

Assessment of Freshwater, Riparian, and Catchment Biodiversity Values in the Pukorokoro-Miranda Catchments



McCartie's Stream, near Kaiaua (photo Jason Roxburgh-Living Matters)

by
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Biodiversity & Ecology Solutions

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Executive Summary:

Department of Conservation's (DOC) Thames Office contracted Living Matters to undertake a freshwater, riparian, and catchment biodiversity assessment within the five catchments from Miranda to Kaiaua, flowing into the western side of Tikapa Moana/Firth of Thames (the Firth). Although this area's coastal margin has high biodiversity values, the catchment also has biodiversity values worthy of protection and restoration. Protecting these values will also help protect the values in the coastal margin, and the Firth.

Significant areas of riparian and catchment vegetation remain, mainly in the mid and upper catchments, due to the efforts of private landowners, the Miranda Naturalists Trust, local and regional government, Ecoquest, DOC, the Auckland Council, and others. However, these catchments are considerably modified, meaning the waterways contain elevated levels of sediments, nutrients, and debris, as well as altered patterns of water flows and flood peaks.

The project brief for this work was in two primary parts; to characterize the broad-scale biodiversity values of these five catchments; and to make recommendations for the further assessment and/or protection of those values. Further investigation is recommended to define the:

1.1 Pest Fish

This and other investigations have recorded *Gambusia* (Mosquito fish) and Perch from the catchment. Assessing the areas surrounding these, and the other areas of similar habitat, would define the extent of the pest fish issues in the catchment, and help prioritise effort

1.2 Stock Exclusion, Riparian Protection Assessment, and Fencing

There is already a considerable amount of riparian fencing and protection in the catchment, though there are many areas that would benefit from stock exclusion. Assessing the current state of stock exclusion from riparian and other indigenous vegetation areas would enable prioritisation of effort to maximise improvements in water quality (nutrients, sedimentation, and fecal coliforms). In turn this would improve freshwater biodiversity, and the shorebird and other habitats of the Firth. The mid-upper parts of the Taramaire, Puaerahuri, Miranda, and Hauarahi Streams are key to at least retaining the existing water quality in these catchments.

1.3 Freshwater Mussels/Kākahi

Live Kākahi were found in the Miranda and Puaerahuri Streams, with surprisingly high numbers in the latter, and shells were found in the Hauarahi. Although Kākahi are widespread across New Zealand, they are suffering serious decline, and finding such large numbers in the Puaerahuri warrants further investigation of at least this stream, if not other areas with suitable habitat. Knowing their extent would enable prioritization of effort for their protection.

1.4 Eels

Eels were found in all but the lower catchment sites in the Miranda, Hauarahi, and Puaerahuri Streams), it would appear that eels might be scarce at lower elevations in these catchments. Riparian protection of streams is likely to be key to having a healthy population of eels in these catchments. There are high numbers of eels in some farm ponds in the Miranda and Taramaire catchment.

1.5 Establishing the extent of former estuarine areas

The Miranda, Pukorokoro, and possibly the Taramaire, probably once flowed into a large shallow estuary between what are now the two most recent landward Chenier ridges. Given the focus to date on the coastal strip, establishing the extent of this former estuarine area could help guide restoration efforts, particularly if land purchases are being considered between the Miranda and Taramaire mouths.

1.6 Significant areas of native forest, and potential for formal land protection

There are several large (relative to the catchment) areas of forest in the catchments. Areas that have formal protection include a large QEII National Trust covenant on private land, the Auckland Water Supply reserves, and public conservation land, all in the headwaters of the Hauarahi. There is a large privately

owned area of forest straddling the mid Taramaire and Puaerahuri catchments. This is significant because it is the only large intact forested area in the mid-catchment area, where there is relatively little continuous native vegetation. The owners have expressed a desire to formally protect the block in the past, and they could be assisted to do so in collaboration with Ecoquest (who have extensively studied the area, and have a very good relationship with the owner), the QEII National Trust, and possibly Waikato Regional Council.

1.7 Potential barriers to fish passage

There are several fords in the catchment that could be causing physical and/or water velocity barriers to fish passage for diadromous species. An assessment of the full catchment for barriers to fish passage would be quick and straightforward. This would enable planning for where to focus for the best biodiversity gains, and where effort could be put to alter the existing ford structures to improve fish passage.

1.8 Inanga spawning sites

Relatively large numbers of Inanga were found in the low-catchment sites in the Hauarahi, Puaerahuri, and Miranda Streams, and are likely present in the Taramaire. Locating where inanga spawn in these streams, and establishing what could be done to protect and enhance these sites, would provide benefits to the freshwater fish fauna.

2 Introduction

The Firth is an 8,500ha wetland of international significance, and includes floodplain, saline wetlands, a large intertidal zone, and one of the world's best examples of an active Chenier plain. Significant habitat exists for a range of threatened flora and fauna, and the Firth's marine environment, especially in the area from Miranda to Kaiaua, is significant to the health of the region as a whole.

The section of the Firth of Thames Ramsar site along this coast supports nine key shorebird species (pers. com. Keith Woodley), including Arctic migrant and New Zealand endemic shorebird species such as bar-tailed godwits, red knots and wrybill plover. A number of threatened wetland birds, lizards, fish, and plants are also present. These catchments sit at the confluence of the Hauraki, Hapuakohe, and Hunua Ecological Districts, and include significant landforms, geology, natural value, land use, and economic value diversity.

DOC and Fonterra have formed the Living Water project (<http://www.fonterralivingwater.com>) to help care for this and four other sensitive catchments nationally. In this case the area contains five catchments¹ between Miranda and Kaiaua, draining into the western side of the Firth. The focus to date has been the high-biodiversity coastal strip, which is internationally important for its wading birds, floodplains, saline wetlands, intertidal areas, and one of the world's finest examples of an active Chenier plain. It is also highly visible, receiving high public visitor and recreation use. This, combined with its very high biodiversity values, presents strong opportunities to involve and inform landowners, tangata whenua, and the wider community and public.

Although the coastal strip has received considerable research and study, considerably less is known about the biodiversity values of these five catchments. DOC contracted Living Matters to undertake this broad-scale biodiversity assessment, to form part of the planning for restoration work in the coastal strip, and examining the values and restoration opportunities in the wider catchment. Hence this report focuses on the catchment upstream of the coastal strip, outlining:

- The broad-scale freshwater, riparian, and native vegetation values of the catchment
- Sites and areas that warrant further investigation
- Sites and areas with potential for restoration
- Specific opportunities to work with landowners

3 Design and Methods

The existing freshwater information on these catchments was extracted from the NZ Freshwater Fish Database, and Waikato Regional Council's information. This shows that, although limited sampling has been undertaken, where sampling had occurred there is a reasonable diversity of freshwater fish species, and high numbers of some species (particularly in the upper-Hauarahi Stream).

3.1 Freshwater Fish

All freshwater fish sampling followed the New Zealand Freshwater Fish Sampling Protocols², which are designed to characterise freshwater fish communities by providing guidance on how to select the most appropriate sampling method to use, how to implement each sampling method, and how best to take and record the data that is collected.

The initial proposal was to sample a representative low, mid, and upper catchment site in each of the five catchments. However, on further investigation Pukorokoro Stream (the smallest of the five catchments) was found to be highly modified and channelised, and had a largely muddy substrate, so it was not

¹ For the purposes of this report, the sampling area includes the Miranda, Pukorokoro, Taramaire, Te Puaeharuri, and Hauarahi Streams

² <http://www.envirolink.govt.nz/PageFiles/31/New%20Zealand%20Freshwater%20Fish%20Sampling%20Protocols.pdf>

sampled. Good information already existed in the NZ Freshwater Fish Database for the upper-Hauarahi Stream, so this area was not sampled. Instead, more effort was put into freshwater mussel sites found in the Miranda and Puaerahuri Streams. Because the upper-reaches of these streams are relatively small, their lower reaches are muddy, and the streams are mostly not large enough to take Fyke nets, the range of sampling techniques that could be used was limited to electric fishing, and Gee Minnow trapping.

