subdivision in some areas. Given these systems are remnants of a once extensive habitat type; they are refuges for many wetland specialist biota (e.g. bittern, fernbird). Where these wetlands/lakes are connected to the ocean, they have the potential to be important habitat for migratory native fish such as eels, inanga and giant kokopu. Wetlands and lakes themselves have often been the focus of previous investigations, but the condition and freshwater-ocean connectivity of the outlet streams has not been specifically covered.

1.4 Native fish, diadromy and in-stream barriers

About half of New Zealand’s approximately 35 native fish species are diadromous meaning they must spend part of their lifecycle in the ocean. Connectivity between freshwater habitat and the ocean is vital for the persistence of such species. In-stream barriers whether natural (e.g. falls) or artificial (e.g. dams, culverts, weirs), can affect the ability of migratory species to colonise and persist in areas of otherwise suitable habitat. Diadromous fish have varying abilities to traverse in-stream structures. This is reviewed by Boubee *et al.* (1999) and discussed by James & Joy (2008).

Coastal wetland and lake outlet streams often cross farm and forestry land where there are numerous crossings, many of which involve culverts. Additionally, many coastal wetlands and lakes have outlet weirs that act to maintain water levels. These weirs have the potential to act as significant barriers to fish passage. Barriers to fish passage may not necessarily always be physical. Physicochemical water quality characteristics such as high temperature (especially in open canopy streams) and low dissolved oxygen (especially in macrophyte dominated streams) may limit the passage of some fish species at certain times of the year.

1.5 Outlet stream restoration

Many coastal wetland and lake outlet streams are relatively short. There are often only kilometres and sometimes hundreds of metres of stream between the wetland/lake and the ocean. Therefore, the restoration and protection of such streams along their complete length is logistically and financially more likely compared to streams with larger catchments. Restoration would involve fencing to prevent direct farm animal access to the stream and its banks, riparian planting that will ultimately result in a closed canopy to shade the stream and reduce macrophyte growth and the removal/alteration of any barriers to fish migration. Landowner cooperation and preferably participation is necessary to achieve meaningful restoration of such streams.

2. Methods

2.1 Site selection and field procedure

A list of wetland and lake sites (Table 1) and landowner details were provided by Horizons along with high definition aerial photographs of the outlet streams. Outlet streams were followed either on foot, with a vehicle or a combination of the two depending on ease of access. Usually starting from the wetland/lake outlet and moving downstream to the ocean, habitat assessment forms were completed (see section 2.2 for detail) wherever there was a noticeable change in riparian characteristics and a fish passage evaluation sheet (see section 2.3 for detail) was completed for all in-stream structures encountered. The habitat assessment and in-stream structure locations were determined by GPS and by referring to features on the aerial photographs. The aerial photographs were annotated in the field to aid in determining the extent of any in-stream and riparian heterogeneity and exact positions of in-stream structures. The majority of sites were assessed between mid-December 2008 and late-January 2009. The last few sites were visited in mid-May 2009.

Table 1. The list of coastal lake and wetland sites provided by Horizons Regional Council for outlet stream assessment

Lake/Wetland		NZMS 260 ref.	Assessment notes
Mowhanau Steam Pond		R22 769-454	Not assessed
Omapu Stream unnamed ponds		R22 767-443	Low priority – not assessed
Lake Westmere		R22 810-436	Low priority – not assessed
Lake Kohata		R22 868-359	Appears landlocked – not assessed
Lake Kaitoke	*Sites*	R22 877-350	Assessed
Lake Wiritoa	*linked*	R22 885-346	Assessed
Lake Pauri		R22 893-343	Assessed
Lake Waipu		S23 938-268	Assessed
Lake Heaton		S23 049-194	Low priority – not assessed
Lake Bernard		S23 046-186	Low priority – not assessed
Lake Hickson		S23 088-172	Low priority – not assessed
Lake Alice		S23 086-165	Low priority – not assessed
Lake Kotiata		S23 970-185	Assessed
Artillerie Swamp		S23 973-157	Assessed
Knottingly Swamp		S23 987-130	Assessed
Haylock Swamp		S23 092-098	Low priority – not assessed
Mt Amon/Mt Taylor Wetlands		S23 031-067	Access denied
Forest Road Wetlands	*Sites*	S23 035-034	Assessed
Scotts Ferry Dune Wetlands*	*linked*	S23 007-007	Assessed as part of Forest Rd wetlands but possibly landlocked
Pukepuke Lagoon	*Sites*	S24 024-935	Assessed
Omanuka Lagoon	*linked*	S24 075-950	Assessed
Pukemarama Lagoon		S24 074-985	Assessed
Lake Kaikokopu		S24 022-898	Assessed except upper ~200m
Lake Koputara		S24 020-872	Assessed
Oruakaitawa Lagoon		S24 014-837	Landlocked – not assessed
Koputara Lakes 1 and 2		S24 013-844	Assessed
Koputara Lake 3	*Sites*	S24 009-823	Assessed
Lake Omanu	*linked*	S24 009-815	Assessed
Round Bush**		S24 038-824	Not assessed
Lake Horowhenua		S25 998-635	Assessed
Lake Papaitonga		S25 982-600	Assessed
Ohau Loop		S25 964-584	Assessed
Te Hakari Wetlands		S25 928-577	Assessed
Ohau River Dune Lakes		S25 926-568	Assessed

* The Scotts Ferry Dune Wetland appeared to be landlocked.

** I was informed that Round Bush was landlocked but subsequently learned from DOC that it does have an outlet with a weir. However, Round Bush has a significant population of mudfish thus DOC would not allow any alteration of this weir that may allow predatory fish easy access or change water levels (pers. com. Logan Brown, DOC).

2.2 Habitat assessment

In-stream and riparian characteristics were assessed using the Qualitative Habitat Assessment Procedure developed by Environment Waikato (Collier & Kelly 2005). This procedure is derived from the revised USEPA Rapid Bioassessment Protocol and modified to suit local stream conditions. To assess stream habitat, the observer estimates the condition of each characteristic over at least a 100 m reach. Two data sheets are completed at each site, a Field Assessment Cover Form and a Habitat Assessment Field Data Sheet (Appendix 1).

The Field Assessment Cover Form describes general watershed and in-stream characteristics. Collier & Kelly (2005) give full details on what is included in this form. This procedure is intended to be used at sites where macroinvertebrate sampling is undertaken and this form includes sampling details. For the purposes of this report where no such invertebrate sampling was performed, the sampling information parts of the form were not used. Spot measures of water quality (i.e. temperature, dissolved oxygen, conductivity) were not taken since such one-off measures provide little useful information on habitat condition.

The second form to be completed at each site is the Habitat Assessment Field Data Sheet. It comes in two variants, one for hard-bottomed and another for soft-bottomed streams. In this survey the majority of habitat assessment sites required the use of the soft-bottomed stream form. This form involves nine in-stream and riparian characteristics that the observer rates from optimal to poor on a 20 point scale (Table 2, Collier & Kelly 2005). These are then summed to derive an overall score for the assessed site. The maximum possible score indicating optimal habitat is 180 while the minimum possible score indicating poor habitat is 18. For the purposes of this report where we are concerned with the entire length of the outlet streams, the total score for each habitat assessment have been averaged to give an overall outlet stream value.

Table 2. The nine in-stream and riparian characteristics included on the Habitat Assessment Field Data Sheet. (Adapted from Collier & Kelly, 2005).

Characteristic	Assesses	Importance
1. Riparian vegetative zone width	Assesses the extent of natural vegetation from the edge of the stream bank out through the riparian zone.	The vegetative zone is a buffer to pollutants entering a stream from runoff, controls erosion, provides habitat and organic matter input and provides shade. Generally, the wider, the better.
2. Vegetative Protection	Evaluates the amount and type of vegetative protection present on the bank and near-stream part of the riparian zone.	The root systems of plants growing on stream banks help hold soil in place and reduce the potential for bank erosion.
3. Bank stability	Assesses the erosion or potential erosion of stream banks.	Eroded banks indicate a problem of sediment movement and deposition.
4. Channel sinuosity	Measures the meanders/bends of the channel.	A high degree of sinuosity creates a more diverse habitat. The absorption of energy by bends prevents erosion, flooding and provides refugia for stream fauna during high flow events.
5. Channel alteration	A measure of large-scale changes in the shape of the stream channel.	Many streams have been straightened, deepened and channelized. Such streams have reduced habitat heterogeneity.
6. Sediment deposition	Measures sediment accumulation and changes to the stream bottom resulting from deposition.	Sediment deposition results from the large-scale movement of sediment. High levels of deposition are symptomatic of an unstable habitat that may be unsuitable for many organisms.
7. Pool variability	Assesses the overall mixture of pool types generally found in soft-bottomed streams according to size and depth.	A stream with many pool types will support a more diverse community of aquatic species than one with a single pool type.
8. Abundance and diversity of habitat	Assesses the relative quantity and variety of natural in-stream features.	The more diverse the range of microhabitats (e.g. cobble, large rocks, logs, branches, leaf packs) the greater the diversity of aquatic organisms.
9. Periphyton growth	Assesses the presence/absence of periphyton growth on the stream bed.	Lower algal biomass is preferable to high levels which can smoother the stream bed.

2.3 In-stream structure fish passage evaluation

When an artificial in-stream structure was encountered, the same record sheet as used by James & Joy (2008) was completed (Appendix 2). This form was originally adapted from that used by Environment Waikato (2007). A 3 m extendable surveyor's staff was used to make a series of measurements including length, width, water depth, undercut length, and perch height where applicable. A digital camera was used to take inlet and outlet photos. On site, structures were assigned to one of four categories following Environment Waikato (2001):

- **None/minimal,** where the structure poses no significant barrier to the upstream or downstream passage of fish likely to be found in the stream under normal flow conditions.
- **Low flow,** where the structure is a significant barrier to fish passage, but only during periods of low flows (e.g. very shallow water depth through structure).
- **High flow,** where the structure is a significant barrier to fish passage, but only during periods of high flow (e.g. velocity barrier forms at high flows).
- **Most flow,** where the structure is a significant barrier to fish passage during most flow conditions.

2.4 Restoration priority calculation

To calculate the relative restoration priority of assessed outlet streams, a matrix style approach was employed. This involved a cumulative barrier severity score plotted against a composite habitat quality score.

Cumulative barrier severity score

Each in-stream structure was given a severity score based on the barrier category to which it was assigned (Table 3).

Table 3. The expression of barrier categories as severity scores.

Barrier category	Severity score
None/minimal	0
Low flows	2.5
High flows	2.5
Most flows	5

For a given stream, the severity scores of all structures were summed to give a cumulative severity score for that stream. For example, a stream may have five structures along it, three identified as ‘none/minimal’, one as ‘low flows’ and one as ‘most flows’. Such a stream would have a cumulative barrier severity score of 7.5. This score separates outlet streams based on how in-stream structures influence fish passage from the ocean to the source lake/wetland.

Composite habitat quality score

The habitat quality score is based on the Environment Waikato (EW) habitat assessment scores with the addition of two other factors, the quality of the source lake/wetland and flow permanence. This composite habitat quality score has a theoretical maximum of 139. The EW habitat assessment score is based on nine factors and not all of these were deemed to be of the same importance when prioritising habitat quality in coastal outlet streams. Thus these scores were weighted to reduce the importance of some factors (Table 4).

Table 4. The weightings applied to Environment Waikato habitat assessment scores and the rationale for doing so.

Factor	Weighting	Restoration priority score (maximum)	Rationale
1. Riparian vegetative zone width	0.5	10	Important as it indicates width of buffer between stream and surrounding land use
2. Vegetative protection	0.5	10	Important as the existing type of riparian vegetation has an effect on in-stream habitat quality
3. Bank stability	0.25	5	Not so important in low gradient streams that do not receive highly erosive flow events
4. Channel sinuosity	0.25	5	Not so important in creating different flow environments in low velocity streams
5. Channel alteration	0.25	5	Difficult to determine and not relevant in deciding restoration priority
6. Sediment deposition	0.1	2	Difficult to determine visually in overgrown, sand substrate streams
7. Pool variability	1	20	Very important as it measures one aspect of habitat diversity
8. Abundance and diversity of habitat	1	20	Very important as the more habitats will support a greater diversity of species
9. Periphyton growth	0.1	2	Not a large issue in streams overgrown by macrophytes and not important in determining restoration priority

The quality of the source lake or wetland was determined from the regional wetland inventory project conducted by Horizons Regional Council (Horizons 2005, Lambie 2008). This project scored wetlands on a scale of 1 (poorest and least important wetlands) to 5 (richest and most important wetlands) taking into account size, the rarity of that wetland type, the size contribution it makes to what remains of that type and diversity. The raw scores from this scheme were converted to categories that match the scale of the EW habitat assessment scores (Table 5). The quality of the source lake or wetland was deemed to be as important as the combination of the two habitat diversity factors (‘pool variability’ and ‘abundance and diversity of habitat’) from the EW habitat assessment score. Thus a high quality source lake or wetland scores the same as the theoretical maximum available for these two factors.

Table 5. The expression of Horizons' wetland inventory scores as a component of the restoration priority habitat quality score.

Horizons' wetland inventory score	Restoration priority score
1 – 1.99	10
2 – 2.99	20
3 – 3.99	30
4 - 5	40

Some coastal lake or wetland streams are not permanently flowing and it was decided that permanently flowing streams should have a higher priority than those that flow intermittently or ephemerally. Permanent streams scored 20 while those that do not flow year-round scored 10.

The restoration priority matrix

The composite habitat quality score (x-axis) is plotted against the cumulative fish barrier score (y-axis). The averages of each score calculated from all the assessed streams, were used to split the sites into four groups (Figure 1).

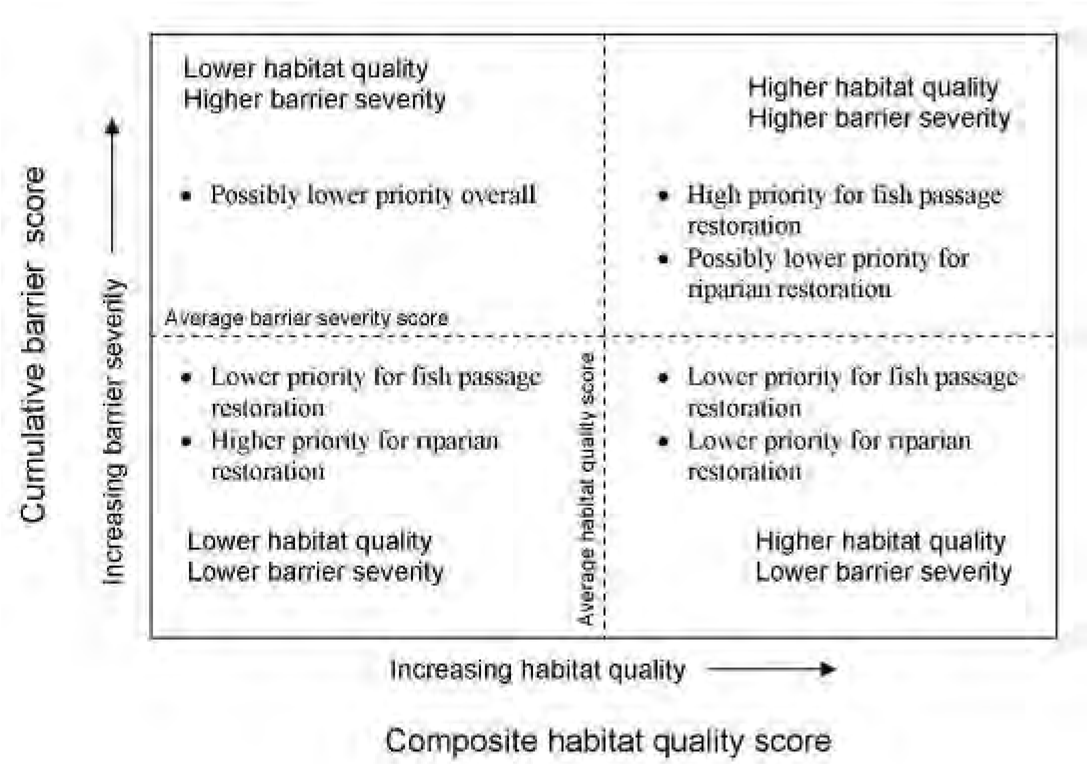

Figure 1. The restoration priority score matrix to assist in deciding the priority of outlet streams for fish passage and riparian restoration.

Streams that plot in the upper right quadrant are those that tend to have both higher relative habitat quality and barrier severity. These are the streams that are of the highest priority for the restoration of fish passage and may benefit from riparian restoration work. Sites that plot in the upper left have lower habitat quality and higher barrier severity and are streams that are of lower priority for any restoration. Streams plotting in the lower right have higher habitat quality and lower barrier severity. These sites may not require restoration work. The streams plotting in the lower left quadrant have lower habitat quality and barrier severity and may benefit from riparian restoration especially.

This matrix is intended to be a guide to prioritising streams for restoration; however, the final decision is always going to involve other considerations such as budget limitations, ease of access, landowner cooperation, politics and the presence of pest species. To aid in determining the final restoration sites it is useful to also rank the streams according to each of the more important factors. This will act to separate the different elements of the composite habitat quality score (e.g. in-stream habitat quality from source lake/wetland quality). While it is relatively straightforward to decide the highest priority streams for the restoration of fish passage, deciding where to target riparian restoration is more difficult given the overall homogeneity of in-stream and riparian habitat that was encountered. It must also be noted that because of this habitat homogeneity, the differences between high and low habitat quality are relatively small even though streams might be separated on the matrix.

3. Results

3.1 Riparian characteristics

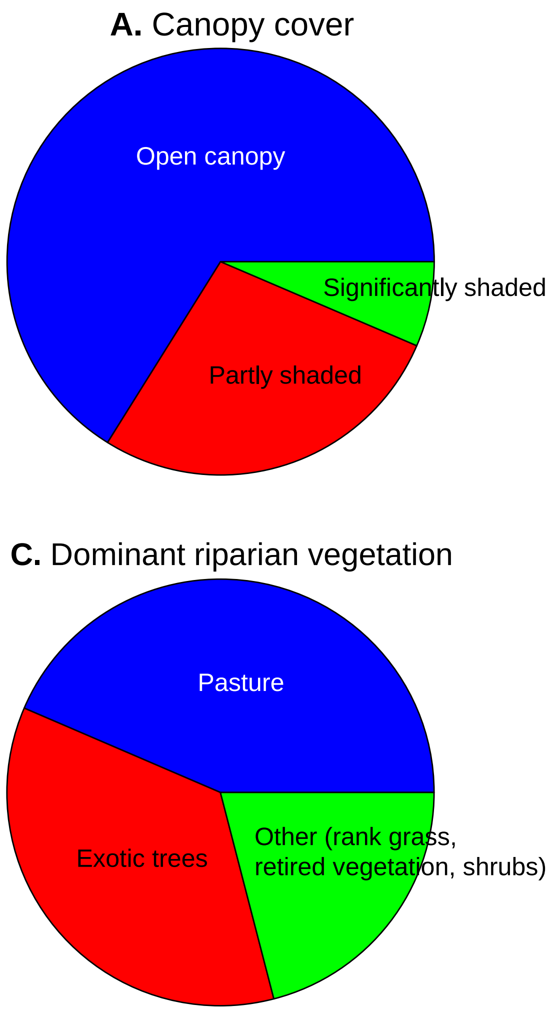

Figure 2. A proportional summary of the riparian characteristics of surveyed coastal lake and wetland outlet streams.

