Ecological and physical characteristics of the Te Awa O Katapaki Stream, Flagstaff, Waikato

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EXECUTIVE SUMMARY

1. The fish, macroinvertebrates, aquatic vegetation, and water quality indicate that the Te Awa O Katapaki Stream is an unpolluted, pastureland stream that is typical of the Waikato region.

2. The stream has very high nutrient concentrations that probably result from the dairy farming upstream.

3. The fish fauna is dominated by the native shortfinned eels. The presence of the migratory common smelt indicates that swimming fish species also have free access to the stream from the Waikato River.

4. Fish of high conservation value, such as giant or banded kokopu (*Galaxias argenteus* or *G. fasciatus*) were absent, which is predictable given the warm, unshaded nature of the stream.

5. Fish and invertebrates would soon recolonise the restored stream following any work in the streambed.

INTRODUCTION

On 22 August 2001 McPherson Goodwin Surveyors requested an evaluation of the ecological and physical characteristics of the Te Awa O Katapaki Stream, Flagstaff, Waikato. This stream flows through pastureland that will become part of an extension of the Flagstaff subdivision, and joins the Waikato River on its true right bank. The study sites are at about map reference S14 27805 63835 (Figure 1), and the purpose of this report is to describe the ecological conditions in this stream.

SITE DESCRIPTION

The Te Awa O Katapaki Stream, Flagstaff, drains 385 ha of land at the Magellan Rise culvert. The principal land use upstream is dairying. The stream channel is incised 0.8-1.0 m between steep banks, a condition typical of pasture streams in the Waikato. Channel conditions were surveyed at three sites within the 180 m of stream between the Sylvester Road culvert (Figure 3).and the Magellan Rise culvert (Figure 4). The water surface width increased in a downstream direction from 0.83 to 2.10 m (Table 1). Mean depths ranged from 0.25 to 0.35 m, but individual depths in the channel were more variable (0.10-0.68 m). Considerable amounts of flocculant iron hydroxide clung to the submerged vegetation at site 3, and appeared to originate from the small tributary entering the stream from the true left bank at site 3.

Site 1 was the narrowest, but had a deep pool that had developed immediately downstream of a fabric sediment trap in position across the channel (Figure 5). Site 2 was slower flowing and wider than site 1, and had finer substrate (Figure 6). Site 3 was immediately upstream of the Sylvester Road culvert, where a small tributary joined from the true left (Figure 7).

Figure 3. The outlet of the culvert under Sylvester Road on 21 September 2001, showing the drowned invert (photo: Brendan Hicks, 21 September 2001).

Figure 4. The 3m by 3m concrete culvert under the proposed Magellan Rise (photo: Brendan Hicks, 21 September 2001).

Table 1. Water surface widths, depths, and area of the sites that were electroshocked on the Te Awa O Katapaki Stream, Flagstaff, Waikato, on 20 September 2001.

Site	Width (m)	Depth (m)			Stream bed
		1	2	3	
1	0.70	0.17	0.22	0.12	Sand and very fine gravel - quite firm
1	0.63	0.17	0.22	0.15	
1	0.70	0.10	0.13	0.16	
1	0.97	0.17	0.22	0.14	
1	1.15	0.65	0.68	0.52	
Mean	0.83	0.25			
Length (m)	13.5				
Area (m^2)	11.2				
2	1.90	0.26	0.30	0.15	Sand, silt, and mud - very soft. 30-40 cm deep sediment above firm clay bottom
2	1.95	0.15	0.32	0.18	
2	1.93	0.16	0.38	0.34	
2	1.85	0.18	0.28	0.22	
2	1.85	0.13	0.16	0.16	
Mean	1.90	0.22			
Length (m)	11.5				
Area (m^2)	21.8				
3	1.87	0.41	0.44	0.45	Very fine gravel, quite firm
3	2.00	0.33	0.36	0.51	
3	2.42	0.33	0.36	0.51	
3	2.10	0.16	0.18	0.12	
Mean	2.10	0.35			
Length (m)	8.5				
Area (m^2)	20.6				

Figure 5. Site 1, showing its narrowness, the two sediment traps across the stream, ungrazed pasture grasses on the margins, and the Magellan Rise culvert upstream (photo: Brendan Hicks, 20 September 2001).