Gee Minnow traps are available in 6 and 3 mm mesh sizes. The traps for this investigation were 6 mm, and would have let through very small eels and fish. Several small inanga were observed stuck at their gills part way out of the traps at the Miranda trapping site, so the use of these traps may underestimate the number of small fish.

3.2 Freshwater Mussels

Live freshwater mussels were found in the Miranda and Puaerahuri Streams, and shells in Hauarahi Stream. The [Kakahi Monitoring Guide](#) was developed for the Wairarapa Moana Wetlands Project, and published by Greater Wellington Regional Council, for Kakahi sampling in lakes. After discussion with the author a modified sampling method was used for the small, incised streams Kakahi were found in during this survey. A section of each stream was manually searched for 5 minutes, and all Kakahi collected and measured (shell depth and length).

3.3 Riparian areas

A basic assessment was made of the riparian and surrounding vegetation, and any weed species were also noted. Fauna seen during the fish sampling were also noted.

3.4 Access to Land for Sampling

Each landowner with a potential sampling reach or reaches on their property was contacted and visited to request permission to enter their property. During the visit landowners were asked what they knew about the freshwater values of their streams, and about water quality and fish passage barriers. Landowners provided some very good information on site selection, and valuable observations of freshwater fauna on their properties, and they were provided with a DOC-supplied Living Waters information.

It is worth noting that the stream substrates in all but the Hauarahi were quite compacted. Hence there was relatively little habitat and sites of refuge for fish. It appears that this is a natural consequence of the angular and crumbly nature of the rock substrate. The Hauarahi catchment's substrate was more rounded and loosely held, so appeared to provide more varied habitat.

4 Results

4.1 Miranda Stream

Miranda Stream is the southern-most of the five catchments, has the least modified outlet to the sea, and the least barriers to fish migration. Gary Dalton (landowner of much of the mid and lower Miranda Stream catchment) reports that this stream originally flowed into a large shallow estuary that ran north from the existing estuarine area, parallel to the sea. This was apparently filled in over time as the area was developed for agriculture.

This stream is tidal up to where it passes through a 1.5 m culvert beneath Miranda Road, and tidally influenced to just below the Dalton's water intake pumps, about 400 m above Miranda Road. The culvert does not pose a barrier to fish passage, and there appear to be no other significant artificial barriers to fish passage in the catchment.

The stream flows through dairy farm in the lower catchment, and mixed dry stock farm and lifestyle blocks in the mid and upper catchment. The overall catchment vegetation is 75% farmland, 10% native forest, 10% native scrub, and 5% exotic forest plantation. The stream substrate in most of the mid and upper reaches of the catchment is compacted, with little loose material for fish to use as refuges or general habitat.

The reaches sampled in the Miranda catchment are on two properties owned by the Dalton family, who run Te Whangai Trust (www.tewhangai.com), a social and environmental enterprise that assists long term unemployed, youth, and people at risk through their large nursery and riparian planting programme, and their dairy farm. Most of the streams through the Dalton's properties are fenced with wide riparian margins.

Although the sampling done in Miranda Stream was within the criteria in the Protocol, there had been a recent "fresh", causing the movement of considerable fine material into the lower parts of the stream. This could also have washed inanga downstream that were further upstream. Gary Dalton reports that flood events like this are common in the catchment. The following three sampling sites were established as representative of the catchment:

4.1.1 Miranda 1 (Location: E1804196, N5882012)

This is representative of the lower catchment, with an average width of 1 m, and an average depth of 0.4 m. The riparian vegetation is dominated by rank grasses, but the stream is riparian fenced on both sides with a 5-10 m margin, and has been recently replanted with a range of native riparian species. The only viable sampling method in this reach was using Gee Minnow Traps, and Table 1 outlines the species found, and the physical characteristics of the reach:

Table 1: Physical Characteristics of, and Species Found in, Miranda 1 Sampling Reach

Species	Abundance	Length Range (mm)
Inanga	55	60-120
Freshwater Shrimp	11	- ³

Substrate type	%	Riparian Vegetation	%	Habitat Type	%	Fish Cover	Y/N
Bedrock	-	Native Forest	40 ⁴	Still	-	Weed/Algae	Y
Boulder	-	Exotic	-	Backwater	-	In stream debris	Y
Cobble	5	Grass/Tussock	60	Pool	80	Undercut banks	Y
Coarse Gravel	5	Exposed bed	-	Run	20	Bank vegetation	Y
Fine Gravel	10	Scrub/Willow	-	Riffle	-	Overhead shade	Y
Sand	-	Raupo/Flax	-	Rapid	-	Substrate	N
Mud	80	Other	-	Cascade	-		

Figure 1: Miranda Stream Sampling Reach 1



(photos Jason Roxburgh-Living Matters, and Google Earth)

³ = As per the NZ Freshwater Fish Database convention, freshwater shrimp were only counted, and not measured

⁴ = Replanted riparian vegetation, as seen in the top right of the Figure 1 photographs

4.1.2 Miranda 2 (Location: E1803351, N5881421)

This reach is representative of the mid-upper catchment, and has an average width of 2.5 m, and an average depth of 0.3 m. The riparian area is fenced with 10-50 m margins, and well vegetated. The canopy at this site dominated by tanekaha, with an understory of manuka, mahoe, kanuka, lemonwood, red matipo, hangehange, tree ferns, and horopito. The ground cover is a mix of native and introduced grasses, Gahnia, water fern, various *Blechnum* ferns. The vegetation condition is good, regenerating after having stock largely excluded for 10+ years. The stream at this site was sampled by electric fishing, and Table 2 shows the results for this reach:

Table 2: Physical Characteristics of, and Species Found in, Miranda 2 Sampling Reach

Species	Abundance	Length Range (mm)
Koura	1	-
Long-finned Eel	1	230
Short-finned Eel	3	180-210
Eel ⁵	23	70-800
Common Bully	1	50
Cran's Bully ⁶	2	70-95
Unidentified Bully	1	70
Banded Kokopu	2	80-185
Unidentified Kokopu	1	200

Substrate type	%	Riparian Vegetation	%	Habitat Type	%	Fish Cover	Y/N
Bedrock	4.5	Native Forest	75	Still	-	Weed/Algae	N
Boulder	1.5	Exotic	-	Backwater	-	In stream debris	Y
Cobble	17.5	Grass/Tussock	25	Pool	50	Undercut banks	Y
Coarse Gravel	31	Exposed bed	-	Run	25	Bank vegetation	Y
Fine Gravel	23	Scrub/Willow	-	Riffle	20	Overhead shade	Y
Sand	23	Raupo/Flax	-	Rapid	5	Substrate	Y
Mud	0.5	Other	-	Cascade	-		

Figure 2: Miranda Stream Sampling Reach 2



(photo Google Earth)

⁵ This comprises eels that were unable to be identified to species level because they were either too small to identify, or could not be caught.

⁶ Dr. Bruno David (Waikato Regional Council) and Stella McQueen advise the taxonomy of Cran's and Common Bullies is unclear. Although adult male Cran's Bullies are relatively simple to distinguish from Common Bullies, other Cran's and Common Bullies are difficult to distinguish from one another in the field, especially when small. As no identifiably male adult Cran's Bullies were found during the sampling, and because many male Common Bullies were found, it is likely that most of the fish noted as "Unidentified Bully", are Common Bullies.