Two thirds of assessed sites were unshaded by riparian vegetation (Fig. 2A). Greater than a third of sites had no riparian fencing (Fig. 2B). Riparian vegetation was dominated by pasture and exotic trees (Fig. 2C). No sites with predominantly native vegetation were encountered.

3.2 In-stream habitat characteristics

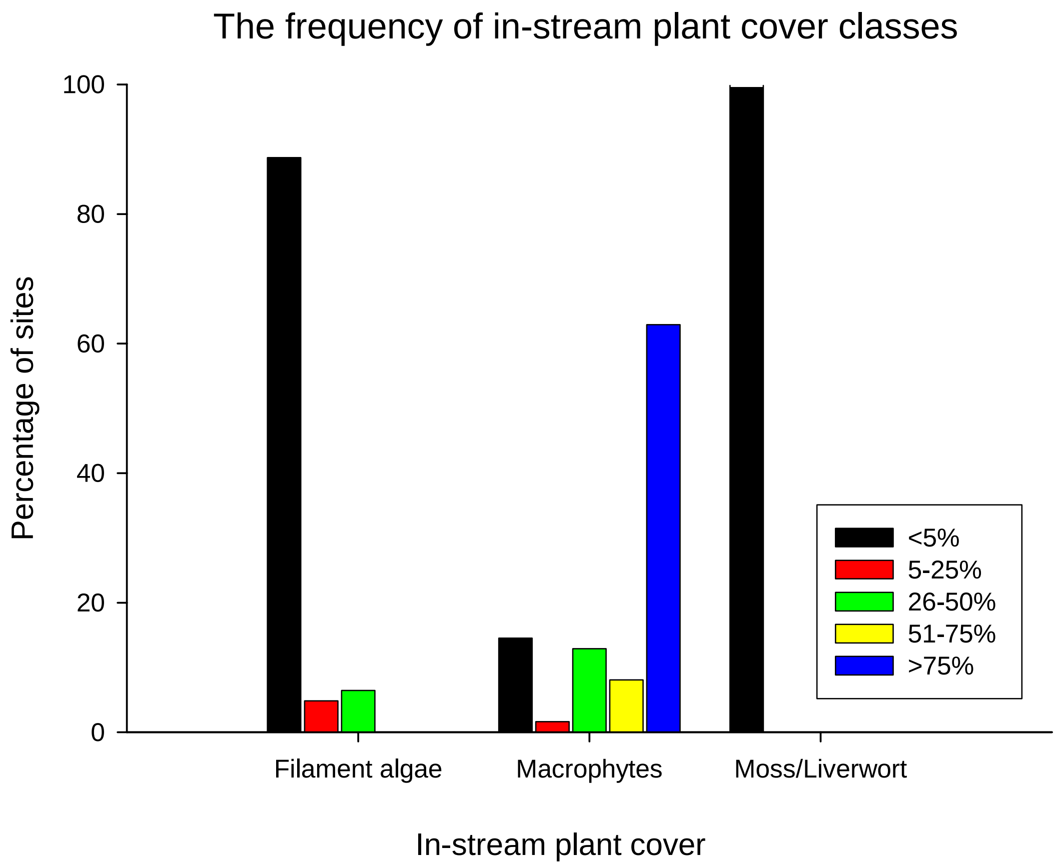

Figure 3. The frequency of in-stream plant cover classes of surveyed coastal lake and wetland outlet streams.

Almost 90% of sites have less than 5% cover of filamentous algae, while moss/liverwort cover was less than 5% at all sites surveyed. Macrophytes dominated in-stream plant cover with two-thirds of sites having macrophyte cover greater than 75% (Fig. 3).

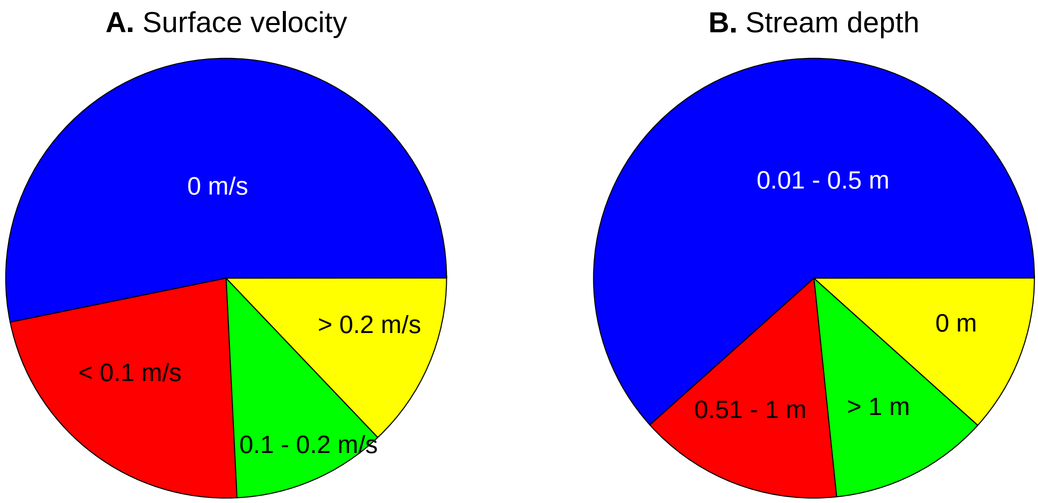

Figure 4. A proportional summary of surface water velocity and water depth of surveyed coastal lake and wetland outlet streams.

There was no visible surface water movement at over half the sites and where there was water movement, it was usually sluggish (Fig. 4A). Water depths were usually no more than 0.5 m and about 10% of sites lacked any surface water (Fig. 4B).

3.3 In-stream structures

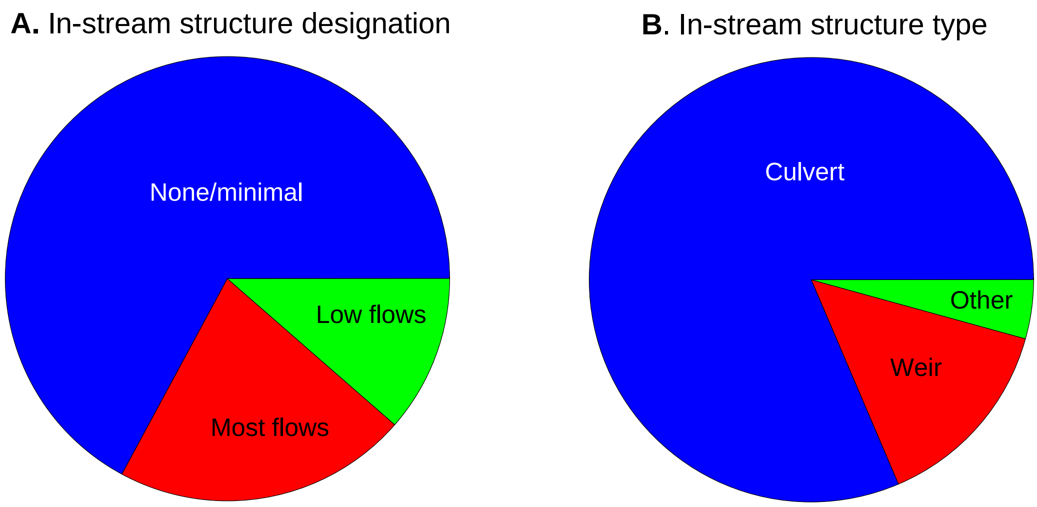

Figure 5. A proportional summary of the fish barrier potential and type of in-stream structures encountered in the surveyed coastal lake and wetland outlet streams.

Most in-stream structures posed no problem for fish passage (Fig. 5A). Culverts were the most common structure encountered (Fig. 5B). Of the structures identified as barriers, around half were culverts and half weirs (Table 6).

Table 6. Summary of the barriers identified in the assessed coastal lake and wetland outlet streams.

Source lake or wetland	Barrier type	Details/Severity
Lake Kaitoke	Lake level weir: concrete and wood	Perched/Most flows
Lake Wiritoa	Weir: Steel with wooden top	Perched/Most flows
	Culvert: Steel pipe	Perched/Most flows
Lake Waipu	Culvert: Plastic pipe	Perched/Most flows
	Drop created by vehicle crossing earthworks	Perched/Most flows
Lake Koitiata	Culvert: concrete pipe	Perched/Most flows
	Culvert: concrete pipe	Perched/Most flows
	Culvert: concrete pipe (double)	Perched/Most flows
Artillerie Swamp	Natural fall	Perched/Most flows
Forest Rd Wetlands	Culvert: concrete pipe with floodgate	Floodgate/Low flows
Pukepuke Lagoon	Lake level weir: concrete (has newly installed fish ramp)	Perched/Low flows
	Old lake level weir: concrete	Perched/Most flows
	Culvert: concrete pipe (double)	Snapped pipe/Low flows
Lake Kaikokopu	Weir: wooden	Perched/Most flows
Lake Koputara	Lake level weir: concrete	Perched/Low flows
Lake Koputara 1,2,3 & Lake Omanu	Koputara 2 lake level weir: concrete	Perched/Low flows
	Culvert: corrugated iron	Flat/Low flows
Lake Horowhenua	Lake level weir: concrete?	Submerged/Low flows
Lake Papaitonga	Lake level weir: concrete?	Perched/Most flows
	Culvert: concrete pipe	Flat/Low flows
Te Hakari Wetlands	Lake level weir: concrete?	Perched/Most flows
Ohau Dune Lakes	Culvert: concrete pipe with cap	Cap submerged/Most flows
Ohau Loop	Culvert: concrete pipe with floodgate	Floodgate/Low flows

3.4 Weighted Environment Waikato habitat assessment score ranking

The Environment Waikato habitat assessment score component of the composite habitat quality score is a good representation of in-stream habitat quality. Ranking sites using this score gives an indication of the relative condition of in-stream habitat among the assessed sites.

Table 7. Assessed outlet streams ranked with the weighted Environment Waikato habitat assessment scores

Ranked source lake and wetlands	Weighted Environment Waikato habitat assessment score
1. Lake Horowhenua	42.19
2. Te Hakari	41.78
3. Artillerie Swamp	40.28
4. Forest Rd	38.03
5. Ohau Loop	38.00
6. Lake Kaikokopu	35.74
7. Lake Papaitonga	34.38
8. Lake Koitiata	33.19
9. Omanuka – Pukepuke Lagoon	31.79
10. Lake Koputara 1, 2, 3 and Lake Omanu	30.83
11. Knottingly Swamp	30.20
12. Ohau Dune Lakes	30.00
13. Lake Koputara	29.23
14. Lake Kaitoke	28.82
15. Pukemarama Lagoon	28.05
16. Lake Waipu	22.53
17. Lake Wiritoa and Lake Pauri	19.93
Theoretical maximum score	**79**

Given the theoretical maximum score of 79, all the outlet streams scored poorly. Only a few sites scored more than half of this maximum and then by only a few points (Table 7). The lack of habitat diversity and overall homogeneity of the outlet streams means none of them are of particularly high quality.

3.5 Source lake or wetland quality and flow permanence score ranking

Table 8. Assessed outlet streams ranked with the source lake/wetland quality and flow permanence score.

Ranked source lake and wetlands	Lake or wetland quality/flow permanence score
1=. Lake Horowhenua	60
1=. Lake Papaitonga	60
1=. Omanuka – Pukepuke Lagoon	60
4=. Forest Rd	50
4=. Lake Koputara 1, 2, 3 and Lake Omanu	50
4=. Lake Koputara	50
4=. Lake Kaitoke	50
8=. Ohau Loop	40
8=. Te Hakari	40
8=. Artillerie Swamp	40
8=. Lake Kaikokopu	40
8=. Ohau Dune Lakes	40
13=. Knottingly Swamp	30
13=. Lake Koitiata	30
13=. Lake Wiritoa and Lake Pauri	30
13=. Lake Waipu	30
17. Pukemarama Lagoon	20
Theoretical maximum score	**60**

Lake Horowhenua, Lake Papaitonga and Omanuka – Pukepuke Lagoon ranked first equal, scoring the maximum. Knottingly Swamp, Lake Koitiata, Lake Wiritoa – Lake Pauri, Lake Waipu and Pukemarama Lagoon scored the least with a number of these having predominantly dry outlet channels (Table 8).

3.6 Restoration priority matrix

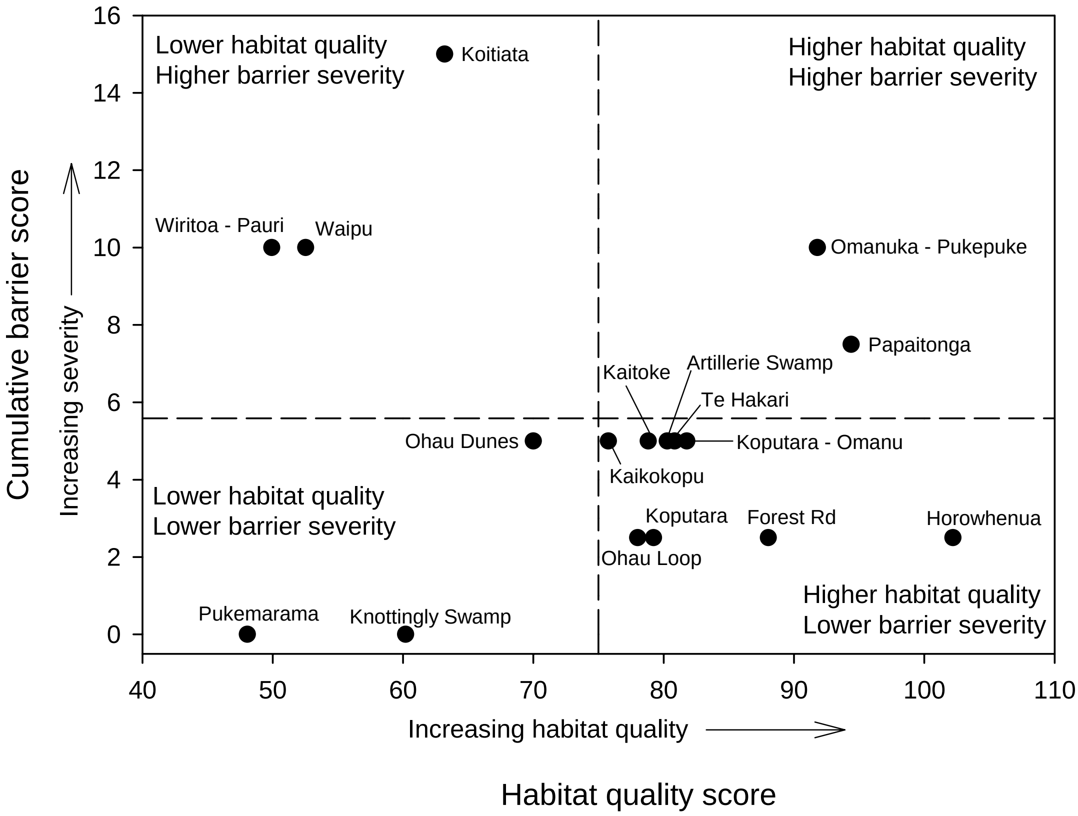

Figure 6. Restoration priority matrix showing the relative positions of assessed coastal lake and wetland outlet streams.

Most outlet streams had few barriers to fish passage with Pukemarama and Knottingly Swamp not having any barriers identified. Lake Koitiata, Omanuka – Pukepuke Lagoon, Lakes Wiritoa – Pauri, Lake Waipu and Lake Papaitonga had the highest barrier severity scores (Fig. 6). The outlet streams with the lowest composite habitat quality score, Lake Koitiata, Pukemarama, Knottingly Swamp, Lakes Wiritoa – Pauri and Lake Waipu all lacked continuous flow from the source to the ocean at the time of assessment. The outlet of Lake Horowhenua, Hokio Stream had the highest habitat quality score and was the only stream with a reach of hard-bottomed, swift flowing riffle habitat. The next highest habitat quality scores were from outlet streams that drain arguably the most intact source lakes/wetlands in the region, Lake Papaitonga and Pukepuke Lagoon (Figure 6).

3.7 Assessed outlet streams

A summary of each lake or wetland outlet stream was produced. The summary includes details of stream length, canopy cover, fencing, substrate size, the number of habitat assessments performed, and the number of in-stream barriers assessed. A written description of the outlet stream is provided as are relevant photos. Full detailed data are included in Appendix 3. A detailed summary page for in-stream structures has been provided only for those that are potential barriers to fish movement. Details of all in-stream structures are given in Appendix 4.

Artillerie Swamp

Artillerie Swamp

NZMS 260: S23 973-157

Outlet stream length: 1.70 km

Date assessed: 29/1/09

Canopy cover: mainly open

Fencing: none

Substrate: 100% sand

Riparian vegetation: near the stream are assorted shrubs, long grass, reeds and wild parsnip with occasional patches of small trees. Further back is production pine forest of various ages.

General description: The lake and stream are entirely within Santoft Forest.
Lake to 450 m: Choked with predominantly raupo and some wild parsnip. Natural perched drop located.
450 m to1st culvert: shaded under exotic trees and the channel clear of macrophytes. Covered in iron floc. Inanga sighted.
1st culvert to estuary: Dense macrophytes mainly wild parsnip with raupo patches. A few areas of open water and deeper pools where channel is shaded.
Estuary: Woody debris and numerous inanga. Not connected to ocean at time of visit.

Habitat assessments completed: 2

Instream structure assessments completed: 2

Potential problem instream structures: 1

Composite habitat quality score: 80.28

Cumulative barrier severity score: 5

Top: The Artillerie Swamp lake.

Middle: Extensive iron floc deposits ~450 m from lake in heavily shaded reach.

Bottom: The channel choked with wild parsnip. This is typical of most of the stream.

Left: The Artillerie Swamp outlet stream estuary.

Artillerie Swamp structure Location: natural fall near lake outlet	
Easting	2696865
Northing	6115900
Date assessed	29/1/09
Structure	Natural fall
Type	Natural fall
Construction	Sand and vegetation
Width	0.5 m
Water depth (inlet)	0.03 m
Water depth (outlet)	0.4 m
Inlet cross section	flat
Outlet cross section	perched
If perched (height)	0.25 m
If perched (undercut)	0
Likely severity of barrier	Most flows
Instream structures known upstream	0
Instream structures known downstream	1

Above: A natural perched fall near the Artillerie Swamp lake. It may become submerged when water levels are high.

Below: This feature was only discovered amongst the raupo by the sound of running water.

Forest Road Wetlands

Forest Road Wetlands

NZMS 260: S23 035-034

Outlet stream length: 4 km

Date assessed: 22/1/09

Canopy cover: mainly open

Fencing: mostly complete

Substrate: 100% sand

Riparian vegetation: The majority of the outlet stream has rank grass, some small shrubs, and patches of blackberry on the banks. Near the outlet from the wetlands there are willows on one side and the stream is adjacent to plantation pine forest one side for some distance.

General description: The outlet begins on a pig farm where the dominant land use is the growing of fodder crops. Most of this land was growing maize at the time of visit. After about 1 km it enters a dairy farm through which it is fully fenced. The stream flows into the Rangitikei River through a floodgate structure beneath the stop bank near the entrance to the Scotts Ferry settlement.

Adjacent to the final reach of the Forest Rd Wetland outlet before it enters the Rangitikei River is the Scotts Ferry Wetland. This appeared to be landlocked with no outlet.

Habitat assessments completed: 5

Instream structure assessments completed: 10

Potential problem instream structures: 1

Composite habitat quality score: 88.03

Cumulative barrier severity score: 2.5

Top: Wild parsnip choking the channel near the start of the outlet stream.