Figure 6. The narrow site 2, showing its wide, slow flowing nature (photo: Brendan Hicks, 20 September 2001).

Figure 7. Riparian vegetation at site 1, including a large Chinese privet (photo: Brendan Hicks, 20 September 2001).

METHODS

The stream was gauged in 21 September 2001 using a Marsh-McBirney Flo-mate model 2000 portable flow meter. There were nine measurement points across a smooth cross section 1.03 m in width. Nutrient analyses were conducted by R. J. Hill Laboratories Ltd, Hamilton, on two water samples taken on 21 September 2001. These analyses conformed to the standards of International Accreditation New Zealand (IANZ), which was formerly known as Telarc certification (http://www.ianz.govt.nz).

Electroshocking was conducted at three sites with a Kainga EFM 300 battery powered electroshocker. Fine-meshed block nets (5-mm mesh size) were positioned at the upstream and downstream ends of each site. Two passes were made in an upstream direction, and fish from each pass were kept separate. Population size was estimated from the removal-method equations of Zippin (1958; in Armour et al. 1983).

The lengths of all fish were recorded after anaesthetising with benzocaine, and the eels and the smelt were weighed. After this procedure fish were allowed to recover and were released back into the stream.

Macroinvertebrates were sampled by two methods. Vegetation in the stream at the margins was sampled with a 250 μm mesh net on a pole. At each site, 10 sweeps were made and the collected vegetation and macroinvertebrates were preserved in 40% ethanol for later identification. Also at each site, a single sample of about 1000 cm^3 of sediment to a depth of about 3 cm was collected and preserved with 40% ethanol. Insects were identified from the keys of Winterbourn et al. (2000). Molluscs were identified using Winterbourn (1973). The macroinvertebrate community index score for presence or absence of key taxa was calculated by the methods of Stark (1993). Pasture weeds on the riparian margins were identified using Roy et al. (1998).

RESULTS

Water quality and discharge

The stream discharge on 21 September 2001, after a prolonged period with little or no rainfall, was 0.0144 $m^3\ s^{-1}$ (14.4 $l\ s^{-1}$ or 3.74 $l\ s^{-1}\ km^{-2}$). The water temperature (13.2-16.3°C) was relatively high for the time of year (Table 2). While dissolved oxygen was within acceptable limits, specific conductance was extremely high. Specific conductance is an indicator of nutrient status, and was 273.7±1.1 μSeimens cm^{-1} (mean±95% confidence interval; Table 2). The concentrations of plant nutrients (nitrogen and phosphorus) were also very high (Table 3). pH, a measure of the acid or basic nature of the stream, was also high, indicating a tendency to be basic. New Zealand streams are typically poorly buffered, and the action of in-stream photosynthesis often elevates pH during the day in the presence of abundant plant nutrients.

Table 2. Water quality at three sites on the Te Awa O Katapaki Stream, Flagstaff, Waikato in 21 September 2001. Specific conductance is conductivity standardised for 25°C.

Date	Site	Time (h)	Temperature (°C)	Dissolved oxygen ($g\ m^{-3}$)	Dissolved oxygen (%)	Specific conductance (μSeimens cm^{-1})	Conductivity (μSeimens cm^{-1})	pH
20 Sep	2	0930	13.2	9.07	86.4	274.9	212.2	9.2
20 Sep	3	1100	14.5	9.96	97.0	274.3	218.9	8.6
21 Sep	1	1149	16.2	10.46	106.5	273.1	227.2	7.8
21 Sep	2	1146	16.3	10.82	110.4	272.6	226.9	8.0
21 Sep	3	1143	16.0	10.60	107.4	273.8	226.4	8.2

Table 3. Available nutrients in the Te Awa O Katapaki Stream, Flagstaff, Waikato, on 21 September 2001.

