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Figure 1. Diagram of the study section of Whangamata Stream, showing sampling sites and seven areas (A–G) used for vegetation descriptions. Diagram not to scale, but approximate distance between Top Site and Bottom Site is 2000 m.

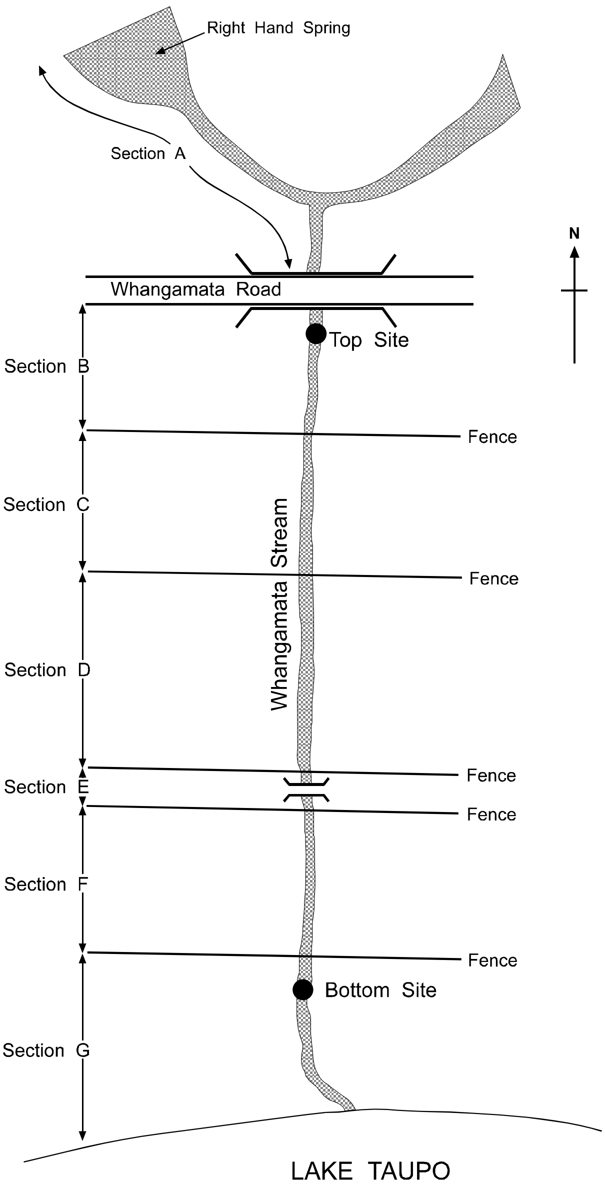


Figure 2. View from the bridge on Whangamata Road, May 2000, over Top Site and the riparian strip along Whangamata Stream downstream of Section B.

Vegetation surveys were carried out by Wildland Consultants Ltd. They involved surveying the length of the stream and reporting on species present or absent in each of seven stream sections (A–G, Fig. 1). An estimate of percentage cover of each species in each area was also made. The full 2003 list of species and their distribution pattern is provided in Appendix 2.

3. Results

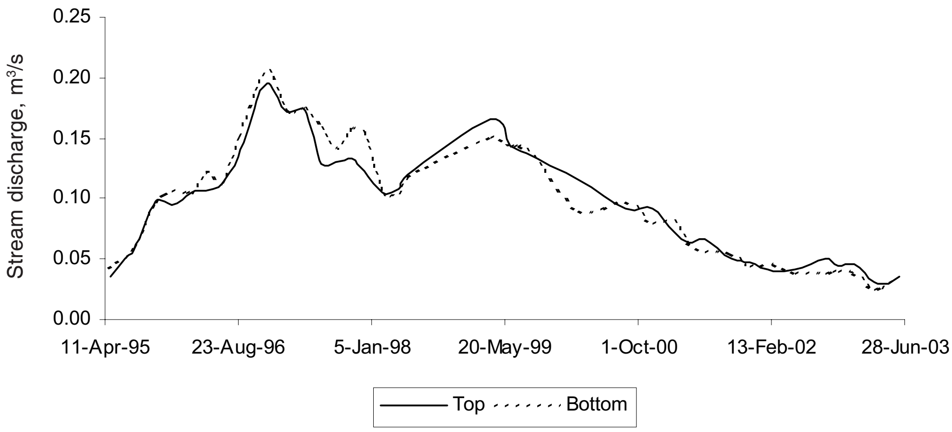
3.1 FLOW RATES

Stream discharge values for the period are shown in Fig. 3. The maximum over the period was 0.166 m^3/s in March 1999, and flows generally stayed above 0.11 m^3/s from June1999 to February 2000. From that time stream flows gradually declined, so that from November 2001 to June 2003, stream discharges have been less than 0.05 m^3/s. Such low rates have not been a feature of the stream since the 'low flow' period of the mid 1980s to early 1990s (Howard-Williams & Pickmere 1999). Over the six-month period of November 2002 to May 2003, discharges were typically 0.03 m^3/s.

All the stream water at base flows arises from the two springs. Recent evidence from Environment Waikato (Hadfield et al. 2001) indicates long residence times (c. 35 years and greater) in the groundwater reservoirs of this area, and it is not known what causes the interannual (interdecadal?) fluctuations in flows from these springs such as those shown in Fig. 3 for the last decade. Nutrient uptake from stream waters is a function of nutrient mass flow (concentrations multiplied by discharge), with higher rates of nutrient uptake occurring at low flows (Hearne & Howard-Williams 1988). Thus, on the basis of the flow data alone, nutrient uptake may be expected to have increased along the stream during the last three years.