4.1.3 Miranda 3 (Location: E1802721, N5881744)

This is representative of the mid-upper catchment, and has an average width of 2.6 m, and an average depth of 0.14 m. The riparian areas are fenced with 40-50 m margins, with a canopy of tall manuka and kanuka, over an understory of rank grass, mahoe, horopito, and tree ferns. Immediately upstream of the sampling site the riparian vegetation is much more established, with large emergent rimu and kauri, and an understory of the above, plus tutu, rangiora, and cabbage tree. The vegetation condition is good, and regenerating after being riparian fenced for 10+ years, although the riparian fenced area is irregularly grazed (there were three yearling cattle present in the area during the sampling). This part of the stream had received a high-water event the previous week, but at the time of sampling flows were back to normal. The stream at this site was sampled by electric fishing, and Table 3 shows the results for this reach:

Table 3: Physical Characteristics of, and Species Found in, Miranda 3 Sampling Reach

Species	Abundance	Length Range (mm)
Koura	8	-
Freshwater Shrimp (Paratya)	3	-
Eel	13	100-900
Common Bully	5	30-70

Substrate type	%	Riparian Vegetation	%	Habitat Type	%	Fish Cover	Y/N
Bedrock	13.6	Native Forest	-	Still	-	Weed/Algae	N
Boulder	7.6	Exotic	-	Backwater	0.5	In stream debris	N
Cobble	25	Grass/Tussock	50	Pool	32.5	Undercut banks	Y
Coarse Gravel	29	Exposed bed	-	Run	23.4	Bank vegetation	N
Fine Gravel	19	Scrub/Willow	50	Riffle	37.3	Overhead shade	Y
Sand	9.2	Raupo/Flax	-	Rapid	5.5	Substrate	Y
Mud	-	Other	-	Cascade	0.5		

Figure3: Miranda Stream Sampling Reach 3 (note strand line from recent high water event)



(photos Jason Roxburgh-Living Matters, and Google Earth)

4.1.4 Fish Surveys by Ecoquest in Miranda Stream

During November 2001, and April & November 2002, [Ecoquest](#) undertook fish surveys in the tidal section of Miranda Stream. This section of the stream provides a range of habitats including open, intertidal mudflats; accumulating Chenier shell banks, sheltered mangrove vegetation, and open inland mudflat. The channel is 5-11 m wide and from 0.1-2 m meters deep. The mangrove channels are steep-sided soft, silty mud in moderately to heavily vegetated stands.

Five sites were sampled, using Gee Minnow traps, Fyke nets, Cast nets, and a Beach Seine net. The following species were caught during the sampling: common bully (*Gobiomorphus cotidanus*), common smelt (*Retropinna retropinna*); Longfin Eel (*Anguilla dieffenbachii*); Shortfin Eel (*Anguilla australis*); Unidentified Eel (*Anguilla* sp); Estuarine triplefin (*Grahamina* sp); Goby (*Favonigobius lateralis*); grey mullet (*Mugil cephalus*); Inanga (*Galaxias maculatus*); Parore (*Girella tricuspidata*); sand flounder (*Rhombosolea plebeia*); speckled sole (*Peltorhamphus novaezeelandiae*); Torrentfish (*Cheimarrichthys fosteri*); yelloweye mullet (*Aldrichetta forsteri*); and yellowbelly flounder (*Rhombosolea leporina*). The full results are available from Ecoquest on request.

4.2 Taramaire Stream

Taramaire Stream has a highly modified lower catchment, and the stream flows for its last 1.5 km to the sea through a straight channelised drain. The stream is tidal to half way up the channelised section, and the tidal influence reaches to near the Fairview Road ford. This ford may be a barrier for Inanga, but does not appear to be a significant barrier to other fish species. The stream flows through dairy farm in the flat coastal parts of the catchment, and through mixed dry stock farm in the hillier mid and upper catchment. The overall catchment vegetation is 60% farmland, 10% native forest, 15 % native scrub, and 15% exotic forest plantation. This is one of the two larger catchments (along with the Huarahi Stream), so the streams could be sampled some way into the upper catchment.

All three sampling sites in the Taramaire Stream were within the property owned by Pete Gasson, a large farm spanning the lower to the upper catchment. The stream substrate in much of the mid and upper reaches of the catchment is compacted, with little loose material for fish to use as refuges or general habitat. Because the first 1.5 km of this stream is channelised and not suitable for sampling, and access to the reaches immediately upstream and downstream of Fairview Road was restricted, the following three sampling sites were established as representative of the catchment:

4.2.1 Taramaire 1 (Location: E1801439, N5884319)

This reach is representative of the upper-catchment. It has an average width of 2.6 m, and an average depth of 0.25 m. Parts of this reach are riparian fenced with 10-20 m margins, though stock have access to other parts of the stream. The true right side of the sampling reach is approx. 10 year old pine forest, and the true left is native vegetation. The stream riparian areas have a canopy of tall kanuka, with some emergent kauri and kahikatea, as well as rank pasture grasses. The understory is mostly pigeonwood, Mamaku, Red Matipo, Mahoe, Kumerahou, Silver Fern, and Koromiko. The upstream 40% of the sampling reach passed into pasture with riparian Kanuka, and a large riparian Kauri. Inside the riparian fenced areas the vegetation condition is good, and although stock can access both ends of the sampling reach, they don't venture far. There were a lot of Mayflies and their larvae found in this reach. The stream at this site was sampled by electric fishing, and Table 4 shows the results for this reach:

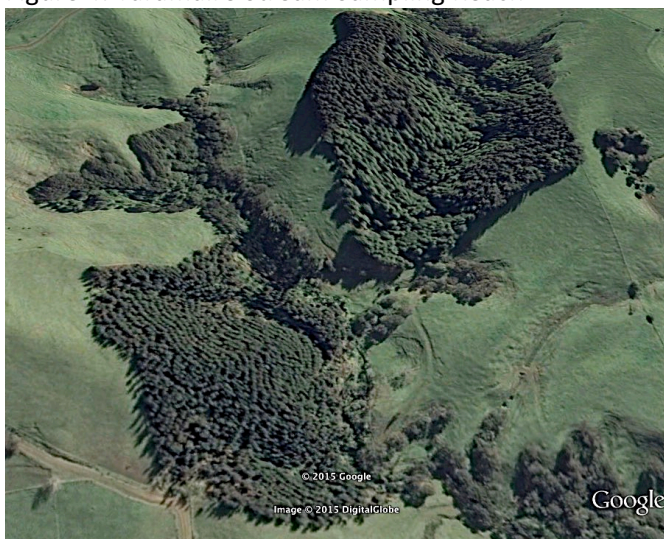
Table 4: Physical Characteristics of, and Species Found in, Taramaire 1 Sampling Reach

Species	Abundance	Length Range (mm)
Koura	16	-
Long-finned Eel	3	350-600
Short-finned Eel	7	140-300
Eel	18	200-1100
Red-finned Bully	1	90

Freshwater Shrimp	1	-
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Substrate type	%	Riparian Vegetation	%	Habitat Type	%	Fish Cover	Y/N
Bedrock	15	Native Forest	20	Still	-	Weed/Algae	Y
Boulder	15	Exotic	10	Backwater	-	In stream debris	Y
Cobble	23	Grass/Tussock	60	Pool	31	Undercut banks	N
Coarse Gravel	12	Exposed bed	-	Run	45	Bank vegetation	Y
Fine Gravel	20	Scrub/Willow	10	Riffle	20	Overhead shade	Y
Sand	6	Raupo/Flax	-	Rapid	-	Substrate	Y
Mud	8	Other	-	Cascade	4		

Figure 4: Taramaire Stream Sampling Reach 1



(photo Google Earth)