Nutrient form	Concentration (g m^{-3})		Derivation
	Sample 1	Sample 2	
Total ammoniacal-N (TAN)	0.18	0.18	Measured
Total Kjeldahl nitrogen (TKN)	1.1	1.2	Measured
Total organic nitrogen	0.92	1.02	TKN minus TAN
Nitrate-N + nitrite-N (TON)	1.54	1.66	Nitrate-N+nitrite-N
Nitrate-N	1.48	1.61	Measured
Nitrite-N	0.053	0.058	Measured
Dissolved inorganic nitrogen (DIN)	1.72	1.84	TON+TAN
Total nitrogen (TN)	2.46	2.68	TON+TKN minus TAN
Dissolved reactive phosphorus (DRP)	0.016	0.014	Measured
Total phosphorus (TP)	0.127	0.123	Measured
Nitrogen:phosphorus ratio	19.4 :1	21.8 :1	TN:TP

Fish

A total of 59 fish were caught in 54 m^2 of stream, including 39 shortfinned eels (*Anguilla australis*), 19 mosquitofish (*Gambusia affinis*), and one common smelt (*Retropinna retropinna*; Table 4). From the removal electroshocking population estimates were made for each site (Table 5). Because of the small size of the stream, fish densities on an areal basis were high (up to 1.10 fish m^{-2} for shortfinned eels). The single common smelt demonstrates that access to the Waikato River is possible for swimming species. Climbing species such as eels clearly have no difficulty reaching the site. The invert of the culvert at Sylvester Road (Figure 3) is below the water surface level, so presents no barrier to upstream migration.

Table 4. Number of fish caught by electroshocking at three sites on the Te Awa O Katapaki Stream, Flagstaff, Waikato, on 20 September 2001.

Site	Number of fish caught at each site			
	Shortfinned eels	Mosquitofish	Common smelt	Total
1	9	5	0	14
2	23	14	1	38
3	7	0	0	7
Total	39	19	1	59

Table 5. Fish densities estimated by electroshocking at three sites on the Te Awa O Katapaki Stream, Flagstaff, Waikato, on 20 September 2001. 95% CI = 95% confidence interval.

Species	Fish caught			Capture	Population estimate		Area	Fish density
	Pass 1	Pass 2	Sum	probability	Number	95% CI	fished (m^2)	(no. m^{-2})
Site 1								
Shortfinned eels	8	1	9	0.88	9.1	0.98	11.2	0.82
Mosquitofish	4	1	5	0.75	5.3	1.99	33.3	0.16
Site 2								
Shortfinned eels	19	4	23	0.79	24.1	3.24	21.8	1.10
Mosquitofish	10	4	14	0.60	16.7	8.31	21.8	0.76
Common smelt	1	0	1	1.00	1.0	0.00	21.8	0.05
Site 3								
Shortfinned eels	5	2	7	0.60	8.3	5.88	20.6	0.40

Mean fish weight

The relationship of weight to length for the shortfinned eels, calculated from the electroshocking data in Appendix 1, was

$$Y = -14.87 + 3.302\,X,$$

where Y = natural log of weight in g and X = natural log of total length in mm ($P << 0.001$, $r^2 = 0.99$, $N = 37$). In the form of a power equation, this relationship is

$$Y = 3.48 \times 10^{-7}\,X^{3.302},$$

where Y = weight in g and X = total length in mm.

Biomass of eels was calculated from the combination of estimated eel density (Table 6) and the mean weight of eels at each site. Estimated eel biomass was high (239-343 g m^{-2}).

Table 6. Geometric mean weights and biomass of shortfinned eels caught by electroshocking at three sites on the Te Awa O Katapaki Stream, Flagstaff, Waikato, on 20 September 2001.

Site	*N*	Mean weight (g)	Biomass (g m^{-2})
1	9	420	343
2	23	328	363
3	7	591	239

Macroinvertebrates

For a lowland stream, the Te Awa O Katapaki Stream had a relatively diverse macroinvertebrate fauna indicative of clean water. A common method of determining the extent of pollution in a stream is the macroinvertebrate community index (MCI). This represents the mean score of pollution intolerance for a community multiplied by 20 (Stark 1993). The MCI score for individual taxa can take values from 1 to 10, where 10 indicates extreme intolerance of pollution, and 1 indicates high tolerance of pollution (Stark 1993). Though unpolluted, upland, stony streams usually score most highly (MCI = 120-160), mainly because of their cobble beds and cool-water fauna such as mayflies and stoneflies, lowland streams can also be ranked by this index. MCI values in the Te Awa O Katapaki Stream ranged from 33-68, and the highest values were associated with sweep samples collected from submerged vegetation (Table 7). These scores are quite high for warm, lowland streams with soft beds.

