

Whangamata Wastewater Scheme
Biological Sampling for Waikiekie Stream
Annual Resource Consent Compliance Report - June 2004

Kessels & Associates Ltd
ecology & environmental planning

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1 Introduction

Environment Waikato (EW) resource consents granted to Thames Coromandel District Council (TCDC) allow for the spray effluent disposal of treated effluent from Whangamata township. Variation of the original consent conditions altered the consent condition to reflect previous monitoring which had been carried out in the Waikiekie Stream in 1999 and 2000 as described in the June 2000 report, "*Whangamata Sewerage Biota Study*" (Kessels, 2000) as well as specifying continued biological monitoring requirements as detailed in Section 2 of this report. Accordingly, Condition 17 of Consent No. 940707 states:

"The consent holder shall undertake a biological sampling programme of the Waikiekie Stream. Sampling locations shall be at least, three of the four existing survey sites as detailed in the report "Whangamata Sewerage Biota Study" (Kessels & Associates, June 2000), one upstream and two downstream of the influence of the irrigation scheme. Sampling frequency shall be in Late December and then again in Late March.

Stream biological monitoring shall include as a minimum algal and macrophyte growth and macro invertebrate assessment and shall be in general accordance with the methods detailed in 'Thames Coromandel District Council, Whangamata Wasterwater Scheme, Application to Change Resource Consent Conditions (Revised to include supplementary information)', dated 30 April 2001, by Montgomery Watson. The design of the sampling shall be forwarded to the Waikato Regional Council for written approval prior to the first sampling being undertaken."

This report presents and discusses the results of the biological monitoring programme of the Waikiekie Stream carried out on 15 February 2002, 27 March 2002, 16 December 2002, 24 March 2003, 9 April 2003 (electric fishing only) and 26 May 2004.

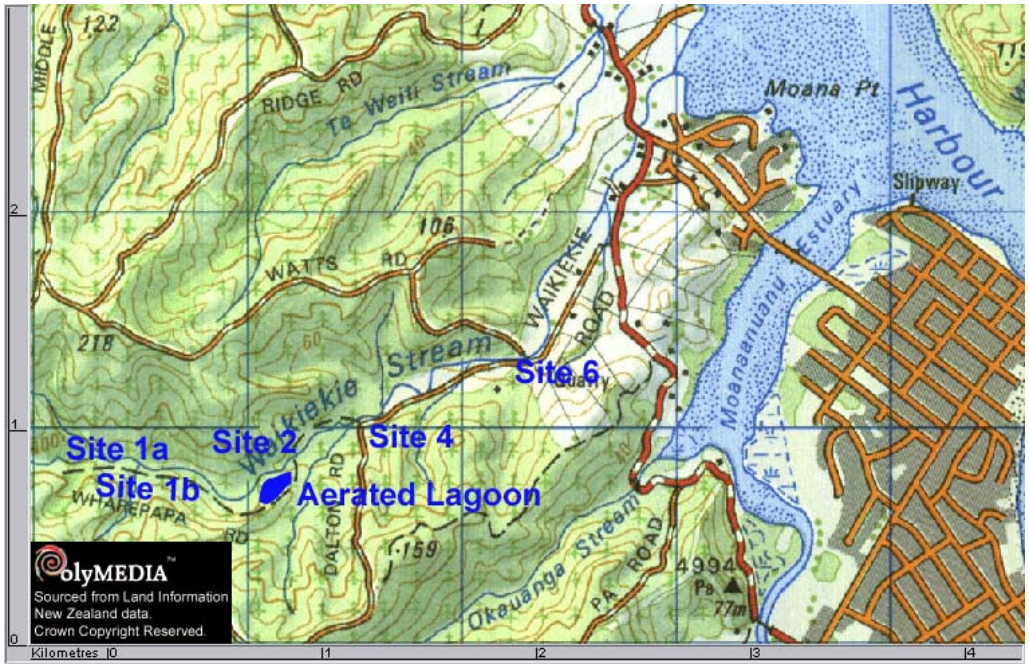


Figure 1. Location of Sampling Sites

2 Methodology

2.1 Survey Sites

Site selection was based on the five sites selected by Penny (1988) and Kessels (1999). In order to allow comparison with the sites used by Penny (1988 & 1991) and Kessels (1999 & 2000) the same site numbers have been used. The locations of the sites are shown in Figure 1. Grid references are approximately:

- Site 1a: NZMS 260 T12 615 398
- Site 1b: NZMS 260 T12 610398 (not surveyed in 2002/2003/2004)
- Site 2: NZMS 260 T12 623 398 (not surveyed in 2002/2003/2004)
- Site 4: NZMS 260 T12 624 400
- Site 6: NZMS 260 T12 634 403

Sites 1, 4 and 6 were sampled for algal and macrophyte growth, aquatic macroinvertebrate larvae and fish.

2.2 In-stream Vegetation

Surveys conducted from March 2002 onwards were based on survey methods described below and on criteria outlined by MFE(1991). The February 2002 survey was based on the MFE 1992 guidelines only.

Specifically, three transects were taken at Sites 1, 4 and 6 at 10-metre intervals. At each transect 3 samples were taken evenly spaced across the transect using a 6.5cm diameter viewing bowl. Within each glass bowl, periphyton abundance, distribution and type was visually assessed on the substrate using the following criteria:

- Thin Mat or film (less than 0.5mm thick) - Green, light brown or black/dark brown.
- Medium mat (0.5 to 3mm thick) - Green , light brown or black/dark brown.
- Thick mat (more than 3mm thick) - Green , light brown or black/dark brown.
- Short filaments (less than about 2cm long) - Green, brown/reddish.
- Long filaments (more than about 2 cm long) -Green, brown/reddish.

The percentage cover of each periphyton type at each transect was estimated and then averaged for each site for each sampling episode.

2.3 Aquatic Macroinvertebrate Composition

Macroinvertebrate assessment was undertaken at 3 of the existing sites (one upstream and 2 downstream) using a 0.25mm standard Surber sampler ($0.1m^2$). Four replicates were taken per site – from the riffle environment in random placement, moving upstream as samples were taken and combined to form a single composite sample for each site[1]. Samples were chilled and preserved in diluted isopropyl alcohol and taken to the laboratory for analysis by a taxonomist (Dr T. Wornoski of Water Care Services Ltd., Auckland). Macroinvertebrate Analysis was assessed using the following metrics as well as identification and abundance of taxa:

a) Macroinvertebrate Community Index (MCI); and

b) Ephemeroptera, Plecoptera, Trichoptera (EPT Taxa criteria).

[1] Note that two composite samples per site were taken in the 26/05/04 survey – which were averaged for the data analysis.

MCI is used to describe the general health of a stream based on abundance, taxonomic richness and pollution/habitat tolerance of the animals within the sample. The MCI values can theoretically range from 20 to 200. However, streams generally do not have an MCI of over 150 (Stark, 1985). Streams with an MCI above 120 are believed to be of pristine condition with very good water/habitat quality. Only streams that are very polluted or have poor habitat will have scores of less than 95 (refer to Table 1).

The EPT criteria provide a guide to the ecological health of the stream, as these "EPT" insects (stonefly, caddisfly and mayfly larvae) are very sensitive to pollution, particularly nutrients/sediments and habitat modification. Generally, for a stream of average water/habitat quality, the EPT Taxa numbers would range from 3 to 9. For a stream of "pristine" quality this number can be very high – above 20 EPT species. Streams with a score below 3 are either of poor water quality or poor substrate habitat.

Table 1 MCI Habitat Score Assessment Chart

Macroinvertebrate Community Index Score	Habitat Quality
>125	Very Good habitat quality
116 – 125	Good – Moderate habitat quality
106 – 115	Moderate habitat quality
95 – 105	Moderate –Poor habitat quality
<95	Poor habitat quality

2.4 Fish

Estimation and analysis of fish population parameters was conducted using the electric-fishing methods as detailed in Allibone (2000).

The electric fishing surveys were supplemented with spotlight sampling over one night – usually the night following the electric-fishing survey.

All electric-fishing survey was undertaken using a certified NIWA "Kainga" model back pack Electro-fishing machine. The presence/absence of particular fish species was assessed by fishing a 50-metre reach up to three times at Sites 1 and 6. Run/riffle, pool and backwater habitat was found in each reach to ensure that all potential fish habitats were surveyed.

Spot light survey was carried out at four sites - Site 1 upstream, Sites 4 & 6 downstream as well as in the vicinity of the State High 25 bridge over the Waikiekie Stream, approximately 1km downstream of Site 6.

3 Results & Discussion

3.1 Stream Morphology

The substrate of Waikiekie Stream changes from one characterised by boulders and sands at the upstream site to one dominated by cobbles and coarse gravel at the downstream site (Table 2). Stream width, wetted width, depth profiles and mean water velocity also reflect changes as the topography flattens and water volumes increase (Table 2). Water depths and mean water columns were typical for streams found in the Coromandel Peninsula (Kessels, 1995; Kessels, 1999a, Kessels, 2000).