Middle: The stream near the entry to dairy farm. Here there is abundant duckweed and orange gunk.

Bottom: Typical nature of the channel through the dairy farm. Much of the channel is totally obscured by rampant wild parsnip growth.

Forest Road Wetland outlet stream selected structures

Top left: Relatively new culvert installed on top of two older ones to add higher flow capacity.

Middle left: A large diameter culvert.

Bottom left: Entrance to floodgate culvert beneath stop bank.

Top right: A number of the culverts were totally obscured by rampant wild parsnip.

Middle right: The stream channel is deeply incised in places. Here the bottom is almost 2 metres below the top of the bridge.

Bottom right: The floodgate. It appears closed but was hanging open at the time of visit.

Lake Horowhenua

Lake Horowhenua
- Hokio Stream

NZMS 260: S25 998-635

Outlet stream length: ~ 8 km

Date assessed: 16/12/08

Canopy cover: some partial shade, some open

Fencing: some complete, some one side and a smaller distance unfenced

Substrate: 100% sand except cobbled reach just downstream of Moutere Rd bridge

Riparian vegetation: Variable along Hokio Stream but predominantly a mixture of rank grass, toitoi, flax, various shrubs and trees with some willow patches. In some places the vegetation is impenetrable (e.g. much of the reach that flows next to Hokio Beach Rd).

General description: The Hokio Stream for most of its length is not wadeable often being great than one metre deep. Much of the bed is covered in macrophytes, especially *Potamogeton* spp. Approximately 800 metres downstream from Lake Horowhenua the Hokio Stream enters a small canyon where there is a hard substrate cobbled reach with riffle habitat. This hard material originates from a fault line at this point (N. Procter, *pers. com.*). For most of its length, the water velocity is sluggish but there are some areas of faster flows.

Habitat assessments completed: 5

Instream structure assessments completed: 1

Potential problem instream structures: 0

Composite habitat quality score: 102.19

Cumulative barrier severity score: 2.5

Top: Lake Horowhenua outlet.
Middle: Hokio Stream just downstream from Lake.
Bottom: Cobbled riffle downstream of Moutere Rd bridge.
Left: Hokio Stream near entrance to Hokio Beach settlement.

Lake Horowhenua structure Location: Lake level weir at outlet	
Easting	2699250
Northing	6064335
Date assessed	16/12/08
Structure	Weir
Type	Weir
Construction	Concrete
Width	~ 20 m
Water depth (inlet)	> 1 m
Water depth (outlet)	> 1 m
Inlet cross section	Pooled
Outlet cross section	Pooled
If perched (height)	0 m
If perched (undercut)	0 m
Likely severity of barrier	Low flows
Instream structures known upstream	0
Instream structures known downstream	0

Top right: The Lake Horowhenua water level weir was underwater at the time of assessment.

Bottom right: All that could be seen of the weir were some concrete posts.

Lake Kaikokopu

Lake Kaikokopu

NZMS 260: S24 022-898

Outlet stream length: 3 km

Date assessed: 16/1/09

Canopy cover: some partial shade, some open

Fencing: some complete, some one side

Substrate: 100% sand

Riparian vegetation: For much of its length, the outlet stream banks are covered in rank grass, and small shrubs. It flows through an area of pine plantation as it exits the Pedersen farm and there are some riparian trees on one side as it flows past the Himatangi Beach settlement.

General description: The first ~200 m including the lake outlet weir in inaccessible because of landowner concerns. This sections flows through a dairy farm and then enters an 800 m reach through pine plantation. The remainder flows parallel to the road before going along the northern edge of the Himatangi Beach settlement and entering the sea. At the entrance to the settlement there is a significant weir structure. Kaikokopu Stream is relatively shallow for much of its length (>0.5 m). It generally has slow water velocities and high proportion of open water. Duckweed is present at the edges and there are some dense beds of macrophytes. In places there are patches of bare sand and growths of filamentous green algae.

Habitat assessments completed: 4

Instream structure assessments completed: 1

Potential problem instream structures: 1

Composite habitat quality score: 75.74

Cumulative barrier severity score: 5

Top: Kaikokopu Stream at Pedersen boundary.
Middle: Kaikokopu Stream at exit from pine plantation.
Bottom: Kaikokopu Stream at Manawatu District Council reserve.
Left: Kaikokopu Stream estuary.

Kaikokopu Stream structure Location: weir at entrance to Himatangi Beach	
Easting	2700435
Northing	6090410
Date assessed	16/1/09
Structure	Weir
Type	Weir
Construction	Wood
Width	5.3 m
Water depth (inlet)	0.43 m
Water depth (outlet)	0.07 m
Inlet cross section	Pooled
Outlet cross section	Perched
If perched (height)	0.25 – 0.67 m
If perched (undercut)	0
Likely severity of barrier	Most flows
Instream structures known upstream	1
Instream structures known downstream	0

Top, bottom and left: The weir structure in the Kaikokopu Stream adjacent to the entrance to Himatangi Beach. A large amount of concrete rubble has been dumped at outlet presumably to prevent scouring of the stream bed.

Lake Kaitoke

Lake Kaitoke
- Kaitoke Stream

NZMS 260: R22 868-359

Outlet stream length: 5 km

Date assessed: 15/5/09

Canopy cover: mostly open of partially shaded, some more shaded reaches in pine forest
Fencing: mostly none, some fencing in pine forest.

Substrate: 100% sand

Riparian vegetation: The first 200m downstream of the lake is pasture and then the stream skirts pine forest. In a few places it enters the forest and has trees on both banks. One reach exits the forest and has dense gorse on the banks before entering the forest again. The final ~2.5 km flows through scrubby pasture with patches of lupin and gorse.

General description: Kaitoke Stream appears to flow permanently and exits the lake over a weir. There is visible water movement along most of the stream and in a few places it is swift. Most of the stream has open water and not choked by macrophytes. The channel meanders a lot and recent erosion is evident in a few places. As it nears the sea, the channel skirts the end of Wanganui airport. About 300 m from the ocean the Lakes Wiritoa – Pauri outlet joins the Kaitoke Stream.

Habitat assessments completed: 5

Instream structure assessments completed: 1

Potential problem instream structures: 1

Composite habitat quality score: 78.82

Cumulative barrier severity score: 5

Top: The Kaitoke Stream just downstream of the lake.
Middle: The Kaitoke Stream in the pine forest.
Bottom: The Kaitoke Stream near the Wanganui airport.
Left: The Kaitoke Stream at the beach facing upstream.

Kaitoke Stream structure Location: lake level weir	
Easting	2686420
Northing	6135865
Date assessed	15/5/09
Structure	Weir
Type	Weir
Construction	Wood and concrete
Width	4 m
Water depth (inlet)	0.45 m
Water depth (outlet)	0.67 m
Inlet cross section	Flat
Outlet cross section	Perched
If perched (height)	0.25 m
If perched (undercut)	0 m
Likely severity of barrier	Most flows
Instream structures known upstream	0
Instream structures known downstream	0

Top: The Lake Kaitoke water level weir facing upstream. The weir structure was on a lean.

Bottom: The Lake Kaitoke water level weir facing downstream.

Knottingly Swamp

Knottingly Swamp

NZMS 260: S23 987-130

Outlet stream length: 2.2 km

Date assessed: 28/1/09

Canopy cover: open

Fencing: none

Substrate: 100% sand

Riparian vegetation: Rank grass and some shrubs on the banks with the channel mostly choked by wild parsnip. Further back is pine plantation.

General description: Knottingly Swamp and its outlet stream are entirely within the Santoft Forest. Most of the channel totally choked with wild parsnip and at the time of visit most of the outlet stream was dry. There were some damp patches with small pools. The stream does not appear to enter the sea and the channel ceases in a large, deep pond. There is a gap in the dunes nearby where it may have flowed in the past. Given the amount of sand accumulation in this gap it is hard to imagine any linkage to the ocean in recent years.

Habitat assessments completed: 3

Instream structure assessments completed: 3

Potential problem instream structures: 0

Composite habitat quality score: 60.2

Cumulative barrier severity score: 0

Top right: The Knottingly Swamp lake.
Middle right: The outlet stream just downstream of the lake. The channel is wetted here and totally choked with wild parsnip.
Bottom right: Deeply incised dry channel in lower reaches of the outlet stream.
Above left: The gap in the outer dunes that the stream may have flowed out in the past.

Knottingly Swamp outlet stream structures

Left: The upstream most culvert. This culvert was overgrown and very difficult to find. It appeared to be made from wood. This was the only culvert of three that had water.
Top right and bottom right: The overgrown state of the other culverts which were all dry at the time of visit.

Lake Koitiata

Lake Koitiata

NZMS 260: S23 970-185

Outlet stream length: 2.7 km

Date assessed: 27/1/09

Canopy cover: Mostly partly shady

Fencing: Mostly none

Substrate: 100% sand

Riparian vegetation: The banks were mostly covered in rank grass and herbage with some shrubs. Most of the channel was dry and filled with grasses and broadleaf herbs with patches of bare sand. Where the channel is still wetted it is choked with wild parsnip. Further back is pine plantation.

General description: The entire outlet stream is within the Santoft Forest. At the time of visit the channel was dry except for a reach in the lower section of the stream. Parts of the dry section were totally dry while others were still damp with isolated pools. Some of the culverts encountered were severely perched. The stream was not flowing to the sea as the gap in the fore dunes was filled with sand.

Habitat assessments completed: 4

Instream structure assessments completed: 4

Potential problem instream structures: 3

Composite habitat quality score: 63.19

Cumulative barrier severity score: 15

Top: Lake Koitiata
Middle and bottom: The typical dry channel habitat that comprised the majority of the outlet stream.
Left: The wetted reach was choked with wild parsnip.

Lake Koitiata outlet stream structures

Lake Koitiata structure Location: First culvert downstream from lake	
Easting	2696775
Northing	6118330
Date assessed	27/1/09
Structure	Culvert
Type	Pipe
Construction	Concrete
Length	12 m
Diameter	0.45 m
Water depth (inlet)	0
Water depth (outlet)	0
Inlet cross section	Flat
Outlet cross section	Perched
If perched (height)	0.44 m
If perched (undercut)	0.91 m
Likely severity of barrier	Most flows
Instream structures known upstream	0
Instream structures known downstream	3

Top: Inlet of first culvert downstream of lake.

Bottom: Perched outlet of first culvert downstream of lake.

Left: The large pool (up to 0.75 m deep) at the culvert outlet presumable caused by scour at high flows.

Lake Koitiata structure Location: Second culvert downstream from lake	
Easting	2696690
Northing	6117895
Date assessed	27/1/09
Structure	Culvert
Type	Pipe
Construction	Concrete
Length	7.5 m
Diameter	0.7 m
Water depth (inlet)	0
Water depth (outlet)	0
Inlet cross section	Flat
Outlet cross section	Perched
If perched (height)	0.17 m
If perched (undercut)	0.75 m
Likely severity of barrier	Most flows
Instream structures known upstream	1
Instream structures known downstream	2

Above: Inlet of second culvert downstream of lake.

Below: Perched outlet of second culvert downstream of lake.

Lake Koitiata structure Location: Third culvert downstream from lake	
Easting	2696435
Northing	6117575
Date assessed	27/1/09
Structure	Culvert
Type	Pipe (double)
Construction	Concrete
Length	12 m
Diameter	0.3 / 0.45 m
Water depth (inlet)	0
Water depth (outlet)	0
Inlet cross section	Flat
Outlet cross section	Perched
If perched (height)	0.1 / 0.33 m
If perched (undercut)	0.92 / 0.48 m
Likely severity of barrier	Most flows
Instream structures known upstream	2
Instream structures known downstream	1

Above: Inlet of third culvert downstream of lake.

Below: Perched outlet of third culvert downstream of lake.

Top left: Inlet of the forth culvert downstream of the lake. Here the channel was wetted.

Bottom left: Outlet of forth culvert downstream of lake.

Lake Koputara

Lake Koputara

NZMS 260: S24 020-872

Outlet stream length: 3 km

Date assessed: 14/1/09

Canopy cover: Mostly open

Fencing: Mostly one side only

Substrate: 100% sand

Riparian vegetation: On the farmland, pasture and in the forested area, rank grass with pine trees further back.

General description: The Lake Koputara outlet stream first flows across a dairy farm before entering plantation forest. Some of this forest has recently been harvested. There is a lake level weir that may act as a fish barrier at lower flows. The stream had very little open water and minimal water movement was perceptible at the time of visit. Nearer the lake outlet weir the surface was covered in duckweed and further downstream the channel was choked with wild parsnip all the way to the estuary.

Habitat assessments completed: 4

Instream structure assessments completed: 4

Potential problem instream structures: 1

Composite habitat quality score: 79.23

Cumulative barrier severity score: 2.5

Top right: Lake Koputara outlet stream habitat just downstream of lake level weir.

Middle right: The Lake Koputara outlet stream as it crosses the Sexton dairy farm.

Bottom right: The Lake Koputara outlet stream as it enters the plantation forest. The water is totally obscured by rampant growth of wild parsnip.

Lake Koputara outlet stream structures

Lake Koputara structure Location: Lake level weir	
Easting	2701380
Northing	6086675
Date assessed	14/1/09
Structure	Weir
Type	Weir
Construction	Concrete
Width	~8 m
Water depth (inlet)	0.34
Water depth (outlet)	0.65
Inlet cross section	Pooled
Outlet cross section	Perched
If perched (height)	0.1 m
If perched (undercut)	0
Likely severity of barrier	Low flows
Instream structures known upstream	1
Instream structures known downstream	2

Top and bottom right: The Lake Koputara water level weir. At the time of visit water was pooled on either side with only a slight trickle flowing over the weir.

Below right and left: Culverts on the Koputara outlet stream that are unlikely to be problematic for fish passage.

Lake Koputara 1, 2 3 and Lake Omanu complex

Lake Koputara 1, 2, 3 and Lake Omanu complex (Whitebait Creek)

NZMS 260: S24 013-844, 009-823, 009-815

Outlet stream length: ~ 3.8 km (includes sections between lakes but not the lakes themselves)
Date assessed: 16,17,18/12/08

Canopy cover: Mostly open

Fencing: Ranging from none, one side to complete. Mostly one side only.

Substrate: 100% sand

Riparian vegetation: Mostly pasture with a section of plantation forest near Foxton Beach.

General description: Three Koputara lakes and Lake Omanu are linked with the outlet flowing into the Manawatu estuary at Foxton Beach. The upper lakes and outlet stream are on dairy farms. Downstream of Lake Omanu it flows across a pig and beef farm then through a small area of pine forest and then through Foxton Beach before entering the Manawatu estuary. Much of the upper part of the outlet stream is choked with wild parsnip. Lower down there is a lot of duckweed and through the pine forest there is more open water where the sandy substrate is visible. Through Foxton Beach to the start of the outlet estuary the channel is choked with wild parsnip. Most of the stream had minimal visible water movement.

Habitat assessments completed: 7

Instream structure assessments completed: 7

Potential problem instream structures: 2

Composite habitat quality score: 80.83

Cumulative barrier severity score: 5

Top: The outlet stream between Koputara lakes '2' and '3' choked with wild parsnip.
Bottom: The outlet stream just downstream of Lake Omanu.
Left: The outlet stream in the pine plantation just before flowing through Foxton Beach.

Above: The outlet stream entering the Manawatu estuary.
Left: The outlet stream is totally obscured by wild parsnip as it flows through Foxton Beach.

Lake Koputara 1, 2, 3 and Lake Omanu outlet stream structures

Lake Koputara '2' structure Location: Lake level weir	
Easting	2701390
Northing	6083550
Date assessed	16/12/08
Structure	Weir
Type	Weir
Construction	Concrete
Width	~1.5 m
Water depth (inlet)	0 (dry)
Water depth (outlet)	0.18 m
Inlet cross section	Dry (likely pooled if water present)
Outlet cross section	Perched
If perched (height)	0.1 m
If perched (undercut)	0
Likely severity of barrier	Low flows
Instream structures known upstream	0
Instream structures known downstream	6

Top: The Koputara '2' lake level weir facing downstream.
Bottom: The Koputara '2' lake level weir facing upstream

Lake Koputara/Omanu complex Location: Seabury Ave culvert, Foxton Beach	
Easting	2700040
Northing	6079520
Date assessed	18/12/08
Structure	Culvert
Type	Pipe (1/2 circle)
Construction	Corrugated iron
Length	~20 m
Diameter	1.08 m
Water depth (inlet)	0.2
Water depth (outlet)	0.05
Inlet cross section	Pooled
Outlet cross section	Flat
If perched (height)	0
If perched (undercut)	0
Likely severity of barrier	Low flows
Instream structures known upstream	6
Instream structures known downstream	0

Top right: The overgrown inlet of the Seabury Ave culvert.
Bottom right: The outlet of the Seabury Ave culvert has boulders placed to prevent scouring and was the only location in the outlet stream where swift flows were encountered. At low flows this could potentially be a barrier to some fish because of the shallow water depth.

Above left: This triple culvert at the outlet of Lake Omanu poses no issue for fish passage.
Above right: A large school of inanga was observed swimming through this culvert below Palmer Rd.

Lake Papaitonga

Lake Papaitonga
-Waiwiri Stream

NZMS 260: S25 982-600

Outlet stream length: ~5 km

Date assessed: 17/12/08

Canopy cover: Open

Fencing: Mostly one side or partial. A few stretches have complete fencing.

Substrate: 100% sand

Riparian vegetation: Pasture and rank grass.

General description: Where Waiwiri Stream exits Lake Papaitonga, there was a lake level weir with a fish pass that lacked water at the time of assessment. This weir was totally overgrown and its size and structure could not be determined. Most of the Waiwiri channel has minimal visible water movement. Some reaches are totally obscured by macrophytes while others have some open water.

Habitat assessments completed: 3

Instream structure assessments completed: 4

Potential problem instream structures: 2

Composite habitat quality score: 94.38

Cumulative barrier severity score: 7.5

Top: A totally fenced reach near the Lake Papaitonga outlet. Here there is a lot of open water. Unfortunately the cattle are inside the riparian buffer zone.

Bottom: Waiwiri Stream just downstream of the Lake Papaitonga outlet.

Left: Waiwiri Stream near where it enters the outer dunes. Here the channel is choked by wild parsnip.

Lake Papaitonga outlet stream structures

Lake Papaitonga – Waiwiri Stream Location: Lake level weir	
Easting	2697580
Northing	6060025
Date assessed	17/12/08
Structure	Weir
Type	Weir
Construction	? Sandbags visible
Width	? at least 2 m
Water depth (inlet)	?
Water depth (outlet)	?
Inlet cross section	? probably pooled
Outlet cross section	Perched
If perched (height)	? at least 0.5 m
If perched (undercut)	0 m
Likely severity of barrier	Most flows
Instream structures known upstream	0
Instream structures known downstream	3

Top: The overgrown lake level weir where the Waiwiri Stream exits Lake Papaitonga

Bottom: The wooden fish pass which lacked water at the time of assessment.

Left: The fish pass was in clear need of maintenance.

Lake Papaitonga – Waiwiri Stream

Location: Just downstream of lake level weir

Easting	2697485
Northing	6060055
Date assessed	17/12/08
Structure	Culvert
Type	Pipe
Construction	Concrete
Length	5 m
Diameter	0.9 m
Water depth (inlet)	no access
Water depth (outlet)	0.09 m
Inlet cross section	Flat
Outlet cross section	Flat
If perched (height)	0 m
If perched (undercut)	0 m
Likely severity of barrier	Low flows
Instream structures known upstream	2
Instream structures known downstream	1

Above: Culvert outlet. The minimal amount of water flowing through this culvert at the time of assessment lead to the conclusion that this structure could be a fish barrier at low flows.