4.2.2 Taramaire 2 (Location: E1801485, N5883604)

This reach was chosen to represent the mid catchment. It has an average width of 2.9 m, and an average depth of 0.3 m. All of the true right of this reach is riparian fenced, with a 2-3 m setback, but none of the true left of this reach is riparian fenced. This reach has some riparian cover, primarily tall kanuka, as well as rank pasture grasses. There is also a mix of shorter species present, including Red Matipo and Mahoe. The downstream half of this reach has overhead riparian cover (see left photo in Figure 5 below), and contained considerable amounts of the native alga *Nitella* (species not known), and some native *Potamogeton cheesemanii*. The upstream end of the sampling reach has no overhead cover, and becomes increasingly choked with introduced water plants such as water celery (*Apium nodiflorum*, see right photo in Figure 5 below). The stream at this site was sampled by electric fishing, and Table 5 shows the results for this reach:

Table 5: Physical Characteristics of, and Species Found in, Taramaire 2 Sampling Reach

Species	Abundance	Length Range (mm)
Koura	4	-
Long-finned Eel	7	350-400
Short-finned Eel	2	200-230
Eel	39	60-600 (Small eels very common)
Common Bully	6	60-95
Unidentified Bully	72	25-60
Freshwater Shrimp (Paratya)	9	-

Substrate type	%	Riparian Vegetation	%	Habitat Type	%	Fish Cover	Y/N
Bedrock	1.5	Native Forest	-	Still	-	Weed/Algae	Y
Boulder	34.5	Exotic	-	Backwater	-	In stream debris	Y
Cobble	12	Grass/Tussock	90	Pool	33.5	Undercut banks	Y
Coarse Gravel	13.5	Exposed bed	-	Run	47	Bank vegetation	Y
Fine Gravel	21.5	Scrub/Willow	10	Riffle	18	Overhead shade	Y
Sand	15.5	Raupo/Flax	-	Rapid	0.5	Substrate	Y
Mud	0.1	Other	-	Cascade	0.5		

Figure 5: Taramaire Stream Sampling Reach 2



(photos Jason Roxburgh-Living Matters, and Google Earth)

4.2.3 Taramaire 3 (Location: E1800995, N5884340)

This reach was chosen to represent the mid-catchment. It has an average width of 2.3 m, and an average depth of 0.25 m. All of this reach is riparian fenced, with a up to 50 m setbacks. This reach has complete canopy cover of Titoki, Rewarewa, Kohekohe, Kanuka, Rimu, Tanekaha, Tawa, Kahikatea, Puriri, and Beech. The understory has Mahoe, Hangehange, Nikau, Pigeonwood, Cyathea dealbata, Black Mamaku, Kiekie, Silver Fern, Red Matipo, and Rangiora. Stream-side vegetation consists of Kiekie, Crown Fern, Wineberry, *Rubus* species, and ground ferns. The forest and riparian vegetation is in good condition. The pine forest near the true right bank of the reach has recently been logged, although this does not appear to have significantly impacted on the stream. The stream at this site was sampled by electric fishing, and Table 6 shows the results for this reach:

Table 6: Physical Characteristics of, and Species Found in, Taramaire 3 Sampling Reach

Species	Abundance	Length Range (mm)
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Koura	32	-
Long-finned Eel	3	250-900
Eel	39	60-600 (Small eels common)
Common Bully	14	45-70
Cran's Bully	2	30
Unidentified Bully	5	40-50
Koaro	2	65-70
Banded Kokopu	10	45-140
Unidentified Kokopu	3	50-130

Substrate type	%	Riparian Vegetation	%	Habitat Type	%	Fish Cover	Y/N
Bedrock	4	Native Forest	100	Still	-	Weed/Algae	N
Boulder	5.5	Exotic	-	Backwater	0.5	In stream debris	Y
Cobble	22.3	Grass/Tussock	-	Pool	31	Undercut banks	Y
Coarse Gravel	22.7	Exposed bed	-	Run	31.6	Bank vegetation	Y
Fine Gravel	39.5	Scrub/Willow	-	Riffle	36.5	Overhead shade	Y
Sand	5	Raupo/Flax	-	Rapid	-	Substrate	Y
Mud	0.1	Other	-	Cascade	-		

Figure 6: Taramaire Stream Sampling Reach 3



(photos Jason Roxburgh-Living Matters, and Google Earth)

4.3 Puaerahuri Stream

Although Puaerahuri Stream is relatively small, it runs the full length of the catchment, sandwiched between the larger Haurahi and Taramaire catchments. As with the other catchments, the Puaerahuri has a highly modified lower catchment and, like the Taramaire, the stream is now straightened and channelised for its last 1.5 km to the sea. This stream is tidal to about half way up the channelized section, and tidally influenced to the large poplar trees on the McCartie's long driveway (pers. com. Rob McCartie). There are two fords across this lower section of the stream, but these do not appear to pose a significant barrier to fish migration, as evidenced by the number of Inanga above them. There appear to be few other significant artificial barriers to fish passage in the catchment. The stream flows through dairy farm in the flat coastal parts of the catchment, and through mixed dry stock farm in the hillier mid and upper catchment. The overall catchment vegetation is 80% farmland, 10% native forest, and 10% native scrub.

This stream is relatively small compared to the others in the catchment, and the waterways in the upper catchment were too small for reliable sampling. Sampling was possible in the mid and lower catchment, but the mid-catchment section of the stream has very dense weed and woody debris cover, so sampling was limited to low and mid catchment sites using Gee Minnow trapping and freshwater mussel samplings. Both

sampling sites used are within the property owned by the McCartie family, represented by Rob McCartie. The stream substrate in the sampled reaches was less compacted than that seen in the other streams. The following two sampling sites were established as representative of the catchment:

4.3.1 Puaerahuri 1 (Location: E1802841, N5888572)

This reach was chosen to represent the mid-catchment. It has an average width of 1.7 m, and an average depth of 0.25 m. None of this reach is riparian fenced, although newly installed fence posts were present on the true-left bank. The riparian vegetation is dominated by a canopy of Hawthorn, with some Kanuka and Mahoe. The stream-side vegetation is pasture grasses with *Carex secta*, small tree ferns, and red matipo. The muddy substrate and tangled in-stream debris precluded the use of electric fishing and Fyke Nets, so the site was sampled for fish using 10 Gee Minnow Traps set overnight. Rob McCartie mentioned there were Kakahi in the lower reaches of the stream, so sampling was undertaken at the upper and lower end of this sampling reach. Table 7 shows the results for this reach:

Table 7: Physical Characteristics of, and Species Found in, Puaerahuri 1 Sampling Reach

Species	Abundance	Length Range (mm)
Cran's Bully	1	65
Banded Kokopu	6	60-80
Common Bully	5	45-60
Koura	3	-
Inanga	4	70-90
Red-finned Bully	2	60-65
Freshwater Shrimp	14	-

Substrate type	%	Riparian Vegetation	%	Habitat Type	%	Fish Cover	Y/N
Bedrock	-	Native Forest	-	Still	-	Weed/Algae	N
Boulder	-	Exotic	-	Backwater	-	In stream debris	Y
Cobble	5	Grass/Tussock	90	Pool	70	Undercut banks	Y
Coarse Gravel	25	Exposed bed	-	Run	20	Bank vegetation	Y
Fine Gravel	35	Scrub/Willow	10	Riffle	10	Overhead shade	Y
Sand	-	Raupo/Flax	-	Rapid	-	Substrate	N
Mud	35	Other	-	Cascade	-		

Figure 7: Puaerahuri Stream Sampling Reach 2 (showing sampling for Mussels)





(photos Jason Roxburgh-Living Matters, and Google Earth)

4.3.2 Kākahi/Freshwater Mussels (Location: E1802841, N5888572)

Dr. Sue Clearwater, the NIWA ecotoxicologist with widely acknowledged expertise with freshwater mussels, was consulted regarding the results of the mussel sampling. Dr. Clearwater was surprised at the high numbers and densities found in the Puaerahuri Stream, and asked to be involved if further sampling is undertaken.