Stream bank vegetation, shading and stability at each site are shown in Table 3. The catchment vegetation is dominated by pine forest with secondary indigenous vegetation and common exotic weeds growing along the stream margins and exposed sites.

Vegetation on the stream banks delineates the terrestrial aquatic interface and to a great extent controls erosive activities such as undercutting of the banks. Riparian vegetative canopy cover was highest at Site 1 (80%) than at Site 4 and Site 6 (30-

40%). This cover affects the amount of sunlight reaching the water, which in turn affects the growth of the aquatic plants. The canopy cover also provides detritus matter which becomes a food source for many organisms in the stream.

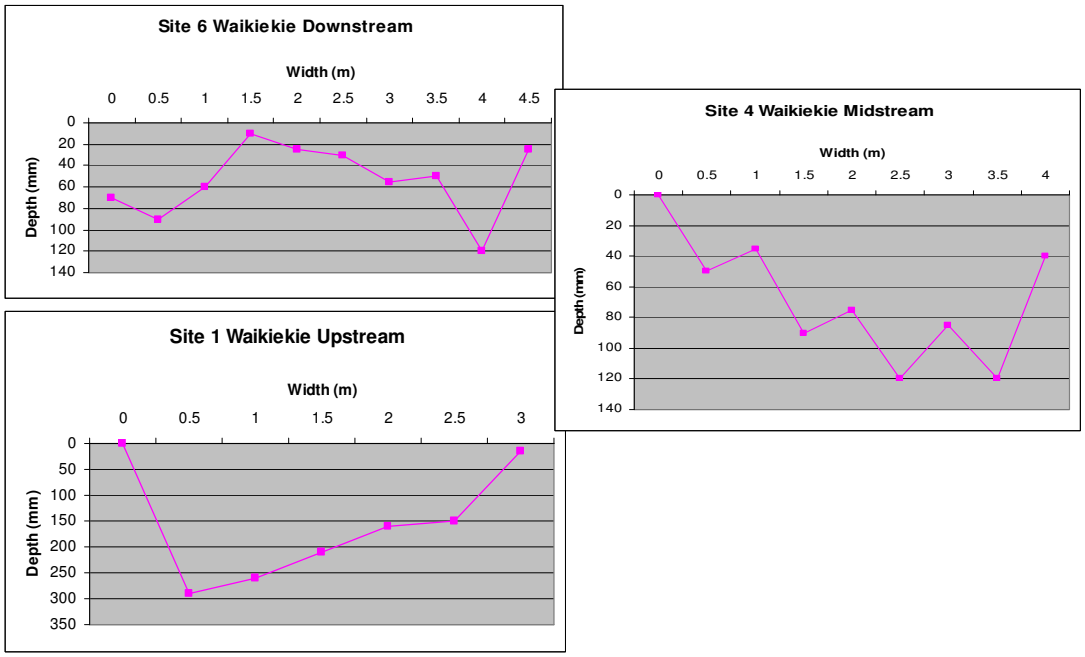
Table 2 Substrate Evaluation (from surface aspect) of survey sites in Waikiekie Stream (mean estimate from visual observations)

		Percentage composition			
Sample Site	Maximum size of boulder (mm)	Boulders > 204mm	Cobbles 20-204mm	Gravel 2-20mm	Fines <2mm
1a	600	5	75	10	10
1b	600	10	60	10	20
2	300	5	55	25	15
4	500	5	50	20	25
6	500	10	60	10	20

Table 3 Stream bank vegetation, shading and bed stability at 3 sites in Waikiekie Stream
(mean estimate from visual observations)

Sample Site	Stream bank vegetation (m)	% shading	Stability
1a	Pampas, *Hebe salicifolia*, mahoe, mingimingi, manuka, rewarewa, puriri, tawa, hinau, *Coprosma robusta, C. grandifolia*, *Blechnum discolor*, nikau, *Dicksonia squarrosa, Lotus major*, red matipo, kawakawa, *Carex secta,* hangehange.	80	Good except for incised clay bank
4	*Pinus patula,* grey willow, *C. robusta*, pampas, manuka, *Hebe salicifolia*, mahoe, ponga, hangehange, pasture grasses	30	Good, although some movement below ford
6	Bracken fern, grey willow, pampas, *Dicksonia squarrosa,* manuka, *Coprosma robusta, Hebe salicifolia, P. radiata,* pasture grasses.	40	Good, although some bank erosion downstream of ford

Figure 2 Physical Characteristics of survey sites in Waikiekie Stream (mean estimate from visual)



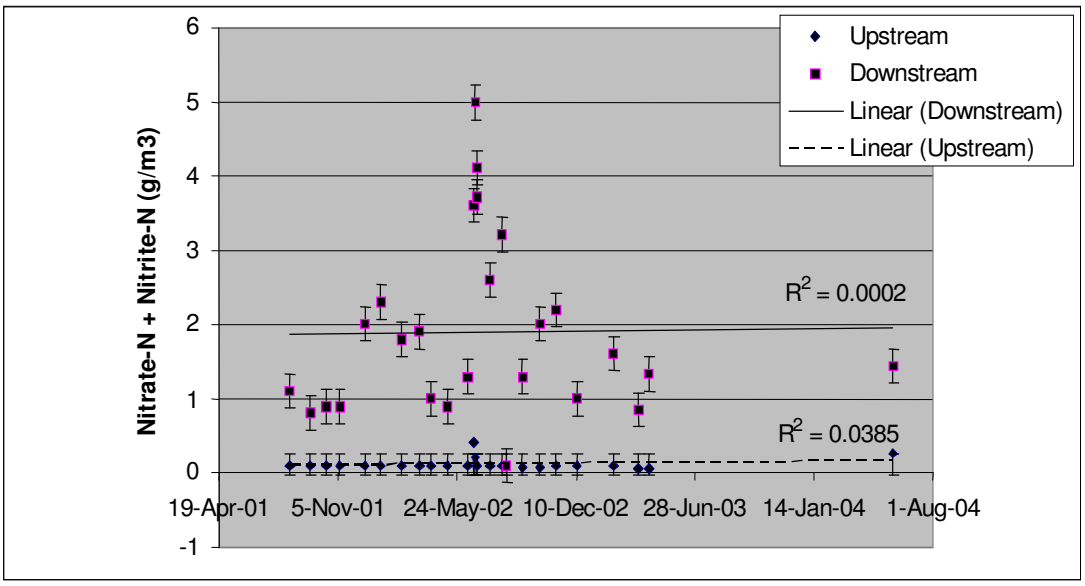
3.2 Water Quality

Water quality sampling was not a requirement of the biological monitoring conditions. However, given that water quality can have a significant influence on in-stream biota, the in-stream water quality sampling undertaken for other consent conditions in relation to the irrigation area have been attached as Appendix I.

Basic temperature, turbidity, pH and nutrient parameters were also taken during the biological sampling episodes, which are also included in the spreadsheet in Appendix I. All of the parameters measured suggest that water quality is characteristic of a typical Coromandel stream within a forestry catchment apart from dissolved nitrogen (in the form of Nitrate –N and Nitrite-N).

Review of the water quality parameters suggests that dissolved nitrogen is significantly higher downstream of the spray irrigation area than upstream, as shown in Figure 3. Dissolved inorganic nitrogen can cause excessive algal growths. Excessive nitrogen can also adversely affect macroinvertebrate diversity and composition. The results show elevated nitrogen concentrations in May 2002 at the downstream site. However, since that time, while still elevated, nitrogen concentrations are tending to be significantly lower (1-1.5 g/m^{-3} as opposed to 2-5 g/m-^{3}.)

Figure 3 Nitrate-N + Nitrite-N (g/m3) concentrations within Waikiekie Stream

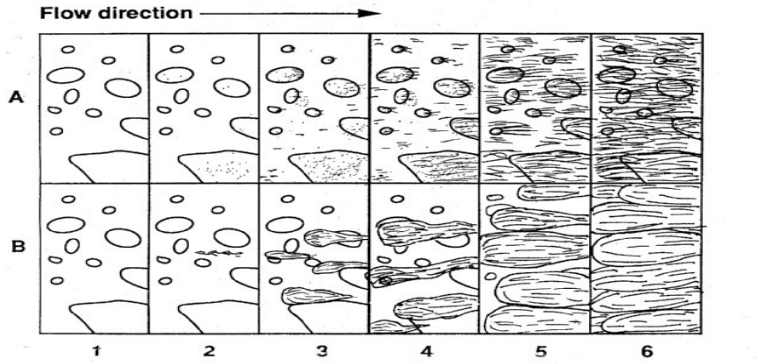


3.3 Aquatic Vegetation

Visual estimation of the percentage periphyton cover by filamentous algae and by mats (>2mm thick) and macrophytes (large aquatic plants) was carried out utilising techniques as detailed in Water Quality Guidelines No 1, (Guidelines for the Control of Undesirable Biological Growths in Water, Ministry for the Environment, June 1992), at the three sites in February 2002 only. Figure 4 is a reproduction of the scales used (MfE, 1992).