The damselflies in particular require moderately unpolluted water, as shown by their relatively high MCI score (5-6). The larval cranefly (*Paralimnophila* sp.) and the undescribed species of amphipod (*Paraleptamphopus* sp.; MCI score 5-6) also require moderately unpolluted water. The marginal vegetation held a more diverse aquatic fauna than the fine sediments, which were dominated by oligochaete worms. Simpson's diversity index is a useful measure of the biodiversity of the aquatic macroinvertebrate fauna, and can take values from 1 (high) to 0 (low). The Simpson's diversity index for the Te Awa O Katapaki Stream was variable, but was quite high for one sample from vegetation, especially considering the limited sampling undertaken.

Table 6. Number, diversity, and macroinvertebrate community index (MCI) score of macroinvertebrates at three sites in the Te Awa O Katapaki Stream, Flagstaff, Waikato, on 21 September 2001.

Taxon	MCI	Number of individuals per sample					
		Vegetation			Sediment		
		Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
Trichoptera (caddis flies)							
Oxyethira albiceps	2	2	14				
Odonata (damselflies)							
Austrolestes colensonis	6	1					
Xanthocnemis zealandicus	5	1	5				
Diptera (two-winged flies)							
Simuliidae (sandflies)							
Austrosimulium	3		3		1		
Tipulidae (crane flies)							
Paralimnophila sp.	6		1				
Chironomidae (midges)							
Chironomus zealandicus	1		5	16	1	4	
Polypedilum sp.	3	12			1	1	2
Orthocladiinae	2		6	4			
Crustacea							
Amphipoda							
Paraleptamphopus sp. (undesc.)	5		1				
Mollusca							
Physa	3		2	4			
Oligochaeta (worms)	1	5	16	5	11	26	37
Hirudinea (leeches)	3		2				
Total		19	41	29	14	31	39
MCI		68	62	35	40	33	40
Number of taxa		5	10	4	4	3	2
Simpson's diversity		0.60	0.82	0.63	0.37	0.28	0.10

Riparian vegetation

Ungrazed pasture grasses formed the riparian vegetation throughout most of the reach, including a mixture of rye grass, cocksfoot, Yorkshire fog, white clover (*Trifolium repens*), with occasional creeping buttercup (*Ranunculus repens*), buck's horn plantain (*Plantago coronopus*), ragwort (*Senecio jacobeaea),* Californian thistle (*Cirsium arvense*), rushes (*Juncus* sp.), and gorse (*Ulex europeaus*). In addition to the pasture grasses, clover, and weeds at site 2 was bracken fern (. At site 3, near the Sylvester Road embankment, there were several large tree privets (*Ligustrum lucidum*, to 6 m tall) that were draped with Japanese honeysuckle (*Lonicera japonica*). Close to the stream were blackberry (*Rubus fruticosus* agg.), wild onion (*Allium* sp.), and cutty grass (*Carex* sp.). In places, long grass and cutty grass dangled into the stream.

In-stream vegetation

Algae attached to the stream bed or marginal plants are collectively known as periphyton. The filamentous green alga *Microspora* sp. was abundant in the upper half of the stream and on the concrete apron and boulder riprap below the culvert. Attached to the filaments of *Microspora* sp. were dense growths of the diatom *Synedra ulna*. *Microspora* is common and widespread, and may proliferate in enriched cold streams. *Synedra ulna* also grows well in response to nutrients, and can dominate the periphyton in enriched lowland streams (Biggs and Kilroy 2000). Also present in the algal samples were *Nitzshcia* sp. or *Hantzshcia* sp., *Navicula* sp., *Gomphonema* sp., *Euglena* sp., *Eunotia* sp., and *Neidium* sp.