Two species were found in the samples; *Echyridella menziesii* (which has one side of its shell more rounded); and *Echyridella aucklandia* (which has a shell with near-parallel long sides). There were considerably more *E. menziesii* than *E. aucklandia* in the samples, and Dr. Clearwater advises it is normal to find them together and in the sorts of proportions found.

Like most freshwater mussels, Kākahi have a glochidium larva that is parasitic on fish in the early part of its life, before moving to soft, sandy sediments in lake and river beds (Walker et al, 2001). Dr. Clearwater advises that freshwater mussels are rarely found below urban areas or dairy farms effluent discharges. A likely reason for this is mussels, especially the glochidia larvae, are sensitive to ammonia and copper, both of which are in dairy farm run-off and urban wastewater. Apparently, inputs of terrestrial particulate organic matter make up the main proportion of mussels' diet in natural (i.e. native forested) habitats.

Although Kākahi are widespread throughout New Zealand in habitats ranging from small, fast-flowing streams, to lakes, they are under threat and are declining. No single impacting factor has been identified as being consistently important in the decline of kākahi, but river regulation; eutrophication; sedimentation; changes in water quality, velocity, and the angle or slope of a stream bed are likely to be key drivers of this decline.

As well as affecting adult populations of Kākahi, these factors also affect host fish species that are essential for completion of the kākahi life cycle ([NIWA website](#)). Figures 8 and 9 show the size (and hence age) distribution of mussels in the two sampling sites in this reach, and Figure 10 shows the mussels found at the upstream of the two sampling sites in the reach:

Figure 8: Puaerahuri Stream Reach 1: Downstream Mussel Site (for raw data see Appendix 1)

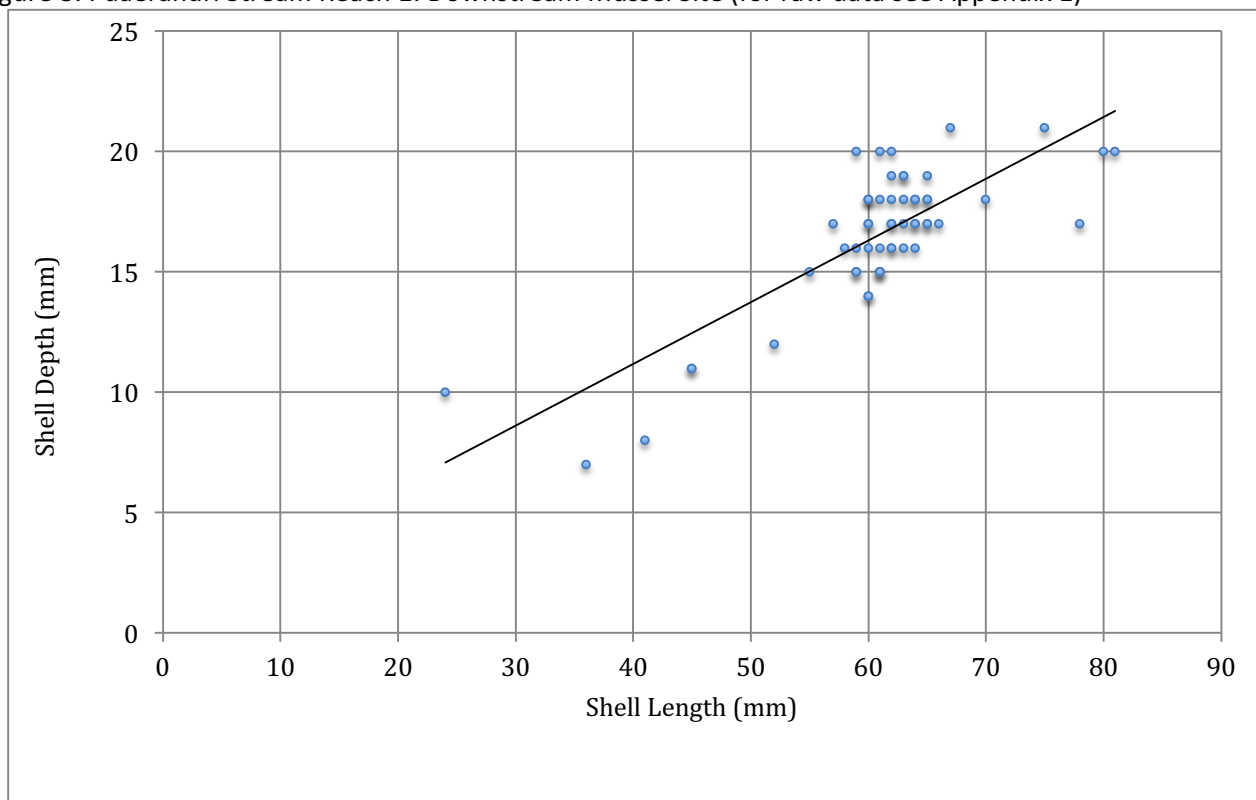


Figure 9: Puaerahuri Stream Reach 1, Upstream Mussel Site

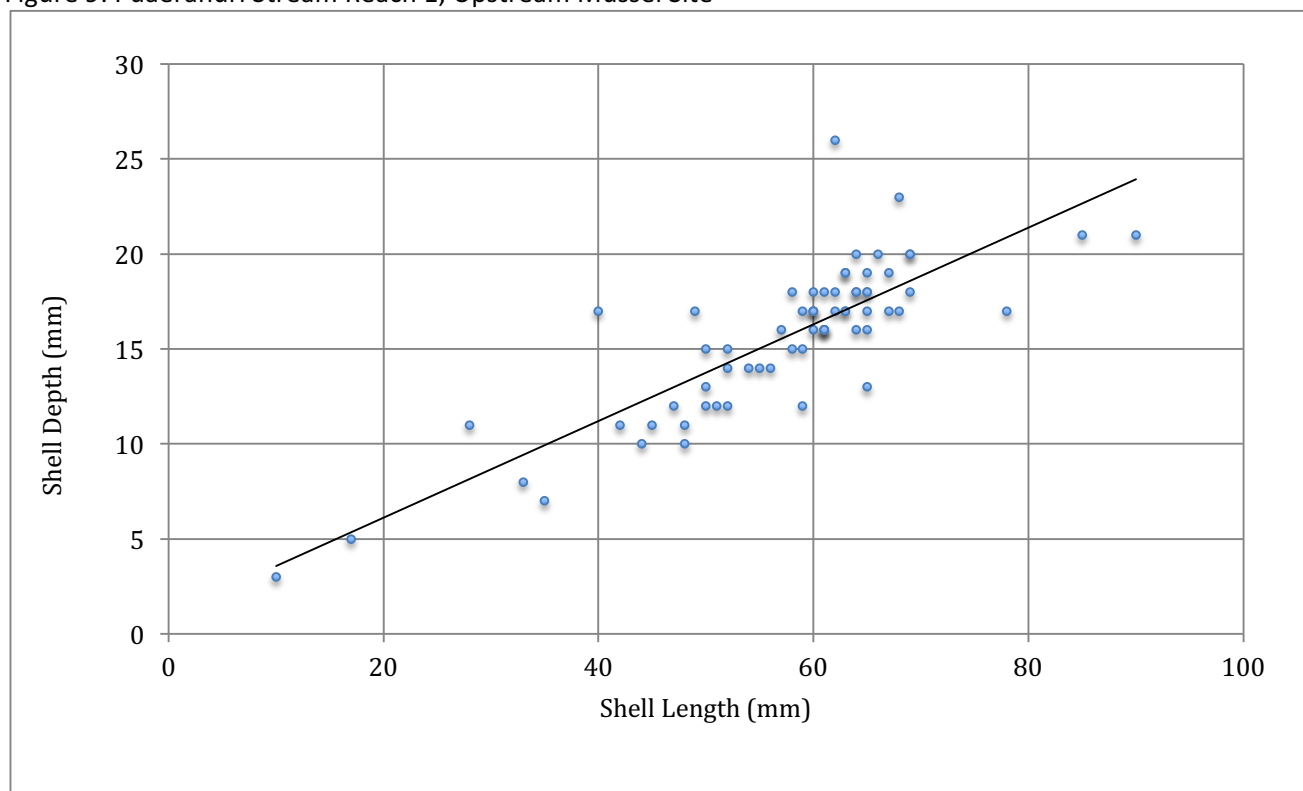


Figure 10: Puaerahuri Stream Reach 1, Mussels from Upstream Mussel Site (noting the small, very young mussels)