"New Zealand Periphyton Guideline" (Biggs, 2000) recommend that a seasonal maximum cover within stream or river beds by periphyton as filamentous growths or mats (> ca. 3mm thick) should not exceed 30% for a stony-bottomed stream. While this limit was breached in the March 1999 and to a lesser extent the December 2002 surveys, periphyton and macrophyte percentage cover in all other survey episodes was well under the guideline limit for all the sites surveyed.

Figure 4 Scales for visual estimation of phototrophic biological growths in streams and rivers (MfE, 1992)



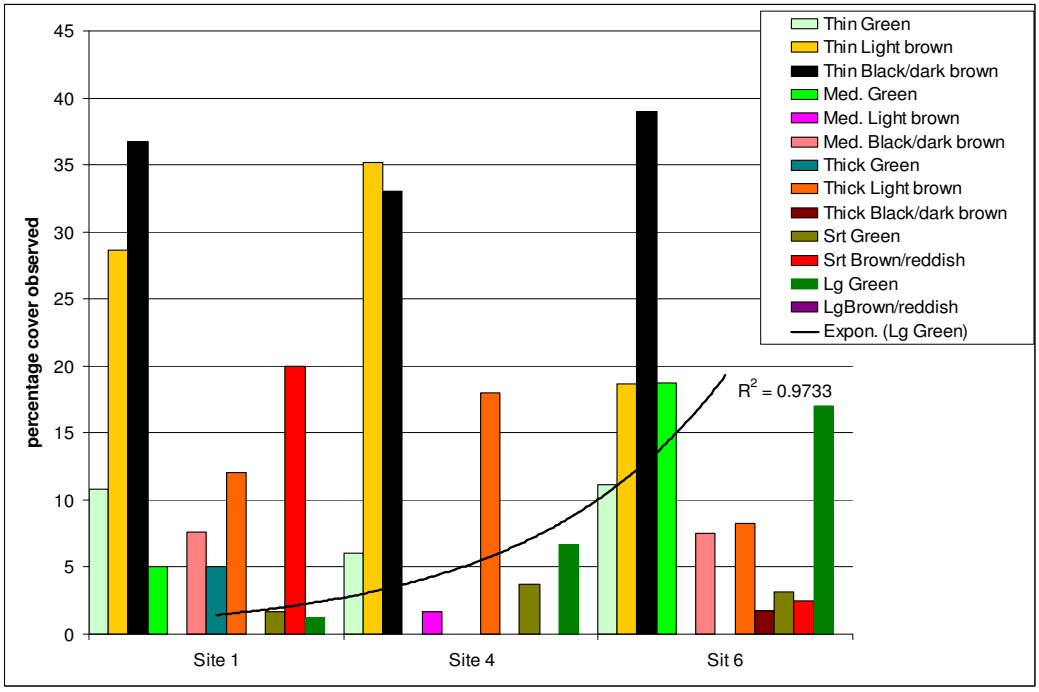
Aquatic vegetation contributes to nutrient and energy flow of the stream by providing food for many aquatic insect species (herbivores/ omnivores) and a "niche" habitat for others. Additionally, they provide a source of oxygen for the water. However, excessive growth can consume too much oxygen and smother habitat.

Seasonal variability in water temperature and sunlight penetration, combined with inputs of nutrients are likely to be the key drivers of aquatic plant cover in the lower Waikiekie Stream. In-stream temperatures and sunlight penetration are determined by overhead vegetation cover, and in this case the dense overhead canopy at Site 1 will be reducing excessive growth to some extent, while at Site 4 and 6, where overhead cover is less dense, water temperatures and sunlight penetration will be greater. Summer low flows often cause a marked increase in periphyton growth where overhead cover is not complete, regardless of nutrient status. Nonetheless, elevated nitrogen loadings may be having a potential effect on percentage composition when water flows are low and temperatures are high, as shown by the noticeable increase in long green filamentous algae growths (probably *Stigeoclonium tenue* and *Spirogyra sp.*) - shown by the sharply inclining regression line in Figure 5. Despite this increase, overall average cover for long green filamentous algae is about 17%, which is half of recommended maximum growth cover (refer to detailed tabulation of results in Appendix II).

Table 4 Summary of Results of In-stream Vegetation Estimations on the Waikiekie Stream

Sample Site	Periphyton Cover 14/03/99	Periphyton Cover 12/12/00	Periphyton Cover 15/2/02	Macrophyte Cover 14/03/99	Macrophyte Cover 12/12/00	Macrophyte Cover 15/02/02
1a	A3	A1	A2	B3	B1	B1
1b	not surveyed	A4	not surveyed	not surveyed	B1	not surveyed
2	A5	A2	not surveyed	B3	B2	not surveyed
4	A4	A1	A3	B5	B1	B2
6	A5	A4	A4	B3	B1	B3

Figure 5 Average Periphyton Type & Composition Cover in Waikiekie Stream
(averages for 2002-2004 surveys)



3.4 Macroinvertebrates

Appendix III list the finding of the Surber sample results 2002-2004. Figure 6 shows that MCI scores from 1999-2004 show a noticeable trend as the sampling is taken down the stream. Site 1 scores are reflective of good quality habitat characteristic of plantation forestry clad catchments, albeit slightly lower than typical bush clad Coromandel streams. The Site 4 MCI results appear to be recovering well from the disturbance caused in 2000 when the new culverts were installed here. Bed disturbances can be important in dictating species composition and richness (Scrimgeour & Winterbourn 1989; Death 1996; Townsend et al. 1997c). This recovery is shown by the inclining regression line over time (Figure 6). Site 6 is generally scoring significantly lower than either Site 1 or Site 4 on almost every sampling occasion. While habitat composition, in terms of a more boulder-dominated substrate and less overhead cover is likely to be an influence, the elevated nitrogen concentrations may be causing lower macroinvertebrate abundance and diversity at this site. Another factor may be slightly elevated levels of suspended sediment concentrations and accumulated fine sediments as a result of road and logging operations occurring upstream of Site 4 and 6 (Harding *et al*, 2000). However, as for Site 4, Site 6 also shows noticeable increases in MCI scores and hence habitat quality for the five years of results as shown by the increasing regression lines in Figure 6. In this time, MCI scores for Site 6 have increased from 77 (poor quality) to 110 (moderate quality).

Taxa number and EPT taxa numbers suggest diverse insect populations with most families well represented at all sites (Figure 7). In particular, the larvae of mayflies and caddis flies are present throughout the length of stream surveyed. There appears to be a clear trend in distribution down the sites - where Site 1 contained higher numbers of the very pollution sensitive mayfly larvae - *Oniscigaster distans, Deleatidium* sp. and *Coloburiscus* sp., the other site samples generally contained lower numbers of these species. In particular, the larvae of *Orthopsyche* sp was commonly captured at the upstream site, where it was usually in lesser numbers or absent in the Site 4 and 6

samples. Stonefly larvae, while present in most samples, only occurred in low numbers and species diversity and showed no clear trends in distribution between the three sites. Figure 8 shows how the pollution-sensitive taxa are less prevalent in the two downstream sites, with the more pollution tolerant two-winged flies (Diptera), freshwater snails (*Potamopyrgus antipodarum*) and aquatic worms (Oligochaeta) becoming noticeably more prevalent at Site 4 and Site 6.