Floating at the stream margins at site 1 was starwort (*Callitriche stagnalis*) and floating sweetgrass (*Glyceria fluitans*). In places, willowherb (*Polygonum* sp.) draped into the stream from the margins. At site 2, flowering watercress (*Nasturtium officianale*) occupied limited areas of the stream margins.

Birds

The only birds observed during the site survey were three pukekos (*Porphyrio porphyrio*) that were foraging along the stream margins near sites 2 and 3. Pukekos are common in the Waikato region.

DISCUSSION

The fish, macroinvertebrates, aquatic vegetation, and water quality indicate that the Te Awa O Katapaki Stream is an unpolluted, pasture-land stream that is typical of the Waikato region. The stream is a highly productive because of the high nutrient concentrations, which most probably result from the dairying activities upstream. The intensive nature of dairy farming, including fertiliser applications, dung and urine deposition, and disposal of cow-shed effluent are well-known contributors to the high nutrient status of waterways in some regions of New Zealand.

The fish community was dominated by shortfinned eels, a native fish species. Estimates of eel biomass in this study (239-343 g m^{-2}) exceed by 3-4 fold those for hill country streams in pasture at Whatawhata (77 g m^{-2}; Hicks and McCaughan 1997). The presence of the migratory common smelt indicates that swimming fish species also have free access to the stream from the Waikato River. Common smelt are seasonal visitors to tributary streams of the Waikato River, and are likely to be most abundant in summer.

Fish of high conservation value that are found in streams elsewhere in the Waikato region, such as giant or banded kokopu (*Galaxias argenteus* or *G. fasciatus*) were absent, which is predictable given the warm, unshaded nature of the Te Awa O Katapaki Stream.

ACKNOWLEDGEMENTS

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Appendix 1. Lengths and weights of fish caught by electroshocking at three sites on the Te Awa O Katapaki Stream, Flagstaff, Waikato, on 20 September 2001.

Site	Species	Pass	Length (mm)	Weight (g)
1	sf eel	1	645	685.5
1	sf eel	1	692	954.8
1	sf eel	1	612	635.2
1	sf eel	1	515	316.0
1	sf eel	1	650	
1	sf eel	2	552	378.0
1	sf eel	2	500	
2	sf eel	1	545	445.0
2	sf eel	1	612	596.0
2	sf eel	1	695	903.6
2	sf eel	1	410	149.6
2	sf eel	1	422	150.0
2	sf eel	1	341	61.5
2	sf eel	1	303	54.5
2	sf eel	1	372	95.5
2	sf eel	1	576	435.8
2	sf eel	1	630	632.8
2	sf eel	1	268	35.0
2	sf eel	1	381	109.8
2	sf eel	1	315	60.6
2	sf eel	1	200	13.8
2	sf eel	1	290	46.2
2	sf eel	1	249	25.9
2	sf eel	1	256	35.0
2	sf eel	1	220	18.9
2	sf eel	1	275	40.9
2	sf eel	2	311	54.7
2	sf eel	2	218	16.6
2	sf eel	2	228	20.8
2	sf eel	2	122	4.0
2	smelt	1	81	1.1
2	mosquitofish	1	25	
2	mosquitofish	1	32	
2	mosquitofish	1	26	
2	mosquitofish	1	25	
2	mosquitofish	1	26	
2	mosquitofish	1	33	
2	mosquitofish	1	23	
2	mosquitofish	1	30	
2	mosquitofish	1	31	
2	mosquitofish	1	22	
2	mosquitofish	2	37	
2	mosquitofish	2	24	
2	mosquitofish	2	20	
2	mosquitofish	2	15	
3	sf eel	1	649	706.2
3	sf eel	1	552	371.7
3	sf eel	1	440	177.0
3	sf eel	1	267	33.2
3	sf eel	1	486	240.0
3	sf eel	1	455	217.0
3	sf eel	1	364	96.0
3	sf eel	1	386	124.0
3	sf eel	2	310	50.9
3	mosquitofish	1	45	
3	mosquitofish	1	2	
3	mosquitofish	1	17	
3	mosquitofish	1	21	
3	mosquitofish	2	22	

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