4.3.3 Puaerahuri 2 (Location: E1802916, N5888546)

This reach was chosen to represent the low-catchment. It has an average width of 1.7 m, and an average depth of 0.25 m. All of this reach is riparian fenced, with a up to 20 m setbacks. The riparian vegetation is primarily rank pasture grasses, willow, and *Juglans ailantifolia*. This reach is just above the tidal area, but is tidally influenced. The riparian fenced areas do not appear to be grazed. The substrate, water depth in places, and tangled in-stream debris precluded the use of electric fishing and Fyke Nets, so the site was sampled using 10 Gee Minnow Traps set overnight. Table 8 shows the physical characteristics of, and species found in, this Puaerahuri 2 Sampling Reach

Table 8: Physical Characteristics of, and Species Found in, Puaerahuri 2 Sampling Reach

Species	Abundance	Length Range (mm)
Inanga	3	70-80
Freshwater Shrimp	42	-
Common Bully	15	45-75
Unidentified Bully	1	40
Banded Kokopu	1	70
Koura	1	-

Substrate type	%	Riparian Vegetation	%	Habitat Type	%	Fish Cover	Y/N
Bedrock	-	Native Forest	20	Still	-	Weed/Algae	Y
Boulder	-	Exotic	-	Backwater	-	In stream debris	Y
Cobble	-	Grass/Tussock	10	Pool	75	Undercut banks	Y
Coarse Gravel	30	Exposed bed	-	Run		Bank vegetation	Y
Fine Gravel	30	Scrub/Willow	70	Riffle	25	Overhead shade	Y
Sand	40	Raupo/Flax	-	Rapid	-	Substrate	Y
Mud	-	Other	-	Cascade	-		

Figure 11: Puaerahuri Stream Sampling Reach 2



(photos Jason Roxburgh-Living Matters, and Google Earth)

While surveying in the Hauarahi Stream, we spoke to another landowner who mentioned that he grew up on a farm in the mid-upper part of the Puaerahuri catchment, and can remember there being mussels right up to the foothills when he was a child (50+ years ago).

4.3.4 McCartie's Stream

In November 2010 DOC's then-Auckland Area Office carried out Gee Minnow trapping in McCartie's Stream, a small estuarine waterway with an exit 50 m south of the Puaerahuri, but effectively in the Puaerahuri catchment. The stream is 2-5 m wide, and 200-500 mm deep, depending on the tide. Eleven Gee Minnow traps were baited with Marmite, and set overnight. Table 8 shows the results for this sampling:

Table 8: Physical Characteristics of, and Species Found in, Puaerahuri 2 Sampling Reach

Species	Abundance	Length Range (mm)
Inanga	188	Not recorded
Long-finned Eel	23	
Gambusia affinalis	43	

Substrate type	%	Riparian Vegetation	%	Habitat Type	%	Fish Cover	Y/N
Bedrock	-	Native Forest	-	Still	-	Weed/Algae	Y
Boulder	-	Exotic	-	Backwater	-	In stream debris	Y
Cobble	-	Grass/Tussock	100	Pool	-	Undercut banks	N
Coarse Gravel	-	Exposed bed	-	Run	100	Bank vegetation	N
Fine Gravel	-	Scrub/Willow	-	Riffle	-	Overhead shade	N
Sand	50 ⁷	Raupo/Flax	-	Rapid	-	Substrate	N
Mud	50	Other	-	Cascade	-		

Considering that this stream is essentially a tidal, turbid farm drain, there were surprisingly large numbers of eels and Inanga found. DOC recommended to the landowner that suitable native vegetation be planted along the riparian margins, to provide cover and spawning habitat.

4.4 Hauarahi Stream

This stream is the northern-most, largest, and most diverse catchment of the streams surveyed. Its largely forested headwaters sit within the Auckland Water Supply reserve, and a large QEII National Trust covenant. The ford on Makeawa Road may be causing a barrier to Inanga, and other diadromous species that are not strong climbers. The stream has a relatively unimpeded exit to the sea, although it has been modified considerably through dredging to maintain a boat access channel.

⁷ From DOC description, and Living Matters observations

The stream flows through some dairy farm in its lower reaches, but mostly mixed dry stock farms in the mid-reaches, and mixed dry stock farms, and native forest in the upper catchment. The overall catchment vegetation is 65% farmland, 25% native forest, 5 % native scrub, and 5% exotic forest plantation. The stream substrate in most of the mid reaches of the catchment is quite compacted, with little loose material for fish to use as refuges or general habitat, but the lower and upper reaches have less compaction. The following three sampling sites were established as representative of the catchment:

4.4.1 Hauarahi 1 (Location: E1803592, N5890913)

This reach was chosen to represent the mid-catchment. It has an average width of 2.5 m, and an average depth of 0.4 m. All of this reach on the true left is riparian fenced with an up to 5 m setback, with the true right bordered by a Hauraki District Council Reserve. The canopy cover and riparian vegetation is largely tall Willow and Japanese Walnut. This reach is above the tidal area, but is tidally influenced. The substrate, water depth in places, and tangled in-stream debris precluded the use of electric fishing and Fyke Nets, so the site was sampled using 10 Gee Minnow Traps set overnight. Kākahi shells were found in this reach, as were quite high numbers of Triplefin (most likely the Estuarine Triplefin). This is primarily a marine species, but it also occurs in river estuaries throughout New Zealand. Triplefins were not found at the other low-catchment sites surveyed, and Eels were not found in this reach. Table 9 shows results for the reach:

Table 9: Physical Characteristics of, and Species Found in, Hauarahi Sampling Reach 1

Species	Abundance	Length Range (mm)
Common Bully	2	45-70
Inanga	26	70-120
Freshwater Shrimp	3	-
Triplefin species	6	65-80

Substrate type	%	Riparian Vegetation	%	Habitat Type	%	Fish Cover	Y/N
Bedrock	-	Native Forest	20	Still	-	Weed/Algae	N
Boulder	-	Exotic	-	Backwater	-	In stream debris	Y
Cobble	-	Grass/Tussock	10	Pool	75	Undercut banks	Y
Coarse Gravel	30	Exposed bed	-	Run	-	Bank vegetation	Y
Fine Gravel	30	Scrub/Willow	70	Riffle	25	Overhead shade	Y
Sand	40	Raupo/Flax	-	Rapid	-	Substrate	N
Mud	-	Other	-	Cascade	-		

Figure 12: Hauarahi Stream Sampling Reach 1



(photos Jason Roxburgh-Living Matters, and Google Earth)

4.4.2 Hauarahi 2 (Location: E1801140, N5889355)

This reach was chosen to represent the mid-catchment. It has an average width of 2.8 m, and an average depth of 0.3 m. All of this reach is riparian fenced with 5-10 m setbacks. The riparian vegetation has a canopy of Japanese Walnut, Grey and Crack Willows, Kanuka, Black Mamaku, and Puriri, with an understory of Mingimingi, Red Matipo, *Coprosma robusta* and *C. grandifolia*, Hangehange, Koromiko, 7-finger, Mahoe, Tutu, and Lemonwood. Weeds present in the understory and ground layers included Privet, Wild Ginger, *Tradescantia*, Montbrecia, Inkweed, Barberry, and Pampas. There is a significant ford downstream of this site, and it probably presents a barrier to non-climbing diadromous fish. This reach was sampled using electric fishing, and Table 10 shows the results for this reach