Figure 6 MCI Scores for Waikiekie Stream 1999-2004

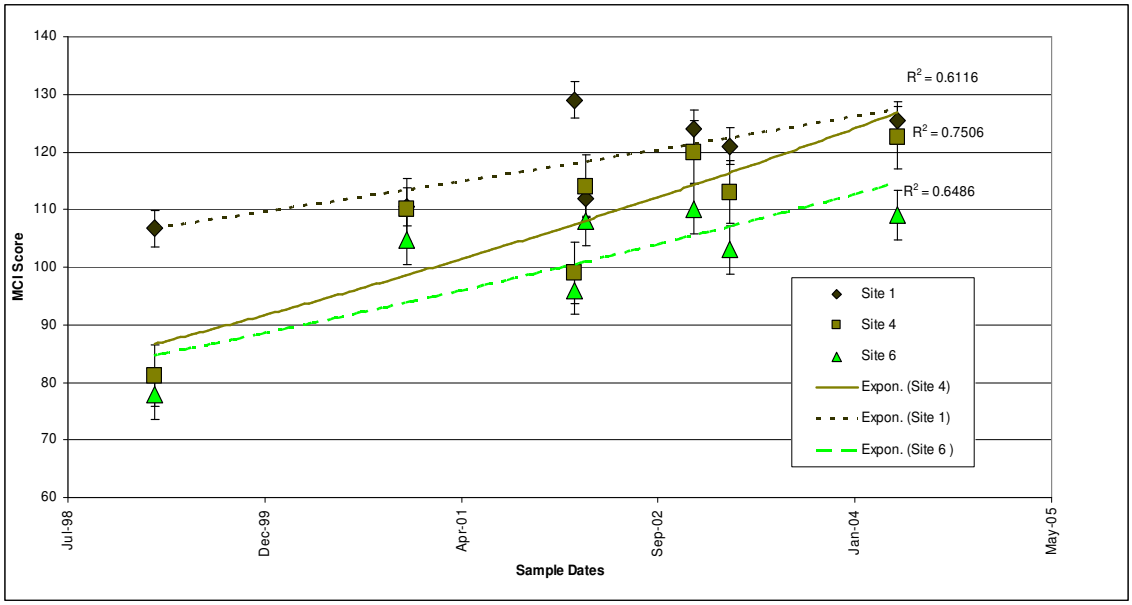


Figure 7 EPT Scores for Waikiekie Stream 1999-2004

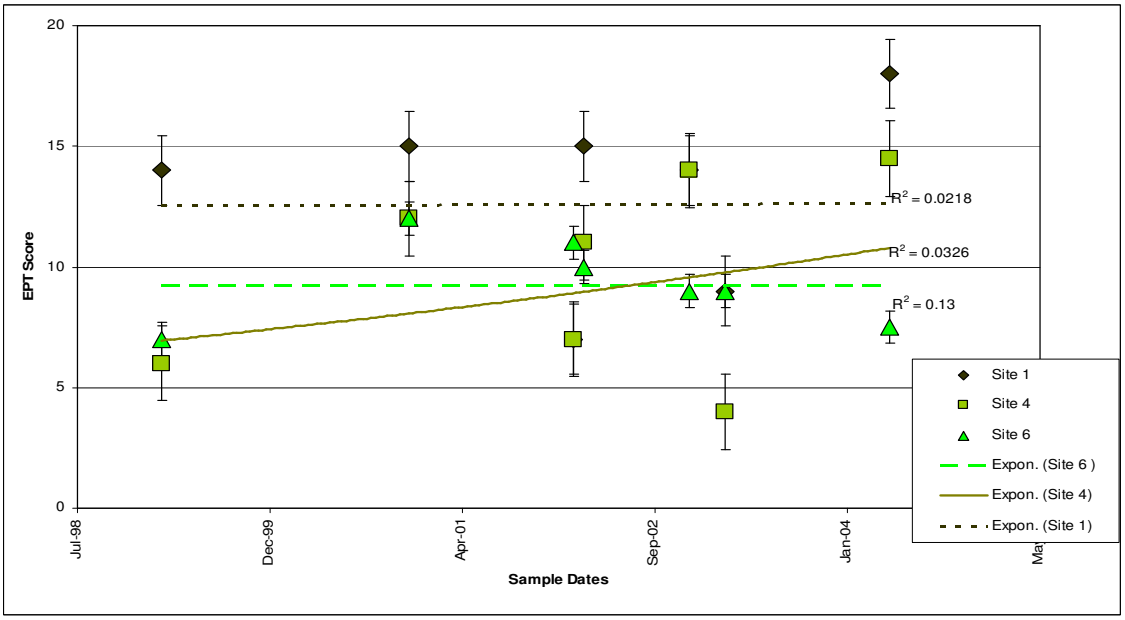
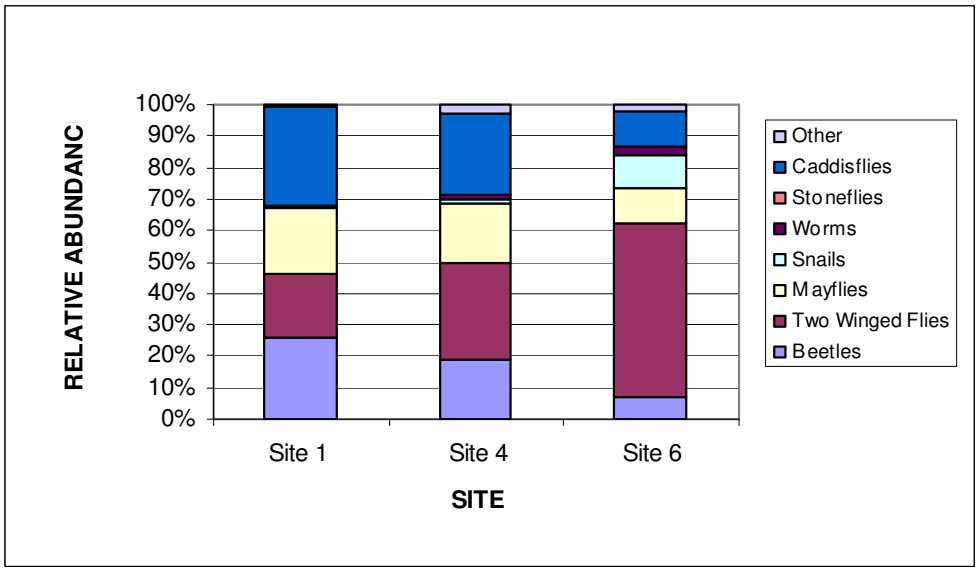


Figure 8 Average Macroinvertebrate Composition in Wikiekie Stream – 1999-2004



3.5 Fish

The fish fauna within the Waikiekie Stream is characteristic of a typical Coromandel waterway within a pine/indigenous forest dominated catchment, near a large harbour (Speirs, 2001; Kessels, *pers obs*).

The most pollution-sensitive fish are the two Galaxiid species - banded kokopu and inanga. Banded kokopu are consistently found both upstream and downstream of the spray irrigation area. Inanga are not found above the spray irrigation area, but this is almost certainly because the habitat is unsuitable for this fish upstream of Site 4 rather than any possible effects associated with the WWTP.

The downstream site consistently yielded reasonable catches of common bully as well as ripe female and coloured male red-finned bully which is to be expected in a stream such as this.

Eels are not particularly common in the Waikiekie, although elvers suggest recruitment is occurring. The absence of shortfinned eel is probably a reflection of the boulder habitat rather than other factors.

The downstream site (6) also often had schools of smelt present.

The spotlighting surveys yielded two interesting species, both downstream of the spray irrigation area – lamprey and giant bully. Little is known about either of these rarely observed and cryptic species and their presence in the Waikiekie is possibly an indicator that habitat quality is reasonable. However, the giant bully population is significant for the region and a close watch on this population is recommended.

Figure 9 and is summary of catches made during the electric-fishing surveys.

Both sites were also always characterised by an abundant population of freshwater shrimp (*Paratya curvirostris*) and the occasional freshwater crayfish (*Parenephrops planifrons),* suggesting that recruitment of these invertebrates is occurring and habitat is suitable.