Ohau River Dune Lakes

Ohau River Dune Lakes

NZMS 260: S25 926-568

Outlet stream length: 1 km

Date assessed: 22/12/08, 13/1/09

Canopy cover: Open

Fencing: Some one side, some none

Substrate: 100% sand

Riparian vegetation: Mostly long, rank pasture grass. Some small shrubs in places.

General description: The outlet stream was overgrown with macrophytes and there was minimal visible water movement at the time of visit. Much of the pasture was long and rank and had not been grazed for some time. The 2nd culvert downstream of the lake was concealed by the collapse of the sandy edges of the crossing. The outlet could not be found but water flow was observed indicating that the culvert was not blocked. Maintenance was required however. The downstream most culvert had a jammed outlet cap originally designed to prevent tidal surges up the stream. This likely prevents fish passage and needs to be either removed or maintained. Just downstream of this capped culvert the outlet stream flows into the Waikawa Stream.

Habitat assessments completed: 2

Instream structure assessments completed: 3

Potential problem instream structures: 1

Composite habitat quality score: 70

Cumulative barrier severity score: 5

Top right: One of the Ohau Dune lakes.

Middle right: The outlet stream near the lake/wetland area.

Bottom right: The outlet stream about 50 metres upstream of Waikawa Stream.

Ohau Dune Lakes outlet stream structures

Ohau Dune Lakes Location: culvert at outlet into Waikawa Stream	
Easting	2692120
Northing	6056125
Date assessed	13/1/09
Structure	Culvert (capped)
Type	Pipe
Construction	Concrete
Length	~ 7 m
Diameter	0.5 m
Water depth (inlet)	0.33 m
Water depth (outlet)	Underwater
Inlet cross section	Pooled
Outlet cross section	Pooled
If perched (height)	0
If perched (undercut)	0
Likely severity of barrier	Most flows
Instream structures known upstream	2
Instream structures known downstream	0

Top: Inlet overgrown by macrophytes.
Bottom: Capped culvert outlet. The cap is jammed and was underwater at time of visit.

Above left: The sides of this crossing had crumbled obscuring this culvert but there appeared to be good water flow.
Above right: Abundant macrophyte growth obscures this culvert.

Ohau Loop

Ohau Loop

NZMS 260: S25 964-584

Outlet stream length: 0.6 km

Date assessed: 18/12/08

Canopy cover: Open

Fencing: Mostly complete both sides

Substrate: 100% sand

Riparian vegetation: retired veg./rank pasture

General description: This channel is artificial to drain the Ohau Loop which itself is a former meandering section of the Ohau River that has been separated from the river to speed up flood flows. The first 100 m is relatively narrow (i.e. 2 m) and then the channel widens substantially. The channel is choked with macrophytes and no water movement was observed. The channel is fenced and the riparian vegetation is dominated by rank pasture grass.

Habitat assessments completed: 1

Instream structure assessments completed: 2

Potential problem instream structures: 1

Composite habitat quality score: 78

Cumulative barrier severity score: 2.5

Top: The channel totally obscured by macrophytes.
Bottom: The outlet channel widens after the first 100 m.
Left: The outlet of the culvert leading from the Ohau Loop to the channel.

Ohau Loop Location: Outlet floodgate structure	
Easting	not assessed*
Northing	not assessed
Date assessed	not assessed
Structure	culvert
Type	pipe (with floodgate)
Construction	concrete
Length	?
Diameter	~1.2 m
Water depth (inlet)	?
Water depth (outlet)	?
Inlet cross section	Pooled
Outlet cross section	Pooled
If perched (height)	NA
If perched (undercut)	NA
Likely severity of barrier	Low flows
Instream structures known upstream	1
Instream structures known downstream	0

Top*: The Ohau Loop flood gated culvert was not visited but would likely be a barrier at low flows when water flow is insufficient to keep the gate open wide enough to allow fish passage.

Bottom and left*: The flood gate mechanism is overgrown with vegetation. This may affect its operation. Regular maintenance of the flood gate is required.

*Photos were taken in June 2007 and were supplied by Horizons Regional Council.

Omanuka Lagoon and Pukepuke Lagoon

Omanuka Lagoon and Pukepuke Lagoon

NZMS 260: Omanuka S24 075-950

Pukepuke S24 024-935

Outlet stream length: Omanuka to Pukepuke 7.13 km, Pukepuke to sea 3.75 km
Date assessed: 15/1/09, 21/1/09

Canopy cover: Open

Fencing: Various from complete to none.

Substrate: 100% sand

Riparian vegetation: Pasture and rank grass are the dominant vegetation types. Downstream of Pukepuke Lagoon the stream enters pine forest but between the trees and the channel is a zone of long grass and some shrubs.

General description: At the time of assessment the channel was dry for some distance downstream of Omanuka Lagoon. Once wetted the channel is choked with macrophytes and no water movement is visible. Much of the channel between Omanuka and Pukepuke Lagoon has obviously been straightened to facilitate drainage. Downstream of Pukepuke Lagoon the channel enters pine forest but the trees are set back from the stream channel and provide little shade. More flow and areas of open water are visible as the stream approaches the sea. Schools of inanga were commonly seen in these areas of open water.

Habitat assessments completed: 5

Instream structure assessments completed: 8

Potential problem instream structures: 2

Composite habitat quality score: 91.79

Cumulative barrier severity score: 10

Top: The channel not far downstream of the upper dry reach.
Bottom: The channel upstream of Pukepuke Lagoon.
Left: The channel downstream of Pukepuke Lagoon with significant areas of open water.

Omanuka Lagoon and Pukepuke Lagoon outlet stream structures

Omanuka Lagoon and Pukepuke Lagoon Location: Pukepuke Lagoon lake level weir with new fish ramp	
Easting	2701605
Northing	6094225
Date assessed	18/5/09
Structure	Weir
Type	Weir
Construction	Concrete & wood
Width	5.5 m
Water depth (inlet)	0.4 m
Water depth (outlet)	0.09 m
Inlet cross section	Flat
Outlet cross section	Flat
If perched (height)	0 m
If perched (undercut)	0 m
Likely severity of barrier	Low flows
Instream structures known upstream	5
Instream structures known downstream	2

Top, bottom, top left, bottom left: The Pukepuke lake level weir. A fish ramp has been installed this summer to improve the fish passage potential of the weir. There may still be fish passage issues during lower lake levels when the water level is below the lip of the weir and no water flows down the ramp.

Omanuka Lagoon and Pukepuke Lagoon Location: Old, partially destroyed Pukepuke Lagoon lake level weir	
Easting	2700575
Northing	6094545
Date assessed	15/1/09
Structure	Weir
Type	Weir
Construction	Concrete
Width	5.3 m
Water depth (inlet)	0.25 m
Water depth (outlet)	0.02 m
Inlet cross section	Pooled
Outlet cross section	Perched
If perched (height)	0.19 m
If perched (undercut)	0 m
Likely severity of barrier	Most flows
Instream structures known upstream	6
Instream structures known downstream	1

Top: This old weir structure has had the middle knocked out of it sometime in the past but still is a perched barrier.
Bottom: From the scale of the concrete surrounds, it is obvious this was once a substantial structure.
Left: The structure has a significant concrete base, which itself creates a small perched step.

Omanuka Lagoon and Pukepuke Lagoon Location: Snapped double culvert just downstream of old weir.	
Easting	2700510
Northing	6094590
Date assessed	15/1/09
Structure	Culvert
Type	Pipe (double)
Construction	Concrete
Length	~6 m
Diameter	1 m
Water depth (inlet)	0.13 m
Water depth (outlet)	0.05 m
Inlet cross section	Flat
Outlet cross section	Flat (would be perched if not snapped)
If perched (height)	0 m
If perched (undercut)	0 m
Likely severity of barrier	Low flows (further subsidence could results in most flows)
Instream structures known upstream	7
Instream structures known downstream	0

Top: The culvert inlet
Middle and bottom: The end section of both pipes has been undermined and has snapped.
Left: The culvert outlet. The left hand pipe is totally separated such that no water flows down the end section. The right hand pipe maintains continuous flow. From the angle of the pipes it is likely they were perched and undercut prior to snapping.

Pukemarama Lagoon

Pukemarama Lagoon

NZMS 260: S24 024-935

Outlet stream length: ~3.5 km

Date assessed: 23/1/09

Canopy cover: Mainly open. Significantly shaded for last ~ 1.2 km.

Fencing: Mostly unfenced.

Substrate: 100% sand

Riparian vegetation: Mostly pasture, some poplar and pine shelter belt trees with the final section flowing through a 'wasteland' of predominantly blackberry, willow, and toitoi.

General description: The first ~2 km of the channel is an unfenced depression in a paddock that was mostly dry at the time of visit. Apart from a damp, swampy section just upstream of Tangimoana Rd, surface water flow only began where the channel dropped down to the Rangitikei River floodplain. The channel then made its way through impenetrable vegetation to the Rangitikei River. It would appear surface flow of the upper reaches of the Pukemarama Lagoon outlet stream is directly related to groundwater levels.

Habitat assessments completed: 2

Instream structure assessments completed: 7

Potential problem instream structures: 0

Composite habitat quality score: 48.05

Cumulative barrier severity score: 0

Top: Pukemarama Lagoon
Bottom: The Pukemarama Lagoon outlet stream habitat where the channel is wetted but not flowing.
Left: The Pukemarama Lagoon outlet stream habitat on the Rangitikei River floodplain where there was surface flow at the time of assessment.

Te Hakari Wetlands

Te Hakari Wetlands

NZMS 260: S25 928-577

Outlet stream length: 0.3 km

Date assessed: 18/12/08

Canopy cover: Open

Fencing: Complete

Substrate: 100% sand

Riparian vegetation: Retired vegetation, predominantly long, rank grass. Small reach with exotic trees.

General description: The Te Hakari outlet is short with little visible water movement and overgrown by macrophytes. About half way between the Te Hakari lake and the outlet into the Ohau estuary there is a lake level weir with a fish pass. The weir is overgrown and the fish pass was lacking water at the time of assessment. There is a large amount of woody debris in the channel downstream of the 2nd culvert which was presumably deposited during storm events.

Habitat assessments completed: 2

Instream structure assessments completed: 3

Potential problem instream structures: 1

Composite habitat quality score: 81.78

Cumulative barrier severity score: 5

Top: The start of the Te Hakari outlet stream.
Bottom: The Te Hakari outlet stream channel full of woody debris just downstream of the downstream-most culvert.
Left: The estuarine lower reach of the Te Hakari outlet stream.

Te Hakari Wetland outlet stream structures

Te Hakari Wetland Location: lake level weir	
Easting	2692765
Northing	6057940
Date assessed	18/12/08
Structure	Weir
Type	Weir
Construction	? Sandbags visible
Width	? at least 2 m
Water depth (inlet)	~0.4 m
Water depth (outlet)	~0.3 m
Inlet cross section	Pooled
Outlet cross section	Perched
If perched (height)	~0.5 m
If perched (undercut)	0 m
Likely severity of barrier	Most flows
Instream structures known upstream	1
Instream structures known downstream	1

Top: The Te Hakari lake level weir and fish pass was totally overgrown by long grass.
Bottom: The fish pass was lacking water and blocked with grass at the time of assessment.

Lake Waipu and Lake Oraekomiko

Lake Waipu and Lake Oraekomiko

NZMS 260: S23 938-268

Outlet stream length: 2.2 km to Turakina River, 7 km to ocean. Lake Oraekomiko to Waipu outlet stream ~0.660 m
Date assessed: 18/5/09

Canopy cover: Open to partly shaded

Fencing: None

Substrate: 100% sand

Riparian vegetation: Rough pasture and some exotic trees.

General description: The outlet stream drains Lake Waipu through a wide earth dam. No surface water was flowing from the lake at the time of assessment and the first section of the outlet stream was dry and looked to have been recently "cleaned out" by a digger. Surface water resumes in a patch of mature pine trees just downstream of the lake. In the forest there is little visible water movement and a number of deep pools with open water and duckweed. The channel then meanders through rough pasture and patches of small pine trees where there are some watercress and grass in the channel. Amongst a patch of small pine trees there is a reach with the substrate covered in iron floc. In the lower reaches the channel becomes wide and indistinct and filled with grass and watercress. Before becoming channelized again just before entering the Turakina River. The Lake Oraekomiko outlet was dry and did not appear to flow very often. No channel was obvious at the lake outlet but the ~400 m before entering the Waipu outlet was a significant depression in the sand indicating that at time there must be significant flows.
Habitat assessments completed: 4

Instream structure assessments completed: 4

Potential problem instream structures: 2

Composite habitat quality score: 52.53

Cumulative barrier severity score: 10

Top: Lake Waipu outlet stream just before exiting stand of mature pine trees.
Upper middle: Waipu outlet stream reach with iron floc.
Lower middle: Waipu outlet stream habitat just downstream of main vehicle crossing.
Bottom: Just before entering the Turakina River, the channel narrows.

Lake Waipu outlet stream structures

Lake Waipu Location: main vehicle crossing	
Easting	2693380
Northing	6125820
Date assessed	18/5/09
Structure	Culvert
Type	Pipe
Construction	Plastic
Length	10 m
Diameter	0.36 m
Water depth (inlet)	0.11 m
Water depth (outlet)	0.05 m
Inlet cross section	Flat
Outlet cross section	Perched
If perched (height)	0.06 m
If perched (undercut)	~0.3 m
Likely severity of barrier	Most flows
Instream structures known upstream	2
Instream structures known downstream	1

Top: The main vehicle crossing culvert perched outlet.

Bottom: The main vehicle crossing culvert perched inlet concealed by vegetation.

Left: The wide earth dam at the outlet of Lake Waipu. Two culverts were visible and at the time of assessment they were dry. Water would only flow when the lake level is higher.

Lake Waipu Location: earthworks ~20 m from Turakina River	
Easting	2693100
Northing	6125600
Date assessed	18/5/09
Structure	Drop created by earthworks
Type	Artificial fall
Construction	Natural substrate
Width	0.55 m
Water depth (inlet)	0.03 m
Water depth (outlet)	0.04 m
Inlet cross section	Flat
Outlet cross section	Perched
If perched (height)	0.4 m
If perched (undercut)	0 m
Likely severity of barrier	Most flows
Instream structures known upstream	3
Instream structures known downstream	0

Above and bottom: Recent earthworks on a vehicle crossing just upstream of the Waipu outlet confluence with the Turakina River. The soil has been removed exposing the mudstone bedrock and the stream has created a fall over this.

Left: The confluence of the Lake Waipu outlet stream with the Turakina River. The stream enters in the mid-right of the photo.

Lake Wiritoa – Lake Pauri

Lake Wiritoa and Lake Pauri

NZMS 260: Wiritoa R22 885-346,
Pauri R22 893-343

Outlet stream length: Wiritoa – sea ~5.2 km, Pauri – Wiritoa ~400 m

Date assessed: 19/5/09

Canopy cover: Mostly open, a few shaded reaches amongst pine trees

Fencing: Mostly none

Substrate: 100% sand

Riparian vegetation: Mostly rough pasture with some patches of pine trees.

General description: The join of Lakes Pauri and Wiritoa is mostly a wetland area with the only distinct channel being obvious at a vehicle crossing with a culvert. Upon exiting Lake Wiritoa the first ~1.7 km of the channel was dry and did not appear to flow very often and had either bare earth or pasture plants growing. Surface water resumed in a patch of pine trees as a series of pools for around 100 m before a continuously wetted channel began. This then flowed ~1.5 km before entering a wetland area that included a lake created by an artificial dam. Downstream of the dam there is another wetland area from which the channel originates before entering the Kaitoke Stream about 300 m from the sea. The channel contains a mix of mostly grass and watercress with many reaches of bare sand.

Habitat assessments completed: 4

Instream structure assessments completed: 6

Potential problem instream structures: 2

Composite habitat quality score: 49.93

Cumulative barrier severity score: 10

Top: The wetland between Lake Pauri and Lake Wiritoa. The only distinct channel between the lakes occurs at a vehicle crossing which has a culvert.

Bottom: The dry Lake Wiritoa outlet channel in the first stand of pine trees downstream of the lake. Surface water flow here appears rare.

Left: The Lake Wiritoa outlet a few hundred metres from where surface water begins.

Right: The Lake Wiritoa outlet with surface water upstream of the dam and wetland area.

Above: The Lake Wiritoa outlet just upstream of the confluence with Kaitoke Stream.

Lake Wiritoa and Lake Pauri outlet stream structures

Lake Wiritoa Location: Weir a few hundred metres upstream of where the channel becomes wetted	
Easting	2686760
Northing	6134615
Date assessed	19/5/09
Structure	Weir
Type	Weir
Construction	Steel with wooden top
Width	1.8 m
Water depth (inlet)	0 m
Water depth (outlet)	0 m
Inlet cross section	Flat
Outlet cross section	Perched
If perched (height)	0.6 m
If perched (undercut)	0 m
Likely severity of barrier	Most flows
Instream structures known upstream	3
Instream structures known downstream	2

Above: Artificial weir a few hundred metres upstream of where the channel becomes wetted. The purpose of this weir was unclear.

Lake Wiritoa Location: Artificial earth dam creating a small lake	
Easting	2684520
Northing	6135125
Date assessed	19/5/09
Structure	Culvert (double but one dry)
Type	Pipe
Construction	Steel
Length	~5 m
Diameter	0.5 m
Water depth (inlet)	0.18 m
Water depth (outlet)	0.05 m
Inlet cross section	Flat
Outlet cross section	Perched
If perched (height)	0.1 m
If perched (undercut)	0.5 m
Likely severity of barrier	Most flows
Instream structures known upstream	4
Instream structures known downstream	1

Top: The dam culvert inlet.

Bottom: The perched outlet of the dam culvert. The second culvert was dry and only flows when the lake level is higher.

Left: The small lake on the Lake Wiritoa outlet stream which appears to have been created by an artificial earth dam.

4. Discussion

4.1 The condition of coastal lake and wetland outlet streams

There was high habitat homogeneity within and among the outlet streams that were assessed. The surrounding land use and low gradient of these streams typically means they are unshaded, at least partially fenced, have very sluggish flow, are quite shallow, have a sand substrate and are choked by macrophyte growth. Visible open water was generally rare with only Hokio Stream (Lake Horowhenua outlet), Waiwiri Stream (Lake Papaitonga outlet), Kaikokopu Stream (Lake Kaikokopu outlet), Kaitoke Stream (Lake Kaitoke outlet), and the Lake Wiritoa and Lake Waipu outlets having channels where the waters surface was not predominantly concealed by macrophyte growth. Even though the streams are typically unshaded, the abundance of emergent macrophytes, especially wild parsnip, means most streams were shaded to some degree. A number of streams also had reaches shaded by stands of pine trees.

Along their length, the assessed outlet streams had little habitat diversity. They lack variability in flow velocity, water depth and substrate size. Natural in-stream structures such as logs and undercut banks are rare or absent. In general, the habitat of coastal outlet streams is analogous to those of long, shallow ponds. A few assessed streams were mostly dry along their length with the channel having no aquatic environment at all. The most extreme case of this was the Pukemarama Lagoon outlet where the stream for much of its length was simply a grassed depression crossing paddocks.