Table 10: Physical Characteristics of, and Species Found in, Hauarahi 1 Sampling Reach

Species	Abundance	Length Range (mm)
Common Bully	8	40-55
Cran's Bully	3	55-60
Unidentified Bully	15	20-55
Unidentified Eel	11	80-550
Long-finned Eel	6	120-550
Short-finned Eel	6	150-500
Koura	1	-
Torrentfish	1	150

Substrate type	%	Riparian Vegetation	%	Habitat Type	%	Fish Cover	Y/N
Bedrock	0.5	Native Forest	-	Still	-	Weed/Algae	Y
Boulder	-	Exotic	-	Backwater	4	In stream debris	Y
Cobble	34	Grass/Tussock	5	Pool	31.5	Undercut banks	Y
Coarse Gravel	34	Exposed bed	-	Run	42.5	Bank vegetation	Y
Fine Gravel	28	Scrub/Willow	95	Riffle	21.5	Overhead shade	Y
Sand	4.5	Raupo/Flax	-	Rapid	-	Substrate	Y
Mud	-	Other	-	Cascade	-		

Figure 13: Hauarahi Stream Sampling Reach 2



(photo Google Earth)

4.4.3 Hauarahi 3 (various upper catchment locations)

Substantial sampling was undertaken at three sites in the upper part of this catchment by Massey University and NIWA in January and March 2001, and recorded in the NZ Freshwater Database. Two of the three sites are inside the Auckland Water Supply area or private land. No information was available on their physical parameters, but they are vegetated in native forest cover with stock excluded. Table 11 shows the species

found at these sites:

Table 11: Physical Characteristics of, and Species Found in, the three Huarahi 3 Sampling Reaches

Site A (NZMS 260 S12, 2710600-6451500)

Species	Abundance	Length Range (mm)
Banded Kokopu	4	Not recorded
Common Bully	1	
Cran's Bully	13	
Common Smelt	3	
Long-finned Eel	6	
Koura	2	

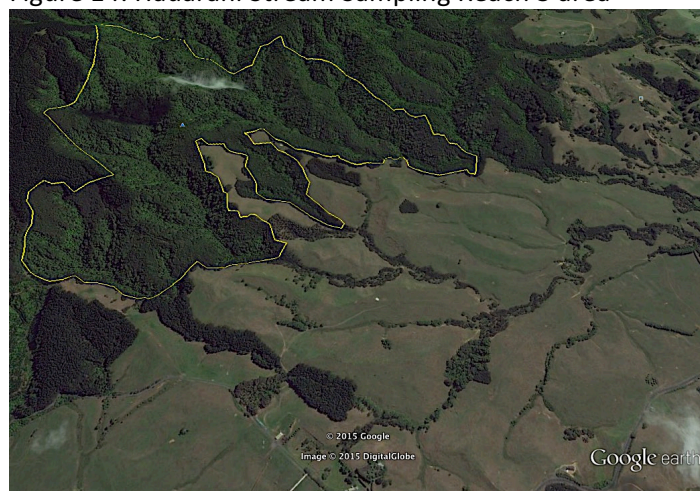
Site B (NZMS 260 S12, 2711500-6451000)

Species	Abundance	Length Range (mm)
Banded Kokopu	1	122
Cran's Bully	66	23-82
Common Smelt	10	78-94
Long-finned Eel	38	110-770
Short-finned Eel	48	102-380
Unidentified Eel	27	59-99
Torrentfish	5	46-89

Site C (NZMS 260 S12, 2711700-6450900)

Species	Abundance	Length Range (mm)
Banded Kokopu	2	54-57
Cran's Bully	93	27-79
Common Smelt	404	46-91
Long-finned Eel	30	103-750
Short-finned Eel	36	100-182
Unidentified Eel	12	67-94
Torrentfish	42	42-78
Inanga	60	46-119

Figure 14: Huarahi Stream Sampling Reach 3 area



(photo Google Earth)

5 Discussion

5.1 Miranda Stream

This stream's upper reaches are steep and small, so could not be reliably sampled. The substrate across the

sampling reaches, as across many sampling reaches in the other catchments, is quite compacted, and provide relatively little loose cobble and boulder material for fish to use as habitat and refuges. This appears to be at least partly natural, and may be reflected in the low diversity of species. All of the sampled reaches in this catchment were riparian fenced with setbacks of up to 50 m.

5.2 Taramaire Stream

This stream has a diverse catchment. The upper reaches are quite steep, and the waterways are small, so could not be reliably sampled. As with Miranda Stream, the substrate across the sampling reaches appears to be compacted, and provides relatively little loose cobble and boulder material for fish to use as habitat and refuges. This may be reflected in the low diversity of species, relative to the other streams in the sampling area. If the riparian areas of the sampling reaches are reflective of the whole catchment, then this stream has well-fenced and vegetated margins, with fencing setbacks of up to 50 m.

5.3 Puaerahuri Stream

This stream has a diverse catchment, though it is relatively small compared to the others sampled. As with the others, the upper reaches are quite steep, and the waterways are small, so could not be reliably sampled. The substrate in the areas of this stream that were sampled is not as compacted as in the Miranda and Taramaire. Since the water in this stream is relatively shallow, riparian shading of the site is important for maintaining the lower temperatures kākahi require. Thus any riparian planting plan will need to allow for new vegetation to grow up to shade the stream before removing old vegetation. This could involve planting on the north side first, leaving the southern side accessible for subsequent veg removal, or planting species that will shade out the existing weeds naturally over time.

5.4 Hauarahi Stream

This is the largest in terms of catchment and normal flows, and most diverse in terms of biodiversity and stream morphology. It has the most native vegetation of all the catchments, and has its headwaters almost fully forested. It appears to have the highest diversity of freshwater fish of the catchments

5.5 Other information from near, but outside, the study area

In April 2006 Ecoquest and NIWA undertook a study comparing electric and non-electric fishing methods, in Waihihi Stream, which is approximately ten kilometres north of the Hauarahi catchment. The Waihihi catchment is mostly forested, so differs considerably in that regard from the Miranda-Kaiaua catchments. In this study they found: Common Bully; Long and short-finned Eel; Smelt; Banded Kokopu; Torrentfish; Inanga; and Short-jawed Kokopu. Ecoquest also have other surveys of water quality and freshwater fish streams further north on the coast between Whakatiwai and Tapapakanga, and the information from these could be used as a comparison because these catchments are largely forested.

6 Recommendations

6.1 Pest Fish

The owner of the lower section of the Puaerahuri Stream reports *Gambusia* in the estuarine wetland adjacent to the Puaerahuri stream mouth (pers. com. Rob McCartie), and this was confirmed by DOC during a survey in November 2010. DOC Thames staff report catching Perch in Gee Minnow Traps in the tidal section of the Hauarahi in early 2015 (pers. com. Kevin Carter). The presence of these species warrants further investigation, particularly because the *Gambusia* site adjoins the area purchased by DOC from the McCartie Family at Rangipo Road. Although eradication of these species would be ideal, eradication of *Gambusia* is very difficult as females are able to store sperm for 6 months, so only one female needs to remain to reestablish the population (pers. com. Stella McQueen). However, if the extent of infestation is limited, it would be worth assessing the feasibility, particularly as part of the restoration of the Rangipo block. Assessing the areas surrounding these, and the other areas of similar habitat, would define the extent of the pest fish issues in the catchment

6.2 Riparian Protection Assessment and Fencing

The upper reaches of these streams have significant areas of indigenous vegetation, and considerable areas have riparian fencing. However, to protect both the catchment biodiversity, and that of the coastal strip and the Firth, an assessment of stock exclusion and riparian protection of the waterways in the catchment would identify the extent of existing protection, and enable prioritisation of currently unfenced areas. The lower reaches of all five streams in the area are highly modified, and all have been channelized and/or straightened to varying degrees.