Figure 9 E-Fishing Results

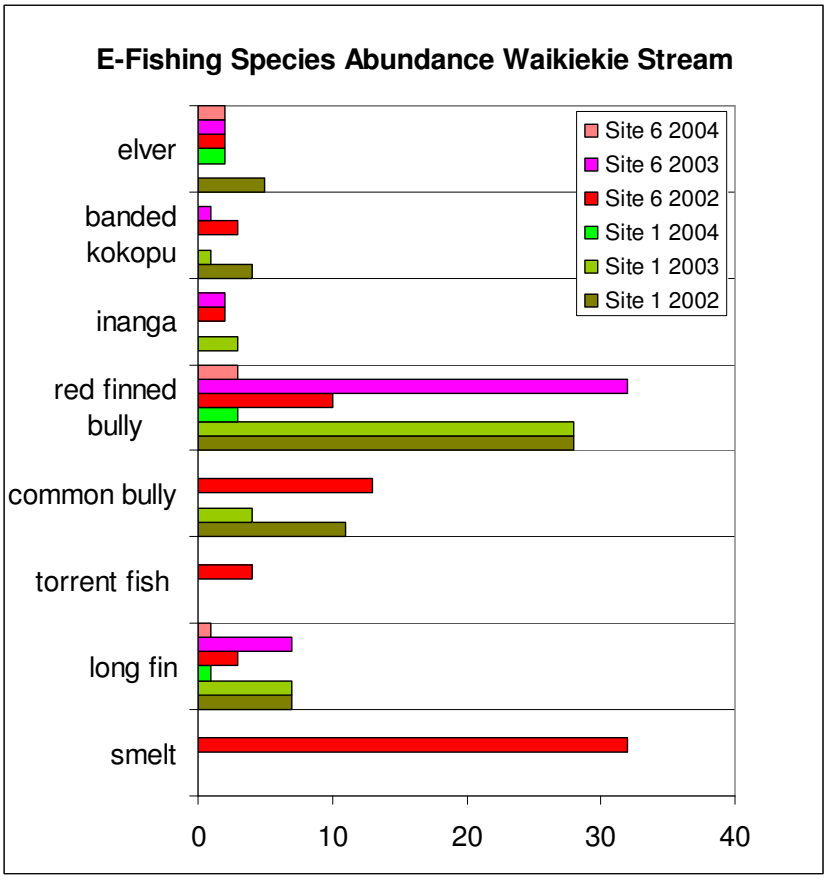
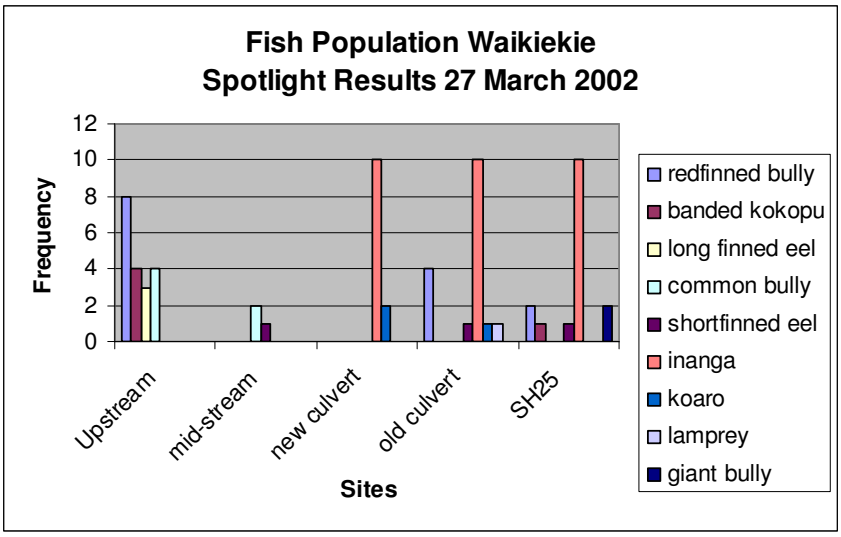
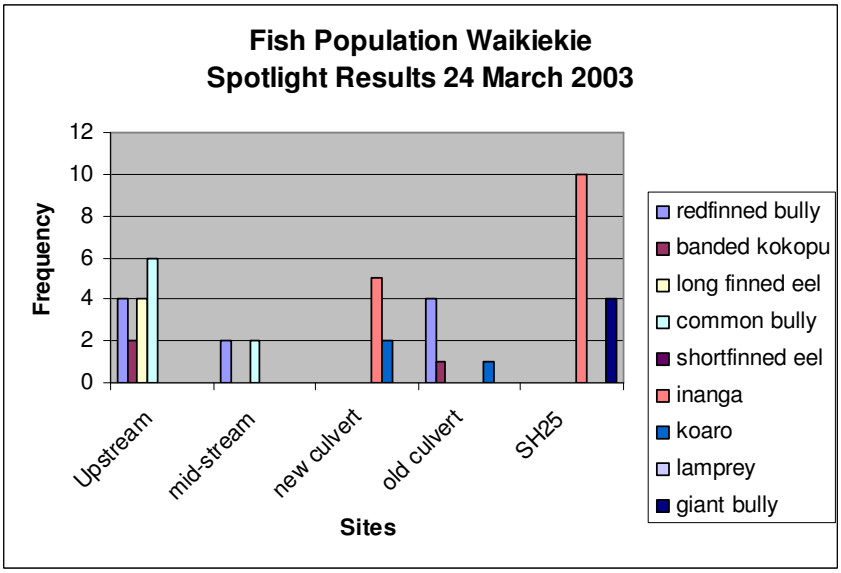
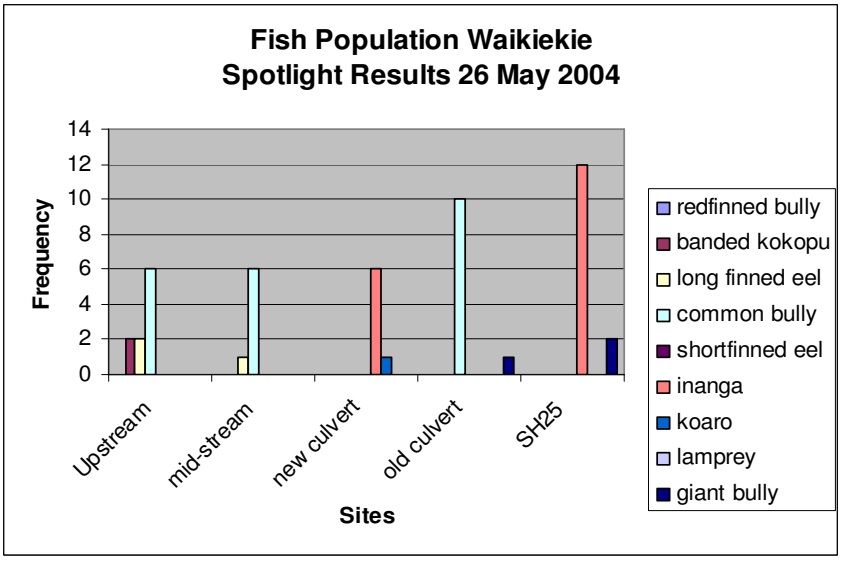


Figure 10 Fish Spot Lighting Results







4 Conclusions and Recommendations

4.1 Survey Conclusions

The following conclusions can be made based on the survey results:

- Periphyton growth within the Waikiekie Stream downstream of the spray irrigation area appears to be noticeably greater than at the upstream site. In particular, long green filamentous algae is averaging about 17% substrate cover as opposed to below 3% cover at the upstream site. This species can be indicative of excessive nutrient loadings. However, the average cover is still less than the recommended maximum cover of 30% for stony-bottomed streams. Further, overhead cover is less dense at the downstream sites which may also be contributing to the elevated periphyton cover observed.
- Aquatic benthic macroinvertebrate populations and diversity are slightly lower in the vicinity of the spray irrigation site than at the upstream sites and noticeably lower at Site 6. Of encouragement, however, is that MCI and EPT scores have shown a gradual improvement in quality since 1999 for Site 4 and for Site 6. MCI scores downstream are now indicative of moderate habitat quality as opposed to poor habitat quality, which was recorded in the 1999 survey.
- The results suggest a stream with a diverse fish fauna, typical of that found in most Coromandel Streams within a forested catchment. There appears to be no noticeable differences between the upstream and downstream sites in terms of diversity or abundance of fish species that could be attributed to any potential effects of the spray irrigation.

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Appendix I
Water Quality Data

Thames Coromandel District Council

Whangamata Wastewater Treatment Plant.

CONSENT: 940707

EXPIRES: 31 DECEMBER 2006

Waikiekie Stream

Condition 13

Monthly: Nitrates

Quarterly: pH, Ammonium, FC, TKN

Date	Flow rate l/s		Turbidity (NTU)		Faecal Coliform MPN/100		pH		Total suspended solids (g.m-3)		Ammonium g/m3		T.K.N g/m3		Total Phosphorus (g.m-3)		Nitrate-N		Nitrite-N (g.m-3)		Nitrate-N+Nitrite-N (TON)		Zinc		Copper		Total Arsenic	
	Waikiekie		Waikiekie		Waikiekie		Waikiekie		Waikiekie		Waikiekie		Waikiekie		Waikiekie		Waikiekie		Waikiekie		Waikiekie		Waikiekie		Waikiekie		Waikiekie	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
10-Apr-00																	0.2	2.3										
16-May-00																	0.1	2.0										
27-Jun-00					640	560	7.94	7.86			<0.01	<0.01	<0.1	0.1			0.2	1.6										
20-Jul-00																	0.2	0.7										
15-Aug-00																	0.1	1.6										
20-Sep-00					100	200	6.73	6.73			<0.01	<0.01	<0.1	<0.1			<0.1	0.9										
16-Oct-00																	<0.1	0.7										
14-Nov-00																	<0.1	0.2										
5-Dec-00					180	300	7.27	7.05			<0.01	<0.01	<0.1	0.1			<0.1	0.9										
16-Jan-01																	<0.1	0.8										
21-Feb-01																	0.1	2.0										
22-Feb-01					250	310																						
27-Feb-01					230	180																						
28-Feb-01					200	270																						
1-Mar-01					120	350																						
6-Mar-01					150	260																						
13-Mar-01					42	110	7	6.96			<0.01	<0.01	<0.1	<0.1			<0.1	2										
10-Apr-01	131	448															0.1	1										
2-May-01					46	50																						
15-May-01	432	896			130	130											1	1.5										
16-May-01					68	96											0.1	2										
17-May-01					52	82																						
21-May-01					40	110																						
22-May-01					310	380																						
23-May-01					62	74																						
22-May-01					310	380																						
24-May-01					46	50																						
28-Jun-01	no data	no data			140	170	7.2	7.24			<0.01	<0.01	no data	no data			<0.1	1.1										
19-Jul-01	133	587															0.1	2.4										
8-Aug-01					240	260																						
9-Aug-01					120	250																						
15-Aug-01	86	192															<0.1	1.1										
19-Sep-01	102	399			68	170	7.62	7.44			<0.01	<0.01	<0.1	<0.1			<0.1	0.8										
17-Oct-01	8	21															<0.1	0.9										
8-Nov-01	255	532															<0.1	0.9										
20-Dec-01	461	902			240	390	7.1	7.1			<0.01	<0.01	<0.01	<0.01			<0.1	2										
17-Jan-02	111	317															<0.1	2.3										
19-Feb-02	98	144															<0.1	1.8										
22-Mar-02	148	248			170	190	7.35	7.45			<0.01	<0.01	not required				<0.1	1.9					<0.01	<0.01	<0.01	<0.01	<0.001	<0.001
10-Apr-02	85	113			62	138	7.2	7.3			<0.01	<0.01	revised consent				<0.1	1										
8-May-02					190	490	7.4	7.4									<0.1	0.9										
11-Jun-02					260	150	7.49	7.64									0.1	1.3										
21-Jun-02					630	480	7.28	7.27									0.4	3.6										
24-Jun-02					150	490	7.29	7.18									0.2	5										
25-Jun-02					150	260	7.33	7.25									0.1	3.7										
26-Jun-02					190	240	7.19	7.21									0.1	4.1										
18-Jul-02					36	180	7.31	7.29			<0.01	0.01					0.1	2.6										
1-Aug-02																							<0.03	<0.03	<0.01	<0.01	<0.001	<0.001
8-Aug-02					320	320	7.52	7.28									0.1	3.2										
15-Aug-02					380	340	7.31	7.32									<0.1	0.1					0.016	0.002	0.0026	<0.0005	<0.001	<0.001
9-Sep-02					96	450																						
10-Sep-02					56	56	7.16	7.18									0.08	1.3										
10-Oct-02					84	710	7.06	7.16			<0.01	0.03					0.08	2										
7-Nov-02					100	530	7.16	7.13									0.09	2.2										
26-Nov-02					100	280																						
10-Dec-02					100	800	7.71	8.29									0.1	1										
13-Jan-03					510	1200	7.24	7..22			<0.1	0.01											<0.001	<0.001	<0.0005	<0.001	<0.001	<0.0005
15-Jan-03					340	370																						
11-Feb-03					<10	<10	7.33	7.41									0.1	1.6										
24-Mar-03			1.30	2.35					5	<3	<0.01	<0.01	<0.1	0.1	0.006	0.005	0.043	0.848	0.002	<0.002	0.045	0.85						
11-Apr-03			1.82	2.30					<3	<3	<0.01	<0.01	<0.1	<0.1	0.008	0.005	0.049	1.34	<0.002	<0.002	0.046	1.34						
26-May-04			1.180	1.230			8.400	8.400			0.070	0.010	0.100	0.200	0.012	0.005					0.267	1.440						