Of all the streams assessed, the Hokio Stream was unique in being deep, not totally choked by macrophytes and having a section of cobbled, fast-flowing riffle habitat. It was probably the largest of the streams assessed and this likely contributes to this uniqueness as smaller, shallower streams would be more likely to be totally choked by macrophytes. Overall, the coastal lake and wetland streams that were assessed are in a poor state. However, with a lack of information on the original ‘pristine’ conditions of such streams it is difficult to determine exactly how degraded they are.

Prior to European development of coastal land for farming and forestry, it is likely the coastal dune environment was much more dynamic with a greater wetland area than now. For example, the once extensive swamp surrounding Lake Kaikokopu was apparently continuous with the swamp associated with Pukepuke Lagoon (Esler 1978). Now these systems are separated by over 3 km of predominantly farmed pasture. Adkin (1948) sums up the situation well in stating that the lagoons in the Manawatu to Otaki section of the dune-belt were “beyond enumeration” and that recently “the general tendency is for these picturesque and moisture-providing sheets of water to disappear from the face of the landscape.” Adkin (1948) also describes the lowering of the water table in the Lake Papaitonga area resulting from clearing and straightening of the Waiwiri Stream in 1938.

Dunes have been stabilised by forestry while wetlands were drained to allow pastoral farming. Some of the outlet streams would not have been simple channels running to the sea as they are now. There would have been other wetland areas downstream of the existing ones and in some places there would not necessarily have been a defined channel. For example, at the outlet end of Lake Papaitonga there was a large wetland area known as Reporoa (Adkin 1948). This area is now pastured. Sand dune movement likely had a major influence on channel geomorphology and connectivity to the sea. Dune movement in some instances may have blocked access to the ocean for periods, altered channel courses, and ultimately in-filled some lakes and wetlands while new ones would form in hollows. Additionally, tectonic events causing uplift have also played a role in channel and wetland formation and will in the future. For example, the 1840 earthquake separated the shared estuary of the Waikawa

Stream and Ohau River, forming the Te Hakari and Ohau Dune Lake wetlands. In summary, the environment has changed from a dynamic one of shifting dunes and river mouths to a static one dominated by fixed channels, drainage and dune stabilisation.

Given this profound change in the physical processes influencing the coastal dune landscape, restoration of outlet streams is never going to recreate “pristine” conditions. Restoration must instead focus on assisting the existing streams reach their ecological potential through fencing to keep farm animals out of the stream and riparian zone, planting of the riparian zone to filter runoff and provide shade, and alteration of any in-stream structures that prevent the free movement of diadromous fish species.

4.2 Artificial in-stream structures

Most of the in-stream structures encountered were culverts, usually being circular concrete or plastic pipes. Because of the catchment morphology (low gradient, low altitude) the coastal outlet streams are not subject to extreme high flow events. Thus despite the soft sand substratum, erosion of the stream bed creating perched and undercut culvert outlets was rare. However, three out of four culverts on the Lake Koitiata outlet stream displayed major outlet erosion and perching resulting from culverts of too small a diameter being installed. At the time of assessment this outlet was dry but it is evident that when water levels are high, water pools upstream of the culvert and is forced at great velocity through the culvert causing significant scouring at the outlet. Other problem culverts were not this extreme and most would benefit from the stream bed at the outlet being built up to meet the level of the culvert. One culvert that does require prompt remediation is on the Pukepuke Lagoon outlet stream. A section of this double culvert has snapped creating a ramp from one pipe and totally separating the other, creating a perch which is likely a barrier to fish movement. Further subsidence will likely result in the structure being totally impassable.

A number of wetland/lake level weirs were recorded and it is this kind of structure that more commonly poses problems for fish passage. During low to normal flow levels these structures typically hold water behind them often with an absence of any surface flow if the upstream level is below the top of the weir. At these times there is no way for any fish to pass them. During high flows if the downstream water surface is significantly lower than the top of the weir, a swift waterfall over the weir may be created. This may also prevent the passage of fish. Other weirs, such as the Lake Horowhenua (Hokio Stream) weir become totally submerged during higher water levels and are not a barrier at these times. Weirs at Lake Papaitonga (Waiwiri Stream), Te Hakari and Lake Kaikokopu (Kaikokopu Stream weir at town not lake weir) appeared to prevent fish passage for most of the time while weirs at Lake Koputara 2, Lake Horowhenua (Hokio Stream) and Lake Koputara likely affect fish passage during low flow periods.

Weirs are often the subject of fish pass construction and these were encountered at some sites. Fish passes had been constructed on the level weirs of Lake Papaitonga (Waiwiri Stream) and Te Hakari but unfortunately none were operational at the time of assessment. The Lake Papaitonga and Te Hakari fish passes were totally overgrown and locating them was fortuitous. In the last two months, the weir at Pukepuke Lagoon has had a fish ramp installed that should allow the free passage of fish except when water levels are lower than the top of the weir.

4.3 Restoration priorities

Given the homogeneity of in-stream and riparian conditions encountered and the relatively degraded state of the outlet streams, prioritising restoration efforts based solely on the condition of the outlet streams is not sensible. Instead the quality of the source lake or wetland is an important determinant of where to begin restoration efforts. There is little point trying to improve the condition of an outlet stream in terms of water quality and fish diversity if the source lake or wetland is in poor ecological condition. Equally, ephemeral channels are unlikely to benefit greatly from riparian restoration. Thus riparian restoration efforts involving fencing and planting of the stream banks should be concentrated on those outlet streams that have a high quality source lake or wetland. We believe the outlets of Lake Horowhenua (Hokio Stream), Lake Papaitonga (Waiwiri Stream) and Pukepuke Lagoon (excluding the section upstream to the Omanuka Lagoon) would benefit most from riparian restoration. Sections of Hokio Stream already have significant riparian vegetation and the removal of willows that is planned (pers. com. Noel Proctor, Horizons Regional Council) will open up areas for the planting of preferred riparian species.

Fish passage restoration would be most beneficial where the removal of barriers would open up the greatest area of quality upstream fish habitat. There is little point for example of repairing the poorly designed culverts of the ephemeral Lake Koititata outlet stream in preference to the barriers on the Pukepuke Lagoon outlet. We recommend that the removal or mitigation of identified barriers on the outlets of Lake Papaitonga (Waiwiri Stream) and Pukepuke Lagoon be of the greatest priority, closely followed by alteration of the Lake Horowhenua (Hokio Stream) weir to allow fish passage at all water levels. Given the proximity to the coast of these wetland/lakes systems, any fish passes must allow the free passage of all native fish species including the poorest of climbers (i.e. inanga and smelt). The planting of riparian vegetation may also ultimately improve fish passage if high temperatures and low dissolved oxygen concentrations are ameliorated by the closing of the canopy and shading out of macrophytes.

4.4 Other issues

A number of factors other than fish barriers and habitat condition may influence the ultimate decision on where to expend restoration efforts. Landowner cooperation and/or participation is crucial to the success of any riparian restoration efforts. The visibility of restoration efforts to the public may also be an issue. For example, much of the Hokio Stream flows alongside the road to Hokio Beach in contrast to the Pukepuke Lagoon outlet which is almost entirely within private forestry land. Budgetary constraints will also be a major issue which may mean the length of riparian restoration possible may be limited and the length of the outlet stream may be a consideration.

The aims of the restoration efforts (increased fish diversity and improved water quality) may not be realised despite riparian fencing and planting and repair of fish barriers. Reinstating fish passage may not necessarily lead to increased diversity of fish species if other factors are limiting fish species diversity and abundance (i.e. pest fish, poor recruitment, overfishing). Lake Horowhenua and Hokio Stream for example, are laden with perch which likely predate and compete with native fish species. Riparian fencing and planting may have limited impact on water quality where there are significant inputs from tributaries and linkages with groundwater. The water quality of the source lake or wetland and its upstream catchment will also be a major influence on outlet stream water quality.

4.5 Further work

There are a number of further investigations that would provide more detailed information on water quality and fish diversity to further improve the prioritisation and future monitoring of stream restoration.

- The drivers of various aspects of outlet stream water quality could be determined. For example, it would be advantageous to know if the source of soluble nitrogen was predominantly from the source lake/wetland, groundwater, tributaries or runoff. Additionally, the diurnal dissolved oxygen range and how this changes during any macrophyte dieback would give an indication of whether the excessive macrophyte growths are necessarily bad.
- Recording the water levels at some lake level weirs (e.g. Lake Horowhenua) would give an indication of how much of the year the weir is actually a barrier to fish passage.
- Predicting what native aquatic species (plant and animal) should be present in such streams needs to be a starting point for any monitoring program.

5. Conclusion

Based on in-stream, riparian and source lake/wetland quality and the presence of fish barriers, the highest priority outlet streams for restoration are those of Lake Horowhenua (Hokio Stream), Lake Papaitonga (Waiwiri Stream) and Pukepuke Lagoon (excluding upstream section to Omanuka Lagoon). Any restoration efforts must have realistic, defined and measurable targets and not nebulous goals such as "improved water quality". If the proposed restoration efforts are to be implemented then sufficient time must be allowed to develop a robust monitoring methodology and perform pre-restoration monitoring.

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Appendix 1 – Environment Waikato Field Assessment Cover Form

Field Assessment Cover Form

Wadeable Hard-Bottomed and Soft-Bottomed Streams

STREAM NAME:	**ASSESSOR:**

SITE NUMBER:	**SAMPLE NUMBER:**	**DATE:**	**TIME (NZST):**

GPS COORDINATES: Downstream end of reach - Easting – Northing –
Upstream end of reach - Easting – Northing –

CHANNEL AND RIPARIAN FEATURES

Canopy Cover:
❍ Open ❍ Partly shaded ❍ Significantly shaded

Fencing:
❍ None or ineffective
❍ One side or partial
❍ Complete both sides

Dominant Riparian Vegetation:
❍ Crops etc ❍ Retired vege.
❍ Pasture ❍ Native shrub
❍ Exotic trees ❍ Native trees

INSTREAM HYDRAULIC CONDITIONS

Estimated or measured reach average:

Stream width (active channel) _________ m
Stream width (water) _________ m
Stream depth _________ m
Surface velocity _________ m/sec

WATER QUALITY

Temperature: _________ °C Conductivity: _______ µS/cm @ 25°C
Dissolved Oxygen: ________ % ________ mg/L
Turbidity: ❍ Clear ❍ Slightly turbid ❍ Highly turbid ❍ Stained ❍ Other ___________

STREAM-BOTTOM SUBSTRATA

Compaction (inorganic substrata):
❍ assorted sizes tightly packed &/or overlapping
❍ moderately packed with some overlap
❍ mostly a loose assortment with little overlap
❍ no packing / loose assortment easily moved.

Embeddedness:
(% gravel-boulder particles covered by fine sediment)
❍<5% ❍5-25% ❍26-50% ❍51-75% ❍>75%

% surficial inorganic substratum size composition (should sum to 100%)

Substratum type	Dimension (middle axis)	Percentage
Bedrock	-	
Boulder	> 256mm	
Cobble	>64-256mm	
Gravel	>2-64mm	
Sand	>0.06-2mm	
Silt	0.004-0.06mm	
Clay	<0.004mm	

ORGANIC MATERIAL (% cover)

Large wood (>10 cm diameter):
❍<5% ❍5-25% ❍26-50% ❍51-75% ❍>75%

Coarse Detritus (small wood, sticks, leaves etc >1 mm):
❍<5% ❍5-25% ❍26-50% ❍51-75% ❍>75%

Fine (<1 mm) Organic Deposits (edges and backwaters):
❍<5% ❍5-25% ❍26-50% ❍51-75% ❍>75%

INSTREAM PLANT COVER (% of streambed area)

Filamentous Algae (>2mm long) & Mats (>3 mm thick):
❍<5% ❍5-25% ❍26-50% ❍51-75% ❍>75%

Macrophytes:
❍<5% ❍5-25% ❍26-50% ❍51-75% ❍>75%

Mosses/Liverworts:
❍<5% ❍5-25% ❍26-50% ❍51-75% ❍>75%

HABITAT TYPES SAMPLED (% of effort; each column should sum to 100%)

Stones: _______%
Wood: _______%
Macrophytes: _______%
Edges: _______%

Riffles: _______%
Runs: _______%

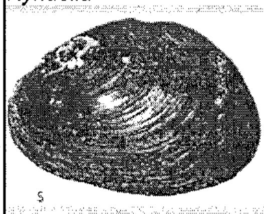
COMMENTS

NO. INVERTEBRATES RETURNED:

Koura: _______ Shrimps: _______
Crabs: _______ Mussels: _______
Others (specify) ________________

Species of mussel (tick)

Hyridella



Shell smooth; up to 100mm long; variable shell shape

Cucumerunio

Nodules and ridges on upper part of shell; up to 90mm long

Environment Waikato Habitat Assessment Field Data Sheet

Wadeable Soft-Bottomed Streams

Qualitative Habitat Assessment Field Data Sheet

STREAM NAME:		**SITE NUMBER:**	
SAMPLE NUMBER:	**ASSESSOR:**	**DATE:**	

Habitat Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Riparian Vegetative Zone Width (score each bank; determine left or right side by facing downstream)	• Bankside vegetation buffer is >10m • Continuous and dense	• Bankside vegetation buffer is <10m • Mostly continuous	• Pathways present and/or stock access to stream • Mostly healed over	• Breaks frequent • Human activity obvious
Left bank	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Right bank	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Mean LB&RB_____				
2. Vegetative Protection (score each bank; determine left or right side by facing downstream)	• Bank surfaces and immediate riparian zones covered by native vegetation • Trees, understorey shrubs, or non-woody plants present • Vegetative disruption minimal	• Bank surfaces covered mainly by native vegetation • Disruption evident • Banks may be covered by exotic forestry	• Bank surfaces covered by a mixture of grasses/shrubs, blackberry, willow and introduced trees • Vegetation disruption obvious • Bare soil/closely cropped vegetation common	• Bank surfaces covered by grasses and shrubs • Disruption of streambank vegetation very high • Grass heavily grazed • Significant stock damage to the bank
Left bank	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Right bank	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Mean LB&RB_____				
3. Bank Stability (score each bank; determine left of right side by facing downstream	• Banks stable • Erosion/bank failure absent or minimal • <5% of bank affected	• Moderately stable • Infrequent, small areas of erosion mostly healed over • 5-30% of bank eroded	• Moderately unstable • 30-60% of bank in reach has areas of erosion • High erosion potential during floods	• Unstable • Many eroded areas • 60-100% of bank has erosional scars
Left bank	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Right bank	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Mean LB&RB_____				
4. Channel sinuousity	• Bends increase stream length 3-4 times longer than if it was in a straight line	• Bends increase the stream length 2-3 times longer than if it was in a straight line	• Bends increase the stream length 1-2 times longer than if it was in a straight line	• Channel straight
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

SUBTOTAL : ____________

Soft bottomed continued

Habitat Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
5. Channel Alteration	• Changes to channel/dredging absent or minimal • Stream with normal pattern	• Some changes to channel/dredging • Evidence of past channel/dredging • Recent channel/dredging not present	• Channel changes/dredging extensive • Embankments or shoring structures present on both banks • 40 to 80% of reach channelised and disrupted	• Banks shored with gabion or cement • >80% of the stream reach channelised and disrupted. • Instream habitat altered or absent
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
6. Sediment Deposition	• Little/no islands or point bars present • <20% of the bottom affected by sediment deposition	• New increase in bar formation, mostly from gravel, sand or fine sediment • 20-50% of the bottom affected; • Slight deposition in pools	• Some deposition of new gravel, sand or fine sediment on old and new bars • 50-80% of the bottom affected • Sediment deposits at obstructions, constrictions, and bends	• Heavy deposits of fine material • Increased bar development • >80% of the bottom changing frequently • Pools almost absent due to sediment deposition
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7. Pool Variability	• Pools evenly mixed • Large/shallow, Large/deep, Small/shallow, Small/deep	• Majority of pools large/deep • Very few shallow pools	• Prevalence shallow pools	• Majority of pools small/shallow
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
8. Abundance and Diversity of Habitat	• >50% substrate favourable for invertebrate colonisation and wide variety of woody debris, riffles, root mats • Snags/ submerged logs/ undercut banks/ cobbles provides abundant fish cover • Must not be new or transient	• 30-50% substrate favourable for invertebrate colonisation • Snags/submerged logs/undercut banks/cobbles • Fish cover common • Moderate variety of habitat types. Can consist of some new material	• 10-30% substrate favourable for invertebrate colonisation • Fish cover patchy • 60-90% substrate easily moved by foot • Woody debris rare or may be smothered by sediment	• <10% substrate favourable for invertebrate colonisation • Fish cover rare or absent • Substrate unstable or lacking • Stable habitats lacking or limited to macrophytes
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
9. Periphyton	• Periphyton not evident on hand held substrates (macrophytes, wood etc) or fine sediments	• Periphyton not visible on substrates but obvious to touch	• Periphyton visible • <20% cover of available substrates	• Periphyton obvious and prolific • >20% cover of available substrates
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Total Score ____	NB: Use only means of LB and RB values			

Appendix 2 – In-Stream Structure Fish Passage Evaluation sheet

FISH PASSAGE EVALUATION SHEET FOR IN-STREAM STUCTURES

Date:………………………………..	**Assessor:** ……………………………
NZMS 260 Map:…………………	**Altitude:**……………………………..
GPS co-ordinates: E………………… **N**………………… Accuracy……….	
Site address/location:………………………………………………………..	
Stream name:………………………….	**Catchment:** …………………………..
Stream flow at inspection: Low Normal High	

Structure form: Culvert Concrete slab ford with ….. culverts Dam/weir
Culvert type: Pipe Box Arch Ford Other…………………………...
Construction: Concrete Steel Corrugated iron Plastic Other…………..........
Gradient compared to stream bed: Same Steeper Flatter
Bed material in culvert: Yes No
Typical Bed Material (%): Mud……………. Sand………..   Gravel………… Cobble …………. Boulders ………..
Culvert dimensions (m): Length…………. Diameter………. Velocity(s)…….   Outlet water depth……… Inlet water depth…………… Sediment depth ………….
Longitudinal cross section: Inlet: Flat Pooled Perched   Outlet: Flat Pooled Perched
Water fall estimate for perched culverts (if multiple culverts note maximums only):   Height (m)……….… Undercut length (m)…………
Likely severity of fish passage restriction: None/minimal Low flows Most flows High flows

Stream bed level relative to culvert base: Same Above Below
Stream width relative to culvert: Same Narrower Wider
Stream alignment: Straight in-out Straight in-curved out Curved in-straight out
Bank erosion at culvert ends: Yes No
Photos: Outlet looking upstream with culvert occupying 30-50% of photograph: taken Outlet looking upstream: taken Inlet looking downstream: taken
Other comments:

Appendix 3 – Field Assessment Cover Form Data

Date	Stream/Lake	Location	Easting	Northing	Canopy cover
16/12/2008	Lake Koputara 1,2,3 and Lake Omanu	Between Lakes 2 and 3	2701160	6082850	Open
17/12/2008		Between Lake 3 and Omanu	2701175	6081950	Open
17/12/2008		Just DS of Lake Omanu - Whitebait Creek	2700660	6081140	Open
18/12/2008		Mather farm near piggery - Whitebait Creek	2700415	6080780	Open
17/12/2008		DS of Palmer Rd culvert - Whitebait Creek	2700170	6080225	Partly shaded
18/12/2008		Mather farm pine trees near Foxton Beach - Whitebait Creek	2700160	6079900	Partly shaded
18/12/2008		Just US of Seabury Ave - Whitebait Creek	2700040	6079550	Open
17/12/2008	Lake Papaitonga (Waiwiri Stream)		2696710	6060520	Open
17/12/2008		On Bryants farm	2695800	6061090	Open
17/12/2008		Ryan farm	2694230	6061805	Open
16/12/2008	Lake Horowhenua (Hokio Stream)	~360 m DS of Lake outlet weir opp. cemetery	2699010	6064570	Open
16/12/2008		DS of Moutere Rd bridge	2698675	6064835	Partly shaded
16/12/2008		Opposite tip entrance	2697375	6064725	Partly shaded
16/12/2008		Just outside Hokio Beach town	2696650	6065060	Open
16/12/2008		Hokio Beach footbridge by old school	2695390	6065825	Partly shaded
18/12/2008	Ohau Loop	Ohau Loop ~100 m DS from outlet culvert	2693238	6058543	Open
18/12/2008	Te Hakari Wetlands	Te Hakari at lake outlet	2692895	6057850	Open
18/12/2008		Te Hakari just DS of 2nd culvert	2692750	6057965	Open
22/12/2008	Ohau Dune Lakes	Ohau Dune Lakes at US most crossing	2692475	6056520	Open
22/12/2008		Ohau Dune Lakes at ~50 m US of Waikawa Stream	2692155	6056125	Open
14/01/2009	Lake Koputara	Koputara behind Sexton house	2701300	6086610	Open
14/01/2009		Koputara near raceway bend	2700670	6086530	Open
14/01/2009		Koputara at furtherst DS I could drive	2700325	6086730	Open
14/01/2009		Koputara entrance to pine forest	2699610	6087180	Partly shaded
16/01/2009	Lake Kaikokopu	Kaikokopu at Pedersen boundary	2701524	6089880	Open

16/01/2009		Kaikokopu bridge DS of forestry block	2700785	6090250	Open
16/01/2009		Kaikokopu just DS of town entrance weir	2700425	6090425	Partly shaded
16/01/2009		Kaikokopu US most in MDC reserve	2700125	6090600	Partly shaded
21/01/2009	Omanuka & Pukepuke Lagoons	Omanuka - Pukepuke	2704050	6095540	Open
21/01/2009		Omanuka - Pukepuke on Jaimeson farm	2703825	6095250	Open
15/01/2009		Pukepuke at 1st bridge DS from weir	2701335	6094140	Open
15/01/2009		Pukepuke just DS of broken double culvert	2700440	6094615	Open
15/01/2009		Pukepuke just US of iron bridge	2699890	6094950	Open
22/01/2009	Forest Rd Wetlands	Forest Rd Wetlands US most on Nitschke Farm	2701631	6102800	Partly shaded
22/01/2009		Forest Rd Wetlands at Nitschke - Ferry Farms boundary	2701620	6101925	Partly shaded
22/01/2009		At Ferry Farms main crossing by new shed	2700850	6101285	Open
22/01/2009		Forest Rd Wetlands just DS of old Ferry Farms shed	2701130	6100875	Open
22/01/2009		Forest Rd Wetlands just US of road bridge	2701270	6100115	Open
23/01/2009	Pukemarama Lagoon	Pukemarama between ford and culvert 6	2705700	6099385	Open
23/01/2009		Pukemarama on Rangitikei floodplain bush	2704843	6100135	Significantly shaded
28/01/2009	Knottingly Swamp	Knottingly Swamp just DS of lake	2698585	6113125	Open
28/01/2009		Knottingly Swamp between 1st & 2nd culverts DS of lake	2698085	6113485	Open
28/01/2009		Knottingly Swamp at derelict footbridge DS of 3rd culvert	2697110	6113830	Open
27/01/2009	Lake Koitiata	Koitiata outlet just US of 1st culvert DS of lake	2696785	6118330	Partly shaded
27/01/2009		Koitiata DS of 2nd culvert DS of lake	2696690	6117895	Partly shaded
27/01/2009		Koitiata just US of 2nd footbridge	2695710	6117420	Partly shaded
27/01/2009		Koitiata just DS of 3rd culvert DS of lake	2696410	6117575	Partly shaded
29/01/2009	Artillerie Swamp	Artillerie Swamp at exit of raupo area just DS of lake	2696837	6115935	Significantly shaded
29/01/2009		Artillerie Swamp DS of 1st culvert	2696445	6115760	Open
15/05/2009	Lake Kaitoke	Kaitoke just DS of lake level weir	2686350	6135865	Open
15/05/2009		Kaitoke in 1st trees DS of lake	2685958	6135920	Partly shaded
15/05/2009		Kaitoke with trees on both sides	2685280	6136000	Significantly shaded
15/05/2009		Kaitoke at exit from last patch of pine trees	2684569	6135750	Open

15/05/2009		Kaitoke adjacent to Wanganui airport	2683693	6135395	Open
18/05/2009	Lake Waipu	Waipu in pine forest just DS of lake	2694056	6126330	Partly shaded
18/05/2009		Waipu in iron floc zone	2693727	6125880	Partly shaded
18/05/2009		Waipu at main vehicle crossing	2693375	6125812	Open
18/05/2009		Waipu ~100m US of Turakina River	2693169	6125630	Open
19/05/2009	Lake Wiritoa and Lake Pauri	Wiritoa in 1st pine trees DS of lake	2687730	6134470	Significantly shaded
19/05/2009			2686760	6134720	Open
19/05/2009			2685675	6134680	Open
19/05/2009			2683675	6135150	Open

Field Assessment Cover Form Data continued………

Easting	Northing	Fencing	Dominant riparian vegetation	Stream width (m)	Stream depth (m)	Surface velocity (m/sec)	Turbidity	Embeddedness %	Substratum type %
2701160	6082850	None or ineffective	Pasture	~ 4	< 0.5	0	slighty turbid	<5	sand 100
2701175	6081950	Complete both sides	Pasture	~ 3	> 1	0	no open water to see	<5	sand 100
2700660	6081140	One side or partial	Pasture	~ 4	> 1	< 0.1	slighty turbid	<5	sand 100
2700415	6080780	One side or partial	Pasture/Exotic trees	~ 6	~ 0.4	< 0.1	clear	<5	sand 100
2700170	6080225	Complete both sides	Exotic trees	~ 3	~ 0.3	< 0.1	clear	<5	sand 100
2700160	6079900	Complete both sides	Exotic trees	~ 2.5	~ 0.3	~ 0.2	clear	<5	sand 100
2700040	6079550	One side or partial	Pasture/urban mowed berm	3	< 0.5	< 0.1	clear	<5	sand 100
2696710	6060520	One side or partial	Pasture	4	> 1	0	slightly turbid	<5	sand 100
2695800	6061090	One side or partial	Pasture	~ 2	0.5	< 0.1	slightly turbid	<5	sand 100
2694230	6061805	One side or partial	Pasture	~ 3	no access	0	clear	<5	sand 100
2699010	6064570	None or ineffective	Pasture	~ 6	> 1	< 0.1	slightly turbid	<5	sand 100
2698675	6064835	Complete both sides	Exotic trees	~ 4	~ 0.4	> 0.5	slightly turbid	5 - 25%	40 cobble, 50 gravel, 10 sand
2697375	6064725	One side or partial	Pasture/Exotic trees	~ 6	> 1	< 0.1	slightly turbid	<5	sand 100
2696650	6065060	Complete both sides	Exotic trees, shrubs, raupo, long grass.	~ 5	> 1	< 0.1	slightly turbid	<5	sand 100
2695390	6065825	One side or partial	Exotic trees, retired veg	~ 7	~ 1	> 0.5	slightly turbid	<5	sand 100
2693238	6058543	Complete both sides	Retired veg/pasture	~ 8	> 1	0	no open water to see	<5	sand 100
2692895	6057850	Complete both sides	Retired veg, long grass	~ 3	~ 0.5	0	no open water to see	<5	sand 100
2692750	6057965	Complete both sides	Exotic trees	2	~ 0.15	< 0.1	slightly turbid	<5	sand 100
2692475	6056520	One side or partial	Retired veg, rank grass, scrub	~ 3	> 0.5	< 0.1	clear	<5	sand 100
2692155	6056125	None or ineffective	Pasture (rough	~ 2	~ 0.5	< 0.1	clear	<5	sand 100

			fescue)						
2701300	6086610	One side or partial	Pasture	~5	~1.7	0	no open water to see	<5	sand 100
2700670	6086530	One side or partial	Pasture	3	0.2	0	slightly turbid	<5	sand 100
2700325	6086730	One side or partial	Pasture	3	0.15	0	no open water to see	<5	sand 100
2699610	6087180	None or ineffective	Exotic trees	2	0.27	0	slightly turbid	<5	sand 100
2701524	6089880	Complete both sides	Pasture and scrub	5	~0.4	0.05	slightly turbid	<5	sand 100
2700785	6090250	One side or partial	Exotic trees, retired veg	5	~0.3	~0.15	slightly turbid	<5	sand 100
2700425	6090425	One side or partial	Pasture, native and exotic shrub	5	~0.35	0.1	clear	<5	sand 100
2700125	6090600	Complete both sides	Pasture, exotic trees	3	~0.3	0.05	clear	<5	sand 100
2704050	6095540	Complete both sides	Pasture	3	0.5	0	slightly turbid	<5	sand 100
2703825	6095250	Complete both sides	Pasture	2	~ 0.5	0	slightly turbid	<5	sand 100
2701335	6094140	One side or partial	Pasture	3	0.14	0	slightly turbid	<5	sand 100
2700440	6094615	None or ineffective	Pasture, exotic trees	3	0.52	0	slightly turbid	<5	sand 100
2699890	6094950	Complete both sides	Pasture, exotic trees	4	0.1	~0.15	clear	<5	sand 100
2701631	6102800	One side or partial	Crops, exotic trees	5	0.5	0	stained	<5	sand 100
2701620	6101925	One side or partial	Crops, pasture, exotic trees	5	0.7	0	stained	<5	sand 100
2700850	6101285	Complete both sides	Pasture	6	~0.5	0	slightly turbid	<5	sand 100
2701130	6100875	Complete both sides	Pasture, retired veg	6	0.75	0	slightly turbid	<5	sand 100
2701270	6100115	Complete both sides	Pasture	4	~1	0	highly turbid	<5	sand 100
2705700	6099385	None or ineffective	Pasture	1.5	0.3	0	stained	<5	sand 100
2704843	6100135	None or ineffective	Exotic trees	3	0.1	0 - 0.05	clear	<5	sand 100
2698585	6113125	None or ineffective	Exotic trees	2	0.2	0	no open water to see	<5	sand 100
2698085	6113485	None or ineffective	Exotic trees (small)	3	0	0	dry	<5	sand 100
2697110	6113830	None or ineffective	Exotic trees	2	0	0	dry	<5	sand 100
2696785	6118330	One side or partial	Exotic trees	2.5	0	0	dry	<5	sand 100
2696690	6117895	None or ineffective	Exotic trees, retired	1.8	0	0	dry	<5	sand 100

			veg						
2695710	6117420	None or ineffective	Exotic trees	2	0.25	0	slightly turbid	<5	sand 100
2696410	6117575	None or ineffective	Exotic trees	2	0	0	dry	<5	sand 100
2696837	6115935	None or ineffective	Exotic trees	2	~0.07	~0.1	clear	<5	sand 100
2696445	6115760	None or ineffective	Exotic trees	~2	no access	0	no open water to see	<5	sand 100
2686350	6135865	None or ineffective	Pasture	4	0.45	~0.3	highly turbid	<5	sand 100
2685958	6135920	One side or partial	Exotic trees, retired vegetation	~3	~0.3	0.3	highly turbid	<5	sand 100
2685280	6136000	Complete both sides	Exotic trees	3	0.26	~0.3	slightly turbid	<5	sand 100
2684569	6135750	None or ineffective	Retired vegetation and scrub	3	0.4	~0.4	slightly turbid	<5	sand 100
2683693	6135395	None or ineffective	Pasture	3	0.45	0.4	slightly turbid	<5	sand 100
2694056	6126330	None or ineffective	Exotic trees	5	>0.5	0	highly turbid	<5	sand 100
2693727	6125880	None or ineffective	Exotic trees, pasture	1.5	0.12	~0.01	clear	<5	sand 100
2693375	6125812	None or ineffective	Pasture	4	0.15	0	clear	<5	sand 100
2693169	6125630	None or ineffective	Pasture, exotic trees	1	~0.25	0.1	clear	<5	sand 100
2687730	6134470	None or ineffective	Exotic trees	2	0	0	dry	<5	sand 100
2686760	6134720	None or ineffective	Pasture	~3	0	0	dry	<5	sand 100
2685675	6134680	None or ineffective	Pasture	2	0.1	0	clear	<5	sand 100
2683675	6135150	None or ineffective	Pasture and scrub	2.5	0.15	~0.2	clear	<5	sand 100

Field Assessment Cover Form Data continued………

		Organic Material			Instream plant cover %			Comments
Easting	Northing	% Large wood	% Coarse detritus	% Fine organic deposits	Filamentous algae	Macrophytes	Mosses/ Liverworts	
2701160	6082850	<5	<5	<5	<5	>75	<5	Totally overgrown with parsnip weed, water surface not visible
2701175	6081950	<5	<5	<5	<5	>75	<5	Channel between Koputara 3 and Omanu. Covered in duckweed, no open water. Raupo on right bank.
2700660	6081140	<5	<5	<5	<5	>75	<5	Pine hedge on left bank
2700415	6080780	<5	<5	<5	<5	>75	<5	Owners refer to it as "Whitebait Creek". No culverts on Mathers Ds of Lake Omanu outlet. The 3 on aerials are bridges.
2700170	6080225	<5	<5	<5	<5	26 - 50	<5	Shallow sandy channel. School of ~100 juvenile inanga sighted swimming US
2700160	6079900	<5	<5	<5	<5	26 - 50	<5	Amongst a patch of pine trees. More open water than other Mather farm sites.
2700040	6079550	<5	<5	<5	<5	>75	<5	Water surface totally obscured by wild parsnip.
2696710	6060520	<5	<5	<5	<5	>75	<5	Pasture
2695800	6061090	<5	<5	<5	<5	>75	<5	Grass and some flax on edges
2694230	6061805	<5	<5	<5	<5	>75	<5	Grass and some flax on edges. Wild parsnip chokes channel. Just Ds of Levin poo land discharge forest.
2699010	6064570	<5	<5	<5	<5	>75	<5	Non-wadeable. Covered in macrophytes. Can't see stream bottom.
2698675	6064835	<5	<5	5 - 25	<5	<5	<5	In "canyon". Quite swfit with hard substrata. Very different to all other Hokio sites visited.
2697375	6064725	<5	<5	<5	<5	>75	<5	Can't access stream side. Patchy willows, raupo, rank long grass and bracken. Minimal flow visible.
2696650	6065060	<5	<5	<5	<5	51 - 75	<5	Murky, raupo, small willow, rank long grass. Right next to road.
2695390	6065825	<5	<5	<5	<5	>75	<5	Failrly swift. Abundant macrophytes mostly Potamogeton sp. Some riparian pines, willows, cabbage trees, flax and rank long grass.
2693238	6058543	<5	<5	<5	<5	>75	<5	Pond conditions. Choked with reeds, wild parsnip. Any open water covered in duck weed. Raupo in channel DS
2692895	6057850	<5	<5	<5	<5	>75	<5	Overgrown with rushes, duckweed covers any open areas.
2692750	6057965	>75	5 - 25	<5	<5	26 - 50	<5	Very near Ohau estuary. Wood possibly shunted US by storms and/or high tides.

2692475	6056520	<5	<5	<5	<5	>75	<5	Raupo swamp just upstream
2692155	6056125	<5	5 – 25	<5	<5	>75	<5	Paddock of very rough pasture (fescue). Dozens of inanga seen.
2701300	6086610	<5	<5	<5	<5	>75	<5	No open water. Macrophytes and duckweed.
2700670	6086530	<5	<5	<5	5 - 25	>75	<5	Minimal open water. Stock have access along cattle race. Evidence of channel clearing/dredging.
2700325	6086730	<5	<5	<5	<5	>75	<5	Totally choked with wild parsnip
2699610	6087180	<5	<5	<5	<5	>75	<5	Totally overgrown by wild parsnip. Channel narrows.
2701524	6089880	<5	<5	<5	5 - 25	26 - 50	<5	Shallow and sluggish with a clear sandy bottom visible.
2700785	6090250	<5	<5	<5	26 - 50	>75	<5	Mostly covered in duckweed. Open water has visible flow.
2700425	6090425	<5	<5	<5	26 - 50	51 - 75	<5	After weir, the stream resumes sluggish nature. Duckweed abundant. Some patches of open water with clear sand visible.
2700125	6090600	<5	<5	<5	26 - 50	26 - 50	<5	Bits of junk instream (i.e. couch, office chair, wooden pallet, corrugated iron)
2704050	6095540	<5	<5	<5	<5	>75	<5	Overgrown, minimal openwater.
2703825	6095250	<5	<5	<5	<5	>75	<5	Just US of boardwalk to little pond on Jaimeson farm. Choked with macrophytes.
2701335	6094140	<5	<5	<5	<5	>75	<5	No visible water movement. No open water, lots of duckweed and macrophytes.
2700440	6094615	<5	<5	<5	<5	>75	<5	Choked with macrophytes.
2699890	6094950	<5	<5	<5	26 - 50	26 - 50	<5	More open water than US. Flow visible. Schools of inanga abundant. Wild parsnip along edges.
2701631	6102800	<5	<5	<5	<5	>75	<5	Very little open water. Lots of duckweed and wild parsnip.
2701620	6101925	<5	<5	<5	<5	>75	<5	Choked with wild parsnip and duckweed. Orange scum on surface.
2700850	6101285	<5	<5	<5	<5	>75	<5	Mostly covered in wild parsnip and duckweed.
2701130	6100875	<5	<5	<5	<5	>75	<5	Some open water. Some parts choked by wild parsnip.
2701270	6100115	<5	<5	<5	<5	>75	<5	Fair bit of open water but murky and can't see bottom. Duckweed abundant.
2705700	6099385	<5	<5	<5	<5	>75	<5	Filled with pasture grass right across channel. No fences. First wetted channel DS of lake.
2704843	6100135	26 - 50	5 - 25	<5	<5	5 - 25	<5	Willow, toitoi, blackberry. Difficult veg to move through with some toitoi thickets. Abundant Potamopyrgus and Amphipoda.

2698585	6113125	<5	<5	<5	<5	>75	<5	Channel totally choked with macrophytes, especially wild parsnip.
2698085	6113485	<5	<5	<5	<5	>75	<5	Dry. Channel choked with wild parsnip.
2697110	6113830	<5	<5	<5	<5	>75	<5	Dry. Channel totally covered in wild parsnip and grasses.
2696785	6118330	<5	5 - 25	<5	<5	<5	<5	Dry. Channel filled with grass, dock and other broadleaf herbage.
2696690	6117895	<5	5 - 25	<5	<5	<5	<5	Dry. Channel grassed. Next to some tussock in a clearing.
2695710	6117420	<5	<5	<5	<5	>75	<5	Channel choked with wild parsnip.
2696410	6117575	<5	<5	<5	<5	<5	<5	Dry. Channel grass and bare sand.
2696837	6115935	<5	<5	<5	<5	<5	<5	Covered in orange scum. Maybe iron floc. Shaded by exotic trees. Inanga sighted.
2696445	6115760	<5	<5	<5	<5	>75	<5	Totally covered in wild parsnip. Too thick to measure depth.
2686350	6135865	<5	<5	<5	<5	>75	<5	Unfenced. Stock trampling evident. Stock keep macrophytes eaten down.
2685958	6135920	<5	<5	<5	<5	51- 75	<5	A few patches of small willows.
2685280	6136000	5 - 25	5 - 25	<5	<5	<5	<5	Pine trees both sides. Clear sandy bottom.
2684569	6135750	<5	<5	<5	<5	26 – 50	<5	Watercress and grass in channel.
2683693	6135395	<5	<5	<5	<5	26 - 50	<5	Gorse and lupin patches in riparian zone.
2694056	6126330	<5	<5	<5	<5	51 - 75	<5	Patches of open water and duckweed.
2693727	6125880	<5	<5	<5	<5	<5	<5	Few bits of grass in iron floc filled channel.
2693375	6125812	<5	<5	<5	<5	>75	<5	Wide and shallow. Very little open water mostly covered in grass, duckweed and watercress.
2693169	6125630	<5	<5	<5	5 - 25	>75	<5	Start of channelised section before entering Turakina River. US is a wide (~10m) indistinct boggy channel.
2687730	6134470	5 - 25	>75	<5	<5	<5	<5	Dry channel with pine needles. Doesn’t look like it has flowed for some time.
2686760	6134720	<5	>75	<5	<5	<5	<5	Dry channel. Pasture growing in channel. A few willows on edges.
2685675	6134680	<5	<5	<5	<5	>75	<5	Filled with grass, some watercress and other wet-loving plants.
2683675	6135150	<5	<5	<5	<5	51 - 75	<5	Water cress, duckweed and grass.