The area from Miranda to Kaiaua is part of a larger area that is the only part of the Waikato Region that does not pay a Catchment Management Rate to Waikato Regional Council (WRC). This means it does not receive WRC subsidies to exclude stock, replant, and retire areas from grazing to protect water quality and reduce erosion. Despite this, landowners in the area appear to have protected as much riparian land as others in the region (pers. com. Warren Coffey, WRC Catchment Management Officer). There are large areas of existing riparian vegetation, at least some of which has fencing and/or protection, in the:

- Mid-upper parts of the Taramaire (e.g. on the Gasson, Twomey, and Glover properties);
- Puaerahuri (e.g. on the deJongh, and Hayward properties);
- Miranda (e.g. on the Dalton, Lo, and Roberts properties);
- Hauarahi (e.g. on the Thompson, West, and Olsen properties);

These are key to at least maintaining water quality in these catchments, and knowing the extent of stock exclusion in these riparian areas is key to understanding and planning water quality improvements. Assessing the current state of stock exclusion would enable prioritisation of effort to maximise improvements in water quality (for nutrients, sedimentation, and fecal coliforms) in the streams, and in the Firth of Thames).

The landowner in the mid and lower Puaerahuri (Rob McCartie) is particularly interested in protecting the riparian areas on this property, and would be worth approaching to discuss this issue. However, in this case caution needs to be taken as removing the existing shade too quickly could have a negative impact on Kākahi, who do not tolerate temperature fluctuations well.

6.3 Kākahi

Live Kākahi were found in the Miranda and Puaerahuri Streams, with surprisingly high numbers in the latter. Shells were found in the Hauarahi, so it is likely Kākahi are present in this stream as well. Although Kākahi are widespread across the country, they have suffered serious decline, so finding such large numbers in the Puaerahuri warrants further investigation of at least this stream, if not other areas with suitable habitat. Knowing their extent would enable prioritization of effort for their protection.

6.4 Eels

Eels were found in all but the lower catchment sites in the Miranda, Hauarahi, and Puaerahuri Streams, indicating eels might be scarce at in the lower elevation, highly modified parts of these catchments. Gary Dalton and Pete Gasson report large ponds on their properties (Miranda and Taramaire respectively) that contain high numbers of eels. If these landowners were amenable, these sites, and potentially other similar ponds, could be a source of eels for cultural harvest or restocking other parts of the catchment.

6.4 Establishing the extent of former estuarine areas

The Miranda, Pukorokoro, and possibly the Taramaire, probably once flowed into a large shallow estuary. Given the focus to date on the coastal strip, establishing the extent of this former estuarine area could help guide restoration efforts in this central focus area, particularly if land purchases are being considered for land between the Miranda and Taramaire outlets. This could also include getting a better idea of the original path of Pukorokoro Stream.

6.5 Significant areas of native forest, and potential for land protection

There are a range of larger areas of indigenous vegetation in these catchments, including (but not limited to):

- A large QEII National Trust covenant on private land in the headwaters of the Hauarahi (details available

on request, if the landowner is amenable), and this is protected in perpetuity. There is probably potential for other private land areas to be protected through QEII National Trust covenants in the catchment.

- The headwaters of the Huarahi are contained within the Auckland Council's Water Supply Reserve, and public conservation land.
- The Thompson's forest block straddling the mid-Taramaire and Puaerahuri catchments is significant as there is little continuous native vegetation in the mid catchments of these streams. The Thompsons have apparently expressed a desire to give the block some form of protection in the past. Ecoquest have carried out a considerable amount of ecological assessment in the block. If the landowner were amenable, Ecoquest would be an excellent partner in achieving stock exclusion and ecological restoration of this block. Potential protection could be progressed with the assistance of the QEII National Trust, and Waikato Regional Council.
- One landowner contacted for permission to work on his property (Rob McCartie on the Puaerahuri Stream), is particularly enthusiastic about the local environment and history. It would be well worth approaching him (and his adjoining neighbor to the west) to discuss the protection of freshwater values in the Puaerahuri Stream. Rob also has a large and particularly significant Pa site (Rangipo) on his land. At his request, his contact details were passed on to Lynette Benson, the local QEII National Trust Regional Representative, regarding potentially covenanting the site.

6.6 Potential barriers to fish passage

There are several vehicle and stock fords in the catchment that could be causing physical and/or water velocity barriers to fish passage for diadromous species. These include (but are not limited to) Makeawa Road crossing the Huarahi; at least two crossing the channelised lower reaches of the Puaerahuri; and the Fairview Road ford crossing the Taramaire. An assessment of the full catchment for barriers to fish passage would be quick and straightforward, and help plan which areas of the overall area that could be focused on for the best biodiversity gains.

6.7 Inanga spawning sites

Relatively large numbers of Inanga were found in the low-catchment sites in the Huarahi, Puaerahuri, and Miranda Streams, and Inanga are likely present in the Taramaire too. Locating their spawning sites in these streams, and establishing what could be done to protect and enhance them, would be a good step toward restoring the freshwater fishery in these catchments. This could also be a good way to involve landowners in the Living Waters programme.

6.8 Non-biodiversity values

The large and significant Rangipo Pa sits atop Rangipo Hill on McCartie's property. Rob McCartie has already sought specialist archaeological input for its protection, and grazes it only with lightweight stock. Rangipo has probably the best view of the five catchments, and could be a good focal point for interpretation of the wider catchment, as well as the cultural history of the area.

7 Acknowledgements

This work was undertaken on several landowners' properties across the five catchments, without whose permission to work on their land, and observations on the freshwater values in their stream, this work would not have been possible, including:

- Gary, Adrienne, and Mark Dalton in the Miranda catchment
- Pete Gasson in the Taramaire catchment
- Rob McCartie in the Puaerahuri catchment
- AJ Bull in the Huarahi catchment

Keith Woodley from the Miranda Shorebird Centre provided information on the catchment, and Ria Brejaart and Jono Clark from Ecoquest generously provided data and reports they and their students have collected

through various studies over the past 15+ years. Kessels Ecology, and Waikato Regional Council supplied electric fishing machine and equipment for this work, and DOC supplied the Gee Minnow traps used.

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Appendix 1: Puaerahuri Reach 2 Mussel Raw Data

Puaerahuri 2 Upstream		Puaerahuri 2 Downstream	
Length	Depth	Length	Depth
65	18	75	21
85	21	62	16
61	16	61	16
62	26	63	17
64	20	55	15
50	12	59	15
68	17	60	14
59	12	65	17
68	23	80	20
52	12	45	11
56	14	60	17
28	11	64	18
65	13	59	16
55	14	58	16
57	16	60	17
63	17	63	19
64	18	62	17
44	10	61	15
78	17	60	18
65	19	62	18
52	15	63	19
67	17	62	17
61	16	60	18
90	21	62	20
61	16	64	17
65	18	65	18
50	13	60	14
45	11	66	17
50	15	59	15

65	16	81	20
69	20	64	18
64	18	65	18
66	20	65	19
64	16	60	16
60	17	62	16
62	18	59	20
60	16	67	21
59	17	70	18
62	17	60	18
59	15	63	16
60	17	65	17
67	19	62	19
63	19	61	15
60	17	61	15
33	8	78	17
35	7	52	12
17	5	61	20
10	3	64	17
48	10	63	18
42	11	61	18
69	18	45	11
63	17	41	8
47	12	64	16
54	14	57	17
69	20	36	7
61	18	24	10
58	18		
40	17		
51	12		
63	19		
61	16		
58	15		
65	17		
48	11		
49	17		
52	14		
60	18		