Appendix II

Periphyton Data

	Thin mat			Med mat.			Thick mat			Short Filaments		Long Filaments	
	Green	Light brown	Black/dark brown	Green	Light bro	Black/dark brown	Green	Light bro	Black/dark brown	Green	Brown/reddish	Green	Brown/reddish
Site 1 27 March 2002	11.67	43.57	43.5	5	0	20	10	10	0	0	0	0	0
Site 1 16 Dec 2002	10	13.7	18	5	0	0	0	0	0	0	0	0	0
Site 1 24 March 2003	0	0	40	5	0	0	0	22.5	0	5	60	5	0
Site 1 26 May 2004	24.6	50.5	45.6		0	10.5	0	15.6	0	0	0	0	0
Site 1 AV.	10.84	28.64	36.78	5.00	0.00	7.63	5.00	12.03	0.00	1.67	15.00	1.25	0.00
Site 4 27 March 2002	7	28.83	40	0	0	0	0	37	0	0	0	5	0
Site 4 16 Dec 2002	5	11.7	27.3	0	0	0	0	0	0	0	0	6.25	0
Site 4 24 March 2003	0	47.5	28.75	0	6.7	0	0	20	0	10	0	0	0
Site 4 26 May 2004	0	52.7	36.2	0	0	0	0	15	0	5	0	15.6	0
Site 4 AV.	6.00	35.18	33.06	0.00	1.68	0.00	0.00	18.00	0.00	3.75	0.00	6.71	0.00
Site 6 27 March 2002	6.7	25	56.7	70	0	30	0	0	0	0	0	6.25	0
Site 6 16 Dec 2002	21.25	10.7	39.1	5	0	0	0	0	0	0	5	5.7	0
Site 6 24 March 2003	0	19	30	0	0	0	0	32.9	5	7.5	0	26.09	0
Site 6 26 May 2004	5.4	20	30	0	0	0	0	0	0	5	0	30.06	0
Site 6 AV.	11.12	18.68	38.95	18.75	0.00	7.50	0.00	8.23	1.25	3.13	1.25	17.03	0.00

Appendix II

Macroinvertebrate Data

		BATCH NO.		02/04772	02/04772	02/04772	**Total**	**TOTAL**
		SAMPLE NO.		13	14	15		
		Gerry Kessels Sites		Upstream 1	Downstream 4	Downstream 6	**Waikiekie**	**All Sites**
		SAMPLING DATE		15/02/2002	15/02/2002	15/02/2002		
CLASS: Order	Family	Taxa	Taxa MCI					
ANNELIDA: Oligochaeta		*Oligochaeta inset type A*	1		1	2	**3**	**6**
MOLLUSCA: Gastropoda	Hydrobiidae	*Potamopyrgus*	4		3	14	**17**	**228**
		Potamopyrgus	4			3	**3**	**52**
	Planorbidae	*Gyraulus sp.*	3					**1**
	Melanopsidae	*Melanopsis fas*	3					**2**
	Ancylidae	*Gundlachia sp.*	3			5	**5**	**74**
	Latiidae	*Latia sp.*	3			28	**28**	**91**
Bivalvia	Sphaeriidae	*Sphaerium nov*	3					**1**
ARTHROPODA: Arachnida	Acarina (mites)	*Hydracarina in*	5	1	1	1	**3**	**11**
Crustacea	Ostracoda	*Ostracoda inde*	3					**4**
	Amphipoda	*Amphipoda ind*	5					**1**
	Decapoda	*Paranephrops*	5			2	**2**	**30**
INSECTA:								
Megaloptera	Corydalidae	*Archichauliode*	7	5	2	2	**9**	**47**
Ephemeroptera	Siphlonuridae	*Nesameletus sp*	9					**96**
		Oniscigaster di	10					**5**
	Oligoneuriidae	*Coloburiscus h*	9	3	2	5	**10**	**190**
	Leptophlebiidae	*Deleatidium 'li*	8	3		2	**5**	**191**
		D. myzobranch	8					**20**
		Austroclima se	9					**2**
		Arachnocolus p	8					**2**
		Zephlebia nodu	7	1			**1**	**85**
Plecoptera	Grypopterygida	*Zelandoperla fo*	10	1			**1**	**8**
	Austroperlidae	*Austroperla cy*	9					**2**
Trichoptera	Hydropsychidae	*Aoteapsyche co*	4	4		86	**90**	**158**
		Orthopsyche th	9			20	**20**	**44**
		Orthopsyche fi	9	4			**4**	**4**
	Hydroptilidae	*Oxyethira albic*	2		10	35	**45**	**154**
	Rhyacophilidae	*Hydrobiosis pa*	5	1	2	4	**7**	**15**
		Neurochorema	6		2	8	**10**	**41**
	Polycentropodid	*Polyplectopus*	8					**2**
	Ecnomidae	*Ecnomina zeal*	8					**21**
	Helicopsychida	*Helicopsyche p*	10					**65**
	Helicophidae	*Zelolessica che*	10		67	19	**86**	**2384**
	Leptoceridae	*Hudsonema am*	6			28	**28**	**418**
	Kokiriidae	*Kokiria sp.*	9			1	**1**	**1**
	Conoesucidae	*Pycnocentrode*	5			36	**36**	**102**
		Beraeoptera ro	8					**330**
		Olinga fereday	9					**174**
Coleoptera	Elmidae	*Elmidae sp. Ty*	6	8	29	26	**63**	**330**
	Hydraenidae	*Hydraenidae in*	8					**20**
Diptera	Tipulidae	*Limonia sp.*	6			2	**2**	**4**
		Aphrophilia ne	5		2	21	**23**	**92**
	Hexatomidae	*Molophilus sp.*	5			2	**2**	**2**
	Simuliidae	*Austrosimulium*	3		6	10	**16**	**46**
	Chironomidae	*Chironomidae*	1	32	27	104	**163**	**479**
	Ceratopogonida	*Ceratopogonid*	3					**2**
	Tabanidae	*Tabanidae inde*	3			1	**1**	**1**
	Tanyderidae	*Tanyderidae in*	4					**4**
		Mischoderus sp	4					**3**
	TOTALS:	**NO. TAXA**		**11**	**13**	**26**	**29**	**49**
		NO. EPT TAXA		**7**	**5**	**11**	**14**	**25**
		NO. INDIVIDUALS		**63**	**154**	**467**	**684**	**6045**
		SITE MCI		**129**	**99**	**96**	**110**	**119**