Qualitative Habitat Assessment Scores

Date	Stream/Lake	Easting	Northing	1. Riparian Veg Zone Width (LB and RB means)	2. Veg Protection (LB and RB means)	3. Bank stability (LB and RB means)	4. Channel sinuosity
16/12/2008	Lake Koputara 1,2,3 and Lake Omanu	2701160	6082850	1	2	18	12
17/12/2008		2701175	6081950	4	7	18	4
17/12/2008		2700660	6081140	7.5	5	12	4
18/12/2008		2700415	6080780	10	6	17.5	5
17/12/2008		2700170	6080225	14	9.5	18	5
18/12/2008		2700160	6079900	17.5	10	9.5	9
18/12/2008		2700040	6079550	9	7	19	5
17/12/2008	Lake Papaitonga (Waiwiri Stream)	2696710	6060520	1	3	18	8
17/12/2008		2695800	6061090	7	5	17	8
17/12/2008		2694230	6061805	5	5	19	8
16/12/2008	Lake Horowhenua (Hokio Stream)	2699010	6064570	2	4	18	8
	This is the single site that had a hard-bottom thus the hard-bottomed assessment form was used. This has two different assessment categories than the soft- bottom form.			1. Riparian Veg Zone Width (LB and RB means)	2. Veg Protection (LB and RB means)	3. Bank stability (LB and RB means)	4. Frequency of riffles
16/12/2008		2698675	6064835	13	9	18	9
				1. Riparian Veg Zone Width (LB and RB means)	2. Veg Protection (LB and RB means)	3. Bank stability (LB and RB means)	4. Channel sinuosity
16/12/2008		2697375	6064725	13	9	19	9
16/12/2008		2696650	6065060	16	10	19	13
16/12/2008		2695390	6065825	13	8	19	7
18/12/2008	Ohau Loop	2693238	6058543	13	4	19	6

18/12/2008	Te Hakari Wetlands	2692895	6057850	15	5	19	7
18/12/2008		2692750	6057965	17	10	19	6
22/12/2008	Ohau Dune Lakes	2692475	6056520	11	4.5	18	6
22/12/2008		2692155	6056125	5	5	18	6
14/01/2009	Lake Koputara	2701300	6086610	6.5	5	18	2
14/01/2009		2700670	6086530	1	1.5	13	7
14/01/2009		2700325	6086730	2	5	19	6
14/01/2009		2699610	6087180	10	8	8	7
16/01/2009	Lake Kaikokopu	2701524	6089880	12	5	18	7
16/01/2009		2700785	6090250	18.5	8	18	5
16/01/2009		2700425	6090425	15	7	18.5	8
16/01/2009		2700125	6090600	16.5	7.5	15	6
21/01/2009	Omanuka & Pukepuke Lagoons	2704050	6095540	16	5	13	10
21/01/2009		2703825	6095250	13	4	19	10
15/01/2009		2701335	6094140	14	4	19	5
15/01/2009		2700440	6094615	19	14	12	2
15/01/2009		2699890	6094950	19	14	18	5
22/01/2009	Forest Rd Wetlands	2701631	6102800	12.5	7.5	19	2
22/01/2009		2701620	6101925	16	10.5	19	8
22/01/2009		2700850	6101285	13	5	19	5
22/01/2009		2701130	6100875	11.5	5	19	7
22/01/2009		2701270	6100115	13	4	19	4
23/01/2009	Pukemarama Lagoon	2705700	6099385	1	2	19	6
23/01/2009		2704843	6100135	20	10	19	9
28/01/2009	Knottingly Swamp	2698585	6113125	19	5	20	4
28/01/2009		2698085	6113485	19	5	20	7
28/01/2009		2697110	6113830	20	5	20	6

27/01/2009	Lake Koitiata	2696785	6118330	18	11	19	8
27/01/2009		2696690	6117895	18	12	18	7
27/01/2009		2695710	6117420	18	14	19	7
27/01/2009		2696410	6117575	18	14	19	7
29/01/2009	Artillerie Swamp	2696837	6115935	19	14	8	11
29/01/2009		2696445	6115760	19	13	19	7
15/05/2009	Lake Kaitoke	2686350	6135865	3	2	8	10
15/05/2009		2685958	6135920	14	10.5	6	8
15/05/2009		2685280	6136000	17	14	15	13
15/05/2009		2684569	6135750	8	5	13	13
15/05/2009		2683693	6135395	2	3	9	16
18/05/2009	Lake Waipu	2694056	6126330	12	14	11	13
18/05/2009		2693727	6125880	7	6	9	11
18/05/2009		2693375	6125812	2	2	13	10
18/05/2009		2693169	6125630	2	2	8	8
19/05/2009	Lake Wiritoa and Lake Pauri	2687730	6134470	8	14	16	11
19/05/2009		2686760	6134720	5	3	16	7
19/05/2009		2685675	6134680	6	4	9	5
19/05/2009		2683675	6135150	3	2	10	11

Easting	Northing	5. Channel alteration	6. Sediment deposition	7. Pool variability	8. Abundance and Diversity of Habitat	9. Periphyton
2701160	6082850	17	18	9	4	10
2701175	6081950	11	17	11	4	16
2700660	6081140	17	18	5	3	10
2700415	6080780	17	18	4	5	16
2700170	6080225	17	18	4	5	8
2700160	6079900	18	16	4	5	9
2700040	6079550	16	18	5	5	16
2696710	6060520	17	19	13	4	7
2695800	6061090	18	17	13	4	7
2694230	6061805	18	18	11	4	16
2699010	6064570	16	18	11	3	16
		5. Channel alteration	6. Sediment deposition	7. Velocity/ Depth regimes	8. Abundance and Diversity of Habitat	9. Periphyton
2698675	6064835	18	18	14	12	13
		5. Channel alteration	6. Sediment deposition	7. Pool variability	8. Abundance and Diversity of Habitat	9. Periphyton
2697375	6064725	19	19	12	4	18
2696650	6065060	19	19	12	5	16
2695390	6065825	18	19	11	4	16
2693238	6058543	15	19	11	5	16
2692895	6057850	14	19	9	5	18
2692750	6057965	16	16	5	14	15
2692475	6056520	17	17	7	5	14
2692155	6056125	16	19	5	4	10

2701300	6086610	13	19	13	4	16
2700670	6086530	9	18	8	5	10
2700325	6086730	14	19	6	4	13
2699610	6087180	16	19	7	5	10
2701524	6089880	13	19	7	5	8
2700785	6090250	16	18	10	5	5
2700425	6090425	16	19	6	5	8
2700125	6090600	16	19	6	5	5
2704050	6095540	16	18	3	5	15
2703825	6095250	17	19	4	4	16
2701335	6094140	13	18	3	4	16
2700440	6094615	14	19	3	3	16
2699890	6094950	14	19	3	3	6
2701631	6102800	13	19	8	5	16
2701620	6101925	16	18	7	5	16
2700850	6101285	16	19	10	5	16
2701130	6100875	16	19	11	5	16
2701270	6100115	13	19	14	5	16
2705700	6099385	16	16	2	3	16
2704843	6100135	19	18	2	4	16
2698585	6113125	19	19	0	4	19
2698085	6113485	19	19	0	4	0
2697110	6113830	19	19	0	5	0
2696785	6118330	18	18	0	3	0
2696690	6117895	18	18	0	4	0
2695710	6117420	19	19	3	4	17
2696410	6117575	18	18	0	4	0
2696837	6115935	19	18	5	2	16

2696445	6115760	19	19	8	5	20
2686350	6135865	16	18	4	5	10
2685958	6135920	18	18	2	5	11
2685280	6136000	18	18	5	3	18
2684569	6135750	18	18	3	5	16
2683693	6135395	18	18	3	4	16
2694056	6126330	16	18	4	3	16
2693727	6125880	16	18	2	2	14
2693375	6125812	15	18	2	2	10
2693169	6125630	12	18	2	2	9
2687730	6134470	18	18	0	1	0
2686760	6134720	15	18	0	1	0
2685675	6134680	14	18	2	2	9
2683675	6135150	18	18	2	2	16

Appendix 4 – In-stream Structures

Date assessed	Easting	Northing	Stream name	Site location	Stream flow at inspection
16/12/2008	2701390	6083550	Lake Koputara 1,2,3 and Lake Omanu	Koputara 2 outlet	Normal
16/12/2008	2701080	6083020		Between Lakes 2 and 3	Normal
17/12/2008	2701160	6081615		Johnston cow crossing	Normal
17/12/2008	2700690	6081170		Lake Omanu outlet	Normal
17/12/2008	2700175	6080260		Palmer Rd culvert	Normal
18/12/2008	2700070	6079630		Edinburgh Tce culvert	Normal
18/12/2008	2700040	6079520		Seabury Ave culvert	Normal
17/12/2008	2697580	6060025	Lake Papaitonga (Waiwiri Stream)	Lake level weir	Normal
17/12/2008	2697565	6060035		Farm track culvert by outlet weir	Normal
17/12/2008	2697485	6060055		Just Ds from farm track culvert	Normal
17/12/2008	2696710	6060520			Normal
16/12/2008	2699250	6064335	Lake Horowhenua (Hokio Stream)	Lake Horowhenua lake level weir at Hokio outlet	High
18/12/2008	2693340	6058571	Ohau Loop	Ohau Loop outlet cow crossing	Normal
not assessed				Ohau Loop flood gated culvert	not assessed
18/12/2008	2692765	6057940	Te Hakari Wetland	Te Hakari - lake level weir	Normal
18/12/2008	2692865	6058860		Te Hakari - US most culvert	Normal
18/12/2008	2692760	6057965		Te Hakari - DS culvert ~10 m DS of lake level weir.	Normal
22/12/2008	2692460	6056400	Ohau Dune Lakes Wetlands	Ohau Dune Lakes 2nd culvert US of Waikawa Stream	Normal
22/12/2008	2692480	6056500		Ohau Dune Lakes 3rd culvert US of Waikawa Stream	Normal
13/01/2009	2692120	6056125		Ohau Dune Lakes capped outlet 1st culvert US of Waikawa Stream	Tidal
14/01/2009	2701465	6086645	Lake Koputara	Koputara outlet US of weir	Normal
14/01/2009	2701380	6086675		Koputara lake level weir behind Sexton house	Normal
14/01/2009	2701270	6086585		Koputara vehicle crossing by Sexton house	Normal
14/01/2009	2701070	6086440		Koputara by ford	Normal

16/01/2009	2700435	6090410	Lake Kaikokopu	Kaikokopu weir just at town entrance	Normal
21/01/2009	2707350	6094850	Omanuka – Pukepuke Lagoons	Omanuka just DS of lake	Dry
21/01/2009	2706630	6094850		Omanuka	Dry
21/01/2009	2704980	6095655		Omanuka	Normal
21/01/2009	2704065	6095545		Omanuka	Normal
21/01/2009	2703480	6094370		Omanuka near Pukepuke	Normal
18/05/2009	2701605	6094225		Pukepuke lake level weir	Normal
15/01/2009	2700575	6094545		Pukepuke old weir structure	Normal
15/01/2009	2700510	6094590		Pukepuke just DS of old weir structure	Normal
22/01/2009	2701631	6102800	Forest Rd Wetlands	Forest Rd Wetlands US most crossing on Nitschke Farm	Normal
22/01/2009	2701060	6101725		Forest Rd Wetlands US of new shed F	Normal
22/01/2009	2701110	6101770		Forest Rd Wetlands US of new shed G	Normal
22/01/2009	2701005	6101675		Forest Rd Wetlands US of new shed E	Normal
22/01/2009	2700805	6101265		Forest Rd Wetlands at main race by new shed	Normal
22/01/2009	2700660	6101100		Forest Rd Wetlands near new shed	Normal
22/01/2009	2700700	6101050		Forest Rd Wetlands near new shed C	Normal
22/01/2009	2700775	6101025		Forest Rd Wetlands near new shed B	Normal
22/01/2009	2700855	6100990		Forest Rd Wetlands adjacent to new shed A	Normal
22/01/2009	2701230	6100025		Forest Rd Wetlands floodgate at stopbank	Normal
23/01/2009	2707185	6098690	Pukemarama Lagoon	Pukemarama at lake outlet	Dry
23/01/2009	2706695	6098990		Pukemarama 2nd culvert DS of outlet	Dry
23/01/2009	2706345	6099000		Pukemarama 3rd culvert DS of outlet	Dry
23/01/2009	2706210	6099095		Pukemarama 4th culvert DS of outlet	Dry
23/01/2009	2706185	6099110		Pukemarama 5th culvert DS of outlet	Dry
23/01/2009	2705695	6099430		Pukemarama 6th culvert DS of outlet	Low
23/01/2009	2705505	6099610		Pukemarama on Tangimoana Rd (7th culvert DS of outlet)	Dry
28/01/2009	2698570	6113175	Knottingly Swamp	Knottingly Swamp 1st culvert DS of lake	Normal
28/01/2009	2697835	6113535		Knottingly Swamp 2nd culvert DS of lake	Dry
28/01/2009	2697385	6113775		Knottingly Swamp 3rd culvert DS of lake	Low
27/01/2009	2696775	6118305	Lake Koitiata	Koitiata 1st culvert DS of lake	Dry

27/01/2009	2696690	6118895		Koitiata 2nd culvert DS of lake	Dry
27/01/2009	2696435	6117575		Koitiata 3rd culvert DS of lake	Dry
27/01/2009	2695600	6117385		Koitiata 4th culvert DS of lake	Dry
29/01/2009	2696865	6115900	Artillerie Swamp	Artillerie Swamp near lake	Normal
29/01/2009	2696622	6115970		Artillerie Swamp 1st culvert DS of lake	Normal
15/05/2009	2686420	6135865	Lake Kaitoke (Kaitoke Stream)	Kaitoke lake level weir	Normal
18/05/2009	2694005	6126610	Lake Waipu	Lake Waipu dam	Dry
18/05/2009	2693435	6125855		Waipu culvert just US of main vehicle crossing	Normal
18/05/2009	2693380	6125820		Waipu main vehicle crossing	Normal
18/05/2009	2693100	6125600		Waipu fresh vehicle crossing cutting just US of Turakina River	Normal
19/05/2009	2688940	6134162	Lake Wiritoa and Lake Pauri	Wiritoa - Pauri connection	Normal
19/05/2009	2688013	6134473		Wiritoa outlet culvert	Dry
19/05/2009	2687415	6134610		Wiritoa 2nd culvert DS of lake	Dry
19/05/2009	2686760	6134615		Wiritoa weir few hundred metres US of start of wetted channel	Dry
19/05/2009	2684520	6135125		Wiritoa dam culvert	Normal
19/05/2009	2683645	6135135		Wiritoa culvert just US of Kaitoke Stream confluence	Normal

In-stream Structures continued……….

Easting	Northing	Structure form	Culvert type	Construction	Gradient	Bed material in culvert	Typical bed material (mud:sand:gravel: cobble:boulder)
2701390	6083550	Weir	Weir	Concrete	NA	NA	0:100:0:0:1
2701080	6083020	Culvert	Pipe	Corrugated iron	same	no	0:100:0:0:0
2701160	6081615	Culvert	Pipe	Concrete	same	no access	0:100:0:0:0
2700690	6081170	Culvert (triple)	Pipe	Concrete	same	no	0:100:0:0:0
2700175	6080260	Culvert	Pipe	Corrugated iron	same	yes	0:100:0:0:0
2700070	6079630	Culvert	Pipe	Corrugated iron	same	yes	0:100:0:0:0
2700040	6079520	Culvert	Pipe (1/2 circle)	Corrugated iron	same	no	0:100:0:0:0
2697580	6060025	Weir	Weir	? Overgrown	NA	NA	0:100:0:0:0
2697565	6060035	Culvert	Pipe	Concrete	same	no	0:100:0:0:0
2697485	6060055	Culvert	Pipe	Concrete	same	no	0:100:0:0:0
2696710	6060520	Culvert	Pipe	Concrete	same	no access	0:100:0:0:0
2699250	6064335	Weir	Weir	NA	NA	NA	0:100:0:0:0
2693340	6058571	Culvert	Pipe	Concrete	same	No	0:100:0:0:0
		Culvert	Pipe (flood gated)	Concrete	probably same	?	0:100:0:0:0 probably
2692765	6057940	Weir	Weir		NA	NA	0:100:0:0:0
2692865	6058860	Culvert	Pipe	Concrete	same	No	0:100:0:0:0
2692760	6057965	Culvert	Pipe	Concrete	same	?	0:100:0:0:0
2692460	6056400	Culvert	Pipe	? Probably plastic	same	?	0:100:0:0:0
2692480	6056500	Culvert	Pipe	Plastic	same	No	0:100:0:0:0
2692120	6056125	Culvert	Pipe	Concrete	same	?	0:100:0:0:1
2701465	6086645	Culvert	Pipe	Concrete	same	?	0:100:0:0:0
2701380	6086675	Weir	Weir	NA	NA	NA	0:100:0:0:0

2701270	6086585	Culvert	Pipe	Corrugated iron	same	No	0:100:0:0:0
2701070	6086440	Culvert	Pipe	Concrete	same	yes	0:100:0:0:0
2700435	6090410	Weir	Weir	Wood	NA	NA	0:100:0:0:0
2707350	6094850	Culvert	Pipe	Concrete	same	No	0:100:0:0:0
2706630	6094850	Culvert	Pipe	Concrete	same	No	0:100:0:0:0
2704980	6095655	Culvert	Pipe	Corrugated iron	same	No	0:100:0:0:0
2704065	6095545	Culvert	Pipe	Corrugated iron	same	No	0:100:0:0:0
2703480	6094370	Culvert	Pipe	Concrete	same	No	0:100:0:0:0
2701605	6094225	Weir	Weir	Concrete & wood	NA	NA	0:100:0:0:0
2700575	6094545	Weir	Weir	Concrete	NA	NA	0:100:0:0:0
2700510	6094590	Culvert (double)	Pipe	Concrete	same (steeper - broken section)	No	0:50:0:50:0
2701631	6102800	Culvert	Pipe	Concrete	same	no	0:100:0:0:0
2701060	6101725	Culvert	Pipe	Concrete	same	no	0:100:0:0:0
2701110	6101770	Culvert	Pipe	Concrete	same	no	0:100:0:0:0
2701005	6101675	Culvert	Pipe	Concrete	same	no	0:100:0:0:0
2700805	6101265	Culvert	Pipe	Concrete (new), Corrugated iron (x2 older)	same	yes	0:100:0:0:0
2700660	6101100	Culvert	Pipe	concrete	same	no	0:100:0:0:0
2700700	6101050	Culvert	Pipe	concrete	same	no	0:100:0:0:0
2700775	6101025	Culvert	Pipe	concrete	same	no	0:100:0:0:0
2700855	6100990	Culvert	Pipe	corrugated iron	same	no	0:100:0:0:0
2701230	6100025	Culvert & floodgate	Pipe	concrete	same	?	0:100:0:0:0
2707185	6098690	Culvert	Pipe	concrete	same	no	0:100:0:0:0
2706695	6098990	Culvert	Pipe	concrete	same	no	0:100:0:0:0
2706345	6099000	Culvert	Pipe	concrete	same	no	0:100:0:0:0
2706210	6099095	Culvert	Pipe	concrete	same	no	0:100:0:0:0