		BATCH NO.		02/07107	02/07107	02/07107	TOTAL
		SAMPLE NO.		17	18	19	
		Gerry Kessels Sites		Site 1	Site 4	Site 6	Waikiekie
		SAMPLING DATE		27/03/2002	27/03/2002	27/03/2003	
CLASS: Order	Family	Taxa	Taxa MCI				
COELENTERATA: Hydrozoa		Hydra sp.	3	3	2		5
ANNELIDA: Oligochaeta		*Oligochaeta inset type A*	1				
MOLLUSCA: Gastropoda	Hydrobiidae	*Potamopyrgus antipodarum*	4	15	5	6	26
		P. antipodarum (corolla form)	4			3	3
		P. pupoides	4				
	Latiidae	*Latia sp.*	3	47	10	10	67
ARTHROPODA: Arachnida	Acarina (mites)	*Hydracarina indet*	5		2	3	5
Crustacea	Ostracoda	*Ostracoda indet*	3				
	Amphipoda	*Aphipoda indet*	5			2	2
	Isopoda	*Isopoda indet*	5				
	Decapoda	*Paranephrops sp.*	5	3		3	6
		Paratya curvinostris	5				
INSECTA:							
Megaloptera	Corydalidae	*Archichauliodes diversus*	7	14		2	16
Odonata	Zygoptera	*Xanthocnemis zealandica*	5	3			3
Ephemeroptera	Ephemeridae	*Ichtybotus hudsoni*	8				
	Siphlonuridae	*Nesameletus sp.*	9				
		Ameletopsis perscitus	10		2		2
		Oniscigaster distans	10				
		Rallidens mcfarlanei	9		2		2
	Oligoneuriidae	*Coloburiscus humeralis*	9	34	23	16	73
	Leptophlebiidae	*Deleatidium lillii*	8	8	2		10
		D. myzobranchia	8	10			10
		D. vernale	8				
		Deleatidium spp.	8	23	10		33
		Neozephlebia scita	7	17		3	20
Plecoptera	Grypopterygida	*Zelandoperla fenestrata*	10	6	2	4	12
		Zelandobius furcillatus	5	3			3
Trichoptera	Hydropsychidae	*Aoteapsyche colonica*	4	7		4	11
		Orthopsyche thomasi	9	16		10	26
	Hydroptilidae	*Oxyethira albiceps*	2		15	34	49
	Rhyacophilidae	*Hydrobiosis parumbripennis*	5	10		2	12
		Neurochorema confusum	6			3	3
		Costachorema sp.	7	5			5
	Psychomiidae	*Zelandaptila moselyi*	8				
	Helicopsychidae	*Helicopsyche poutini*	10		3		3
	Oeconesidae	*Oeconesus similis*	9		4		4
	Helicophidae	*Zelolessica cheira*	10				
	Leptoceridae	*Hudsonema amabilis*	6			80	80
	Pycnocentrillidae	*Pycnocentrella eruensis*	9	10	100	20	130
	Conoesucidae	*Pycnocentrodes sp.*	5	10	20		30
		Beraeoptera roria	8	6		3	9
		Olinga feredayi	9	5			5
Hemiptera	Veliidae	*Microvelia sp.*	5	2	2	2	6
Coleoptera	Elmidae	*Elmidae Type A*	6	24	33	25	82
Lepidoptera		*Nymphula nitens*	4				
Diptera	Tipulidae	*Tipulidae indet*	5				
		Aphrophilia neozelandica	5	2	8	20	30
		Hexatomini indet	5				
		Paralimnophila skusei	6	3			3
	Simuliidae	*Austrosimulium tillyardium*	3	8	71	21	100
	Chironomidae	*Tanypodidae indet*	5				
		Tanytarsini indet	3	35	49	19	103
		Chironomius sp.(blood woorms)	1	5	2		7
	Ceratopogonidae	*Ceratopogonidae indet*	3	2	2		4
	TOTALS:	**NO. TAXA**		**29**	**22**	**23**	**39**
		NO. EPT TAXA		**15**	**11**	**10**	**22**
		NO. INDIVIDUALS		**336**	**369**	**295**	**1000**
		SITE MCI		**112**	**114**	**108**	**121**

BATCH NO.		03/4036	03/4036	03/4036	**TOTAL**
SAMPLE NO.		4	3	5	
Gerry Kessels Sites		Site 1	Site 4	Site 6	**Waikiekie**
SAMPLING DATE		16/12/2002	16/12/2002	26/12/2002	
Taxa	Taxa MCI				
Hydra sp.	3				
Oligochaeta inset type A	1	10			**10**
Potamopyrgus antipodarum	4	14	12		**26**
P. antipodarum (corolla form)	4	6	16		**22**
Latia sp.	3	6	4		**10**
Hydracarina indet	5	3	4		**7**
Paracalliope sp.	5				
Paranephrops sp.	5			10	**10**
Paratya curvinostris	5				
Archichauliodes diversus	7	8	1		**9**
Xanthocnemis zealandica	5			6	**6**
Rallidens mcfarlani	9	3			**3**
Nesameletus sp.	9				
Coloburiscus humeralis	9	12	2	12	**26**
Deleatidium spp.	8		1		**1**
Cryophlebia aucklandensis	10	4			**4**
Arachnocolus phillipsi	8	10			**10**
Mauiulus luma	5			10	**10**
Zephlebia dentata	7			3	**3**
Neozephlebia scita	7			10	**10**
Zelandoperla fenestrata	10	8	4		**12**
Zelandobius sp.	5		1		**1**
Aoteapsyche colonica	4	13	16		**29**
Orthopsyche fimbriata	9	12	30		**42**
Oxyethira albiceps	2	14	3		**17**
Hydrobiosis parumbripennis	5	12	10	1	**23**
Neurochorema confusum	6	10	4	1	**15**
Costachorema sp.	7	8			**8**
Edpercivalia maxima	9		7		**7**
Hydrochorema crassicaudatum	9		2	1	**3**
Hudsonema amabilis	6	16	50	10	**76**
Pycnocentrella eruensis	9	16	30	3	**49**
Beraeoptera roria	8	1			**1**
Pycnocentra evecta	7	6	61		**67**
Anisops sp.	5		2		**2**
Elmidae Type A	6	48	28		**76**
Elmidae Type B	6	2		1	**3**
Aphrophilia neozelandica	5	10			**10**
Paralimnophila skusei	6		2		**2**
Eriopterini indet	9		2		**2**
Empididae indet Type A	3	6			**6**
Austrosimulium tillyardium	3	64	56	1	**121**
Tanypodidae indet	5	121		110	**231**
Chironomius sp.(blood woorms)	1	60			**60**
Muscidae sp.	3	12			**12**
Stratiomyidae indet	5	10			**10**
NO. TAXA		**29**	**24**	**14**	**42**
NO. EPT TAXA		**14**	**14**	**9**	**22**
NO. INDIVIDUALS		**525**	**348**	**179**	**1052**
SITE MCI		**124**	**120**	**119**	**119**

		BATCH NO.		03/10024	03/10024	03/10024	**TOTAL**
		SAMPLE NO.		1	2	3	
		Gerry Kessels Sites		Site 1	Site 4	Site 6	**Waikiekie**
		SAMPLING DATE		11/04/2003	11/04/2003	11/04/2003	
CLASS: Order	Family	Taxa	Taxa MCI				
MOLLUSCA: Gastropoda	Hydrobiidae	*Potamopyrgus antipodarum*	4	12	1	3	**16**
		P. antipodarum (corolla form)	4	5		4	**9**
	Latiidae	*Latia neritoides.*	3	6	1	10	**17**
ARTHROPODA: Arachnida	Acarina (mites)	*Hydracarina indet*	5	1	1	2	**4**
Crustacea	Decapoda	*Paranephrops sp.*	5			6	**6**
INSECTA:							
Megaloptera	Corydalidae	*Archichauliodes diversus*	7	5			**5**
Ephemeroptera	Siphlonuridae	*Nesameletus sp.*	9			3	**3**
	Oligoneuriidae	*Coloburiscus humeralis*	9	7			**7**
	Leptophlebiidae	*Deleatidium lillii*	8	10		6	**16**
Plecoptera	Grypopterygidae	*Zelandoperla fenestrata*	10	1			**1**
Trichoptera	Hydropsychidae	*Aoteapsyche colonica*	4			16	**16**
		Orthopsyche thomasi	9			6	**6**
	Hydroptilidae	*Oxyethira albiceps*	2			7	**7**
	Rhyacophilidae	*Hydrobiosis parumbripennis*	5	5			**5**
		Neurochorema confusum	6	2			**2**
	Leptoceridae	*Triplectidina oreolimnetes*	5			3	**3**
	Pycnocentrillidae	*Pycnocentrella eruensis*	9	4	6	10	**20**
	Conoesucidae	*Pycnocentrodes sp.*	5	13	46	40	**99**
		Beraeoptera roria	8	3	2		**5**
		Pycnocentra evecta	7	12	26	15	**53**
Coleoptera	Elmidae	*Elmidae Type A*	6	30	13	6	**49**
	Hydraenidae	*Hydraenidae indet*	8		2		**2**
Diptera	Tipulidae	*Aphrophilia neozelandica*	5	10	6	8	**24**
	Simuliidae	*Austrosimulium tillyardium*	3	25	17	8	**50**
	Chironomidae	*Tanypodidae indet*	5	48	10	16	**74**
Vertebrata	Galaxidae	*Galaxias sp*	*			3	**3**
	TOTALS:	**NO. TAXA**		**18**	**12**	**19**	**26**
		NO. EPT TAXA		**9**	**4**	**9**	**14**
		NO. INDIVIDUALS		**199**	**131**	**172**	**502**
		SITE MCI		**121**	**113**	**103**	**116**

		BATCH NO.		04/15381	04/15381	04/15381	04/15381
		SAMPLE NO.		1	2	3	4
		Gerry Kessels Sites		1A	1B	4A	4B
		SAMPLING DATE		26/05/2004	226/05/04	26/05/2004	26/05/2004
CLASS: Order	Family	Taxa	Taxa MCI				
ANNELIDA: Oligochaeta		*Oligochaeta inset type A*	1	10			1
MOLLUSCA: Gastropoda	Hydrobiidae	*Potamopyrgus antipodarum*	4	45	25	11	38
	Lymneaidae	*Lymnea tomentosa*	4	36	18	3	17
ARTHROPODA: Arachnida	Acarina (mites)	*Hydracarina indet*	5	2			
		Oribatid indet	5	5	4		1
Crustacea	Amphipoda	*Aphipoda indet*	5		2		
	Decapoda	*Paratya curvinostris*	5	1			4
INSECTA:							
Megaloptera	Corydalidae	*Archichauliodes diversus*	7	16	1		
Odonata	Zygoptera	*Xanthocnemis zealandica*	5	1			
	Anisoptera	*Antipodochlora braueri*	6			1	
Ephemeroptera	Oligoneuriidae	*Coloburiscus humeralis*	9	78		2	3
	Leptophlebiidae	*Leptophlebiidae indet*	10	12	6	4	2
		Cryphlebia aucklandensis	10	2	2		
Plecoptera	Grypopterygidae	*Zelandoperla fenestrata*	10	30	20	33	25
		Zelandobius furcillatus	5	38			
		Z. confusus	5		10		2
		Zelandobius sp.	5	20			
Trichoptera	Hydropsychidae	*Aoteapsyche colonica*	4	48	8	10	28
		Orthopsyche thomasi	9	40	1	3	8
	Hydroptilidae	*Oxyethira albiceps*	2	2	8	2	3
	Rhyacophilidae	*Hydrobiosis parumbripennis*	5	4		3	1
		Hydrobiosis sp.	5	2	1		
		Psilochorema nemorale	8	3	2	1	4
		Edpercivalia maxima	9	1	1		
	Psychomyiidae	*Zelandoptila moselyi*	8			4	3
	Helicopsychidae	*Helicopsyche poutini*	10	9			
	Oeconesidae	*Oeconesidae indet*	9			2	
	Helicophidae	*Zelolessica cheira*	10	10			
	Leptoceridae	*Hudsonema amabilis*	6				
	Kokiriidae	*Kokiria miharo*	9	1			
	Pycnocentrillidae	*Pycnocentrella eruensis*	9	20	30	80	20
	Conoesucidae	*Pycnocentrodes sp.*	5	10	20	18	40
		Beraoptera roria	8	20	20	20	30
		Olinga feredayi	9	10	2		1
		Pycnocentra evecta	7	4	3	4	3
Coleoptera	Elmidae	*Elmidae Type A*	6	36	23	14	18
	Ptillodactylidae	*Ptilodactylidae indet*	8		6		
	Hydraenidae	*Hydraenidae indet*	8				
Diptera	Tipulidae	*Limonia sp.*	6	1	1		
		Aphrophilia neozelandica	5	8	1	6	2
	Simuliidae	*Austrosimulium tillyardium*	3	89	28	108	115
	Chironomidae	*Tanypodidae indet*	5	16	20	18	26
		Tanytarsini indet	3	10	16	12	8
	Ceratopogonidae	*Ceratopogonidae indet*	3				
	Tanyderidae	*Mischoderus sp.*	4				
	Stratiomyidae	*Stratiomyidae indet*	5	2			
	TOTALS:	**NO. TAXA**		**36**	**27**	**22**	**25**
		NO. EPT TAXA		**21**	**15**	**14**	**15**
		NO. INDIVIDUALS		**642**	**279**	**359**	**403**
		SITE MCI		**124**	**127**	**126**	**119**

		BATCH NO.		04/15381	04/15381
		SAMPLE NO.		5	6
		Gerry Kessels Sites		6A	6B
		SAMPLING DATE		26/05/2004	226/05/04
CLASS: Order	Family	Taxa	Taxa MCI		
ANNELIDA: Oligochaeta		*Oligochaeta inset type A*	1	5	
MOLLUSCA: Gastropoda	Hydrobiidae	*Potamopyrgus antipodarum*	4	27	39
	Lymneaidae	*Lymnea tomentosa*	4	18	16
ARTHROPODA: Arachnida	Acarina (mites)	*Hydracarina indet*	5	1	
		Oribatid indet	5		
Crustacea	Amphipoda	*Aphipoda indet*	5		
	Decapoda	*Paratya curvinostris*	5	1	4
INSECTA:					
Megaloptera	Corydalidae	*Archichauliodes diversus*	7		
Odonata	Zygoptera	*Xanthocnemis zealandica*	5	1	
	Anisoptera	*Antipodochlora braueri*	6		
Ephemeroptera	Oligoneuriidae	*Coloburiscus humeralis*	9		
	Leptophlebiidae	*Leptophlebiidae indet*	10		2
		Cryphlebia aucklandensis	10		
Plecoptera	Grypopterygidae	*Zelandoperla fenestrata*	10	10	23
		Zelandobius furcillatus	5		
		Z. confusus	5		
		Zelandobius sp.	5		
Trichoptera	Hydropsychidae	*Aoteapsyche colonica*	4	3	2
		Orthopsyche thomasi	9	1	
	Hydroptilidae	*Oxyethira albiceps*	2	2	10
	Rhyacophilidae	*Hydrobiosis parumbripennis*	5		
		Hydrobiosis sp.	5		
		Psilochorema nemorale	8		
		Edpercivalia maxima	9		
	Psychomyiidae	*Zelandoptila moselyi*	8		
	Helicopsychidae	*Helicopsyche poutini*	10	2	
	Oeconesidae	*Oeconesidae indet*	9		
	Helicophidae	*Zelolessica cheira*	10		
	Leptoceridae	*Hudsonema amabilis*	6	1	
	Kokiriidae	*Kokiria miharo*	9		
	Pycnocentrillidae	*Pycnocentrella eruensis*	9	25	85
	Conoesucidae	*Pycnocentrodes sp.*	5	15	20
		Beraoptera roria	8		10
		Olinga feredayi	9		
		Pycnocentra evecta	7		
Coleoptera	Elmidae	*Elmidae Type A*	6	2	
	Ptillodactylidae	*Ptilodactylidae indet*	8		
	Hydraenidae	*Hydraenidae indet*	8	1	
Diptera	Tipulidae	*Limonia sp.*	6		
		Aphrophilia neozelandica	5	10	21
	Simuliidae	*Austrosimulium tillyardium*	3	51	74
	Chironomidae	*Tanypodidae indet*	5	42	46
		Tanytarsini indet	3	38	50
	Ceratopogonidae	*Ceratopogonidae indet*	3		2
	Tanyderidae	*Mischoderus sp.*	4		1
	Stratiomyidae	*Stratiomyidae indet*	5		
	TOTALS:	**NO. TAXA**		**20**	**16**
		NO. EPT TAXA		**8**	**7**
		NO. INDIVIDUALS		**256**	**405**
		SITE MCI		**113**	**105**

Appendix III

Summary of E-Fishing Data

Site 6 2002		
N	**Average Fork Length**	
32	**73.4375**	smelt
3	**168.6667**	long fin
4	**86.5**	torrent fish
13	**43.69231**	common bully
10	**54**	red finned bully
2	**56.5**	inanga
3	**61.33333**	banded kokopu
2	**77.5**	elver
69		

Site 1 2002		
N	**Average Fork Length**	
0	**0**	smelt
7	**204.2857**	long fin
0	**0**	torrent fish
11	**43.18182**	common bully
28	**56.17857**	red finned bully
0	**0**	inanga
4	**58.25**	banded kokopu
5	**103**	elver
55		

Site 6 2003		
N	**Average Fork Length**	
0	**0**	smelt
7	**200.7143**	long fin
0	**0**	torrent fish
0	**0**	common bully
32	**51.25**	red finned bully
2	**69.5**	inanga
1	**93**	banded kokopu
2	**77.5**	elver
44		

Site 1 2003		
N	**Average Fork Length**	
0	**0**	smelt
7	**210**	long fin
0	**0**	torrent fish
4	**37.5**	common bully
28	**57.10714**	red finned bully
3	**84**	inanga
1	**103**	banded kokopu
0	**0**	evler
43		

Site 1 2004		
N	**Average Fork Length**	
0	**0**	smelt
1	**550**	long fin
0	**0**	torrent fish
0	**0**	common bully
3	**50.33333**	red finned bully
0	**0**	inanga
0	**0**	banded kokopu
2	**172.5**	elver
6		

Site 6 2004		
N	**Average Fork Length**	
0	**0**	smelt
0	**0**	long fin
1	**113**	torrent fish
4	**37**	common bully
7	**0**	red finned bully
0	**0**	inanga
2	**67.5**	banded kokopu
1	**79**	elver
15		