2706185	6099110	Culvert	Pipe	plastic	same	yes	0:100:0:0:0
2705695	6099430	Culvert	Pipe	concrete	same	no	0:100:0:0:0
2705505	6099610	Culvert	Pipe	concrete	same	no	0:100:0:0:0
2698570	6113175	Culvert	Pipe	wood	same	no	0:100:0:0:0
2697835	6113535	Culvert	Pipe (double)	Plastic	same	no	0:100:0:0:0
2697385	6113775	Culvert	Pipe	Plastic	same	no	0:100:0:0:0
2696775	6118305	Culvert	Pipe	Concrete	same	no	0:100:0:0:0
2696690	6118895	Culvert	Pipe	Concrete	same	no	0:100:0:0:0
2696435	6117575	Culvert	Pipe (double)	Concrete	same	no	0:100:0:0:0
2695600	6117385	Culvert	Pipe	Corrugated iron	same	yes	0:100:0:0:0
2696865	6115900	Natural fall	Fall	Sand and vegetation	NA	NA	0:100:0:0:0
2696622	6115970	Culvert	Pipe	Concrete	same	no	0:100:0:0:0
2686420	6135865	Weir	Weir	Wood and concrete	NA	NA	0:100:0:0:0
2694005	6126610	Dam	Pipe (double)	Concrete/plastic	same	no	0:100:0:0:0
2693435	6125855	Culvert	Pipe	Concrete	same	no	0:100:0:0:0
2693380	6125820	Culvert	Pipe	Plastic	same	no	0:100:0:0:0
2693100	6125600	Drop created by earthworks	NA	NA	NA	NA	mudstone (papa) bedrock
2688940	6134162	Culvert	Pipe	Concrete	same	yes	0:100:0:0:0
2688013	6134473	Culvert	Pipe	Concrete	same	yes	0:100:0:0:0
2687415	6134610	Culvert	Box	Concrete	same	no	0:100:0:0:0

2686760	6134615	Weir	Weir	Steel with wood top	NA	NA	0:100:0:0:0
2684520	6135125	Culvert	Pipe	Steel	flatter	no	0:100:0:0:0
2683645	6135135	Culvert	Pipe	Concrete	same	yes	0:100:0:0:0

Easting	Northing	Culvert dimensions (m)					Cross section		If Perched (m)	
		length	diameter	outlet water depth	inlet water depth	sediment depth	Inlet	Outlet	Height	Undercut length
2701390	6083550	width: ~1.5	NA	0.18	0	NA	Dry	Pooled (slight perch)	0.1	0
2701080	6083020	6	0.87	0.37	0.29	0	Pooled	Pooled	NA	NA
2701160	6081615	~ 5	~ 1	~ 0.4	? No access	?	Pooled	Pooled	NA	NA
2700690	6081170	~ 5	0.93	> 0.5	0.35	0	Pooled	Pooled	NA	NA
2700175	6080260	19	1.5	0.3	0.42	~0.7	Flat	Flat	NA	NA
2700070	6079630	~ 22	1.1	0.3	0.35	?	Pooled	Pooled	NA	NA
2700040	6079520	~ 20	1.08	0.05	0.2	0	Pooled	Flat	NA	NA
2697580	6060025	width: > 2	NA	?	?	NA	Pooled	Perched	~0.5	NA
2697565	6060035	~ 6	0.5	0.12	no access	0	Pooled	Pooled	NA	NA
2697485	6060055	5	0.9	0.09	no access	0	Flat	Flat	NA	NA
2696710	6060520	5	~ 0.8	~ 0.4	~ 0.4	?	Pooled	Pooled	NA	NA
2699250	6064335	underwater by 0.3 - 0.4 m at visit		Pooled	Pooled	NA	NA	NA	NA	NA
2693340	6058571	7.5	1.2	0.7	0.6		Pooled	Pooled	NA	NA
		?	~1.2	?	?	?	Pooled	Pooled	NA	NA
2692765	6057940									
2692865	6058860	~ 7.5	0.6	0.29	0.33		Pooled	Pooled	NA	NA
2692760	6057965	~ 5	0.35	0.25	0.25	?	Pooled	Pooled	NA	NA
2692460	6056400	? Maybe 10	? Maybe 0.48	?	?	?	Pooled	Pooled	NA	NA
2692480	6056500	10	0.48	0.36	0.34		Pooled	Pooled	NA	NA
2692120	6056125	~ 7	0.5	underwater	0.33	?	Pooled	Pooled	NA	NA
2701465	6086645	~ 6	~ 2	>1	>1	?	Pooled	Pooled	NA	NA

2701380	6086675	width: ~8	NA	0.65	0.34	NA	Pooled	Pooled (slight perch)	0.1	0
2701270	6086585	6	0.6	0.04	0.09	NA	Flat	Flat	NA	NA
2701070	6086440	5.1	1	0.3	0.2	0.2	Flat	Flat	NA	NA
2700435	6090410	width: 5.3	NA	0.07	0.43	NA	Pooled	Perched	0.25 - 0.67	NA
2707350	6094850	4	0.6	0	0	NA	Dry	Dry	NA	NA
2706630	6094850	4	1	0	0	NA	Dry	Dry	NA	NA
2704980	6095655	10	0.6	0.5	0.7	NA	Pooled	Pooled	NA	NA
2704065	6095545	6	1.1	0.25	0.34	NA	Pooled	Pooled	NA	NA
2703480	6094370	6	1	0.35	0.2	NA	Pooled	Pooled	NA	NA
2701605	6094225	width: 5.5	NA	0.09	0.4	NA	Flat	Flat	NA	NA
2700575	6094545	width: 5.3 wetted:~2.5	NA	0.02	0.25	NA	Pooled	Perched	0.19	0
2700510	6094590	~6	1	~0.05	0.13	0	Flat	Flat (would be perched if pipe wasn't snapped)	0	0
2701631	6102800	5	1.4	0.4	0.35	0	Pooled	Pooled	NA	NA
2701060	6101725	5	1.27	~0.7	~0.7	0	Pooled	Pooled	NA	NA
2701110	6101770	5	~1.2	~0.7	~0.7	0	Pooled	Pooled	NA	NA
2701005	6101675	5	1.2	0.7	0.7	0	Pooled	Pooled	NA	NA
2700805	6101265	~14	corrugated iron: half rounds 0.8 high	0.35	?	?	Pooled	Pooled	NA	NA
2700660	6101100	~5	1.2	0.8	0.9	0	Pooled	Pooled	NA	NA
2700700	6101050	5	1.6	0.8	1.2	0	Pooled	Pooled	NA	NA
2700775	6101025	5	1.2	0.8	0.9	0	Pooled	Pooled	NA	NA
2700855	6100990	6.5	1.55	0.7	0.7	0	Pooled	Pooled	NA	NA
2701230	6100025	~15	1.55	1	1	0	Pooled	Pooled	NA	NA

2707185	6098690	3	0.75	0	0	0	Flat	Flat	NA	NA
2706695	6098990	4	0.75	0	0	0	Flat	Flat	NA	NA
2706345	6099000	4	0.6	0	0	0	Flat	Flat	NA	NA
2706210	6099095	4	0.45	0	0	0	Flat	Flat	NA	NA
2706185	6099110	6	0.5	0	0	0	Flat	Flat	NA	NA
2705695	6099430	4.5	0.9	0.19	0.19	0	Pooled	Pooled	NA	NA
2705505	6099610	~13	0.9	0	0	0	Flat	Flat	NA	NA
2698570	6113175	~8	0.45	0.45	0.04	0	Flat	Pooled	NA	NA
2697835	6113535	10.5	0.4/0.4	0	0	0	Flat	Perched	0/0.35	0/0.07
2697385	6113775	~5	0.4	0.25	0.15	0	Flat	Pooled	NA	NA
2696775	6118305	12	0.45	0	0	0	Flat	Perched	0.44	0.91
2696690	6118895	7.5	0.7	0	0	0	Flat	Perched	0.17	0.75
2696435	6117575	12	0.3/0.45	0	0	0	Flat	Perched	0.1/0.33	0.92/0.48
2695600	6117385	6	1	0	0	~0.1	Flat	Flat	NA	NA
2696865	6115900	width: 0.5	NA	0.4	0.03	NA	Flat	Perched	0.25	0
2696622	6115970	15	1.8	0.15	0.75	0.05	Pooled	Flat	NA	NA
2686420	6135865	width: 0.4	NA	0.67	0.45	0	Flat	Perched	0.25	0
2694005	6126610	~13	0.7/0.4	0	0	0	Flat	Flat	NA	NA
2693435	6125855	7.5	1.25	0.1	0	0	Flat	Flat	NA	NA
2693380	6125820	10	0.36	~0.05	~0.11	0	Flat	Perched	0.06	~0.3
2693100	6125600	width: 0.55	NA	~0.04	~0.03	0	Flat	Perched	0.4	NA
2688940	6134162	5	~0.65	~0.3	0.25	~0.3	Flat	Flat	NA	NA
2688013	6134473	~14	0.9	0	0	~0.05	Flat	Dry	NA	NA
2687415	6134610	~5	0.68 high x 1.25 wide	0	0	0	Flat	Flat	NA	NA
2686760	6134615	width: 1.8	NA	0	0	0	Flat	Perched	~0.6	0
2684520	6135125	~5	~5	0.05	0.18	0	Flat	Perched	0.1	0.5
2683645	6135135	~8	~8	0.07	no access	0.35	Flat	Flat	NA	NA

Easting	Northing	Likely severity of fish passage	Stream bed relative to culvert base	Stream width relative to culvert	Stream alignment	Bank erosion at ends	Other comments
2701390	6083550	Low flows	below	same	straight in-out	no	Lake level weir. Dry US at time of visit with ~13 cm lip US and 10 cm lip above water DS. Proabably inundated when lake levels are higher.
2701080	6083020	None/minimal	below	wider	straight in-out	yes	
2701160	6081615	None/minimal	?	wider	straight in-out	no	Inlet totally overgrown with wild parsnip
2700690	6081170	None/minimal	below	wider	straight in-out	no	Small lake directly upstream of culvert. No visible water movement.
2700175	6080260	None/minimal	above	wider	straight in-out	yes	clear sandy channel at outlet
2700070	6079630	None/minimal	same	wider	straight in-out	no	Stream choked with wild parsnip through Foxton Beach
2700040	6079520	Low flows	below	wider	straight in-out	no	Outlet built up with boulders. Lots of inanga DS. Stillwater intertidal DS. Curved pipe.
2697580	6060025	Most flows					
2697565	6060035	None/minimal	?	wider	straight in-out	no	Lake level weir and non-working fish pass ~ 10 m US
2697485	6060055	Low flows	below	wider	straight in-out	no	
2696710	6060520	None/minimal	?	wider	straight in-out	no	Almost no visible water movement. Channel mostly overgrown.
2699250	6064335	Low flows	NA	same	straight in-out	no	~ 20 m wide. Weir underwater at this visit. Abundand macrophytes, mostly Potamogeton sp.
2693340	6058571	None/minimal	Below	wider	straight in-out	no	No visible water movement. Lake/pond conditions.
		Low flows	?	?	?	no	Not visited but severity inferred from photos and assessment of similar structures.
2692765	6057940	most flows					
2692865	6058860	None/minimal	?	same	straight in-out	no	
2692760	6057965	None/minimal	same	wider	straight in-out	no	~ 10 m US is lake level sandbag weir with fish pass (wooden with baffles). Currently inoperable, no water flowing down it. It has been observed

							allowing inanga passage in the past.
2692460	6056400	None/minimal	?	wider	straight in-out	yes	The edges of the crossing are eroded and pipe cannot be seen but there is obvious flow. Needs attention and possible clearing.
2692480	6056500	None/minimal	Below	Wider	straight in-out	no	The DS concealed culvert is lpossibly the same type as this one.
2692120	6056125	Most flows when cap closed	Below	Wider	straight in-out	no	Jammed closed tidal flap
2701465	6086645	None/minimal	?	Wider	straight in-out	no	Outlet not really begun yet as extensive swamp on both sides of culvert. May have been drainage ditch dug in past.
2701380	6086675	Low flows	NA	Narrower	straight in-out	no	Lake level weir. Perched. Slight trickle only at center.
2701270	6086585	None/minimal	Below	Wider	straight in-out	yes	No visible water movement.
2701070	6086440	None/minimal	same	wider	straight in-out	yes	Just DS from a vehicle ford.
2700435	6090410	Most flows	below	same	straight in-out	no	Significant weir with a lot of large (i.e. > 1m long) concrete rubble dumped to prevent scour. Top of weir above inlet substrate base.
2707350	6094850	None/minimal but dry	below	wider	straight in-out	no	Ephemeral. Dry at time of visit.
2706630	6094850	None/minimal but dry	same	wider	straight in-curved out	no	Ephemeral. Dry at time of visit.
2704980	6095655	None/minimal	same	wider	straight in-out	no	
2704065	6095545	None/minimal	same	wider	straight in-out	no	
2703480	6094370	None/minimal	same	wider	straight in-out	yes	
2701605	6094225	Low flows	NA	narrower	straight in-out	no	Fish ramp of rock material built this summer. Swift flow but passable to fish. May still be a barrier when lake level is below the top of the weir.
2700575	6094545	Most flows to inanga. Eels probably fine.	NA	narrower	straight in-out	no	Old concrete structure. Maybe old lake level weir. Has had middle smashed out but still perched. Large concrete apron with its own 5 cm drop. Abundant iron floc.

2700510	6094590	Low flows maybe	same	same	straight in-out	yes	End sections of culverts have snapped forming a ramp. Only one has water flowing down "ramp". If it breaks further they could be severely perched. A deep outlet pool has formed at outlet.
2701631	6102800	None/minimal	same	wider	straight in-out	no	
2701060	6101725	None/minimal	same	wider	straight in-out	no	Totally overgrown with wild parsnip. Can't access ends.
2701110	6101770	None/minimal	same	wider	straight in-out	no	Totally overgrown with wild parsnip. Can't access ends. Raupo wetland ~100m US then pine trees.
2701005	6101675	None/minimal	same	wider	straight in-out	no	Totally overgrown by wild parsnip.
2700805	6101265	None/minimal	same	wider	straight in-out	no	Inlet totally overgrown with wild parsnip. New concrete pipe above older ones to cope with high flows.
2700660	6101100	None/minimal	same	wider	straight in-out	no	Overgrown with wild parsnip.
2700700	6101050	None/minimal	same	wider	straight in-out	no	
2700775	6101025	None/minimal	same	wider	straight in-out	no	
2700855	6100990	None/minimal	same	wider	straight in-out	no	Crossing surface subsiding at edges.
2701230	6100025	Low flows	same	wider	straight in-out	no	Manual operation floodgate on outlet of culvert through stop bank. Coarse weed screen on inlet (lifted out of water at time of visit).
2707185	6098690	None/minimal except when dry	same	wider	straight in-out	no	Obviously only flow here when lake is higher. Channel unfenced and full of pasture grass.
2706695	6098990	None/minimal except when dry	same	wider	straight in-out	no	Not far after small pond. Channel still dry. Dead sheep on crossing.
2706345	6099000	None/minimal except when dry	same	wider	straight in-out	no	Dry channel unfenced and full of pasture grass. Debris inlet implies significant flows at some time. Dead sheep part of debris.
2706210	6099095	None/minimal except when dry	above	wider	straight in-out	yes	Dry channel infilled by sheep trampling. Channel just a depression in pasture.
2706185	6099110	None/minimal except when dry	above	wider	straight in-out	yes	Sheep trampling has caused inlet to infill. Evidence of high flows from looking at debris at inlet.
2705695	6099430	None/minimal	same	wider	straight in-out	no	First culvert DS of lake with water. Channel totally filled with grass but is wetted.
2705505	6099610	None/minimal	above	wider	curved in -	yes	Road culvert. Currently dry. Channel moist but no

		except when dry			straight out		water.
2698570	6113175	None/minimal but needs unblocking	same	wider	straight in-out	no	Very overgrown. Found inlet pipe but not outlet. Outlet seems to be under water and very overgrown by macrophytes and edge vegetation.
2697835	6113535	None/minimal	same	wider	straight in-out	no	Small boulders/cobbles dumped at outlet to prevent scour.
2697385	6113775	None/minimal	same	wider	straight in-out	no	Overgrown, especially outlet that is hard to find. Patch of raupo just DS. Damp patch with sitting water.
2696775	6118305	Most flows	same	wider	straight in-out	no	Dry. Perched outlet. Deep pool at outlet caused by scour (max. 0.75 m deep).
2696690	6118895	Most flows	below	wider	straight in-out	yes	Dry. Similar to first culvert but less perched and outlet pool dry.
2696435	6117575	Most flows	below	wider	straight in-out	yes	Dry. Concrete rubble slabs placed to reduce erosion at outlet.
2695600	6117385	None/minimal	above	wider	straight in-out	no	Dry.
2696865	6115900	Most flows	NA	NA	straight in-out	no	Perched drop. Appears natural. Only found because of sound of water. Surrounded in raupo.
2696622	6115970	None/minimal	same	wider	straight in-out	yes	
2686420	6135865	Most flows	same	same	straight in-out	no	Small weir for lake level control. Just DS of wooden bridge
2694005	6126610	None/minimal	above	wider	straight in-out	yes	Only flows when lake level high. Large dam/causeway vehicle crossing with 2 culverts. Ephemeral outlet.
2693435	6125855	None/minimal	above	wider	straight in-out	yes	Massive thick culvert. Little visible water movement.
2693380	6125820	Most flows	same	wider	straight in-out	no	Overgrown inlet.
2693100	6125600	Most flows	NA	same	curved in – straight out	yes	Perched drop created by earthworks of a small vehicle crossing cutting.

2688940	6134162	None/minimal	same	wider	straight in-out	no	Main pipe measured. At least 3 smaller pipes visible but are dry (above water). Outlet concealed by rubble.
2688013	6134473	None/minimal	same	wider	straight in-out	yes	Obviously only flows when lake level is higher.
2687415	6134610	None/minimal	same	same	straight in-out	no	More like a bridge than a culvet. Concrete ramp to reduce erosion at outlet.
2686760	6134615	Most flows	same	same	straight in-out	no	Function unknown. Lots of rubble dumped to reduce scour. Small wooden bridge ~30 m DS
2684520	6135125	Most flows	same	wider	straight in-out	yes	Double culvert (one dry) draining small lake. Large wet area DS of drain and wetland US.
2683645	6135135	None/minimal	below	wider	straight in-out	yes	Inlet inaccessible with blackberry.