Since 1998, flows at Bottom Site have frequently been lower than those at Top Site. This is a reversal of the situation that prevailed through the 1980s up to 1998. The reason for this is not clear. It suggests a water loss somewhere down the stream system.

Figure 3. Stream discharge at Top and Bottom Sites in Whangamata Stream, 1995–2003.



3.2 TOTAL SUSPENDED SOLIDS

Suspended solids (SS) concentrations followed a strongly seasonal pattern, with low values in the summer months that increased to a peak each year in late winter (Fig. 4). Values at Bottom Site were consistently higher than those at Top Site except for short periods in the summers of 2001–2003. The very high values in 1996 and 1997 followed the Ruapehu eruption. However, in more recent years the maximum value was 35 mg/L in July 2001, with more typical winter maxima being less than 20 mg/L. Summer values at Top Site were frequently less than 1 mg/L.

Mass flow of suspended solids (kg/hr) declined with declining discharge since 1999 (Fig. 5) and the values in May 2003 were only 0.12 kg/hr. Since then, very little suspended matter left the stream.

Figure 4. Suspended solids concentration (mg/L) in Whangamata Stream, 1995–2003.

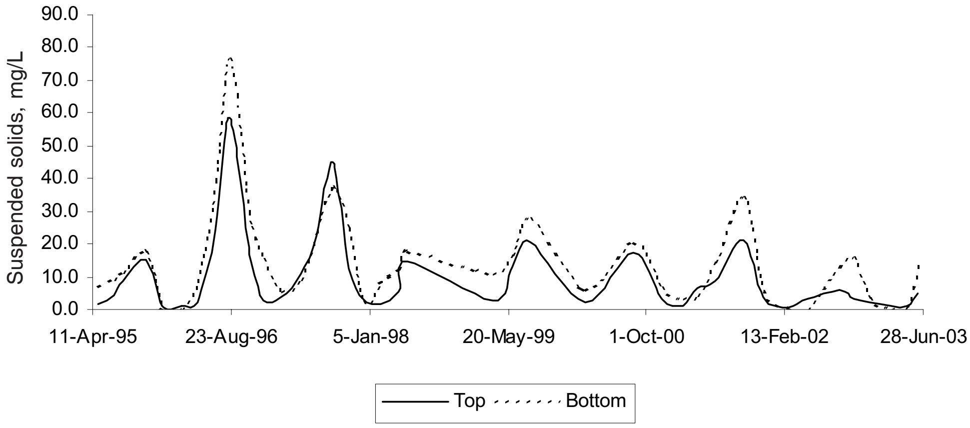
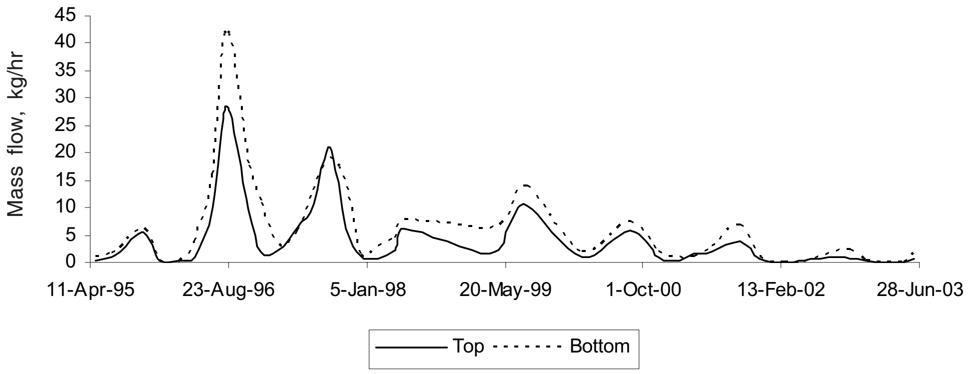


Figure 5. Mass flow of suspended solids in Whangamata Stream, 1995–2003.



3.3 DISSOLVED NUTRIENTS

Dissolved nutrients are expressed as micrograms/L (µg/L), equivalent to parts per billion (ppb).

Nitrate-N

Spring Nitrate-N data from Right Hand Spring varied between 986 µg/L and 1380 µg/L, with very little variability over the 1995–2003 period, although the summer months appear to have had slightly lower values (Table 1). This probably resulted from the springs emerging in dense watercress- and musk-dominated wetland, so some

TABLE 1. DISSOLVED NUTRIENT CONCENTRATIONS (AS μg/L) FROM BELOW RIGHT HAND SPRING, 1995-2002.

	DRP	DOP	TDP	NH_4-N	NO_3-N	DON	TDN
Date collected							
3 May 95	78.1	0.0	78	0.5	1053	53	1106
27 Jun 95	81.5	6.5	88	3.7	1114	97	1215
31 Jul 95	78.8	2.6	81	4.1	1129	88	1221
19 Oct 95	81.0	1.3	82	5.9	1017	99	1121
23 Apr 96	80.0	1.0	81	7.0	1103	164	1274
2 May 97	66.2	negl	66	10.9	1346	148	1505
25 Aug 97	78.8	1.6	80	6.9	1094	41	1142
20 May 98	88.3	negl	88	6.2	1106	0	1112
10 Aug 99	80.6	1.7	83	7.3	1179	17	1203
17 Aug 00	80.0	7.0	87	9.0	1120	125	1254
27 Nov 00	70.0	7.0	77	5.0	1050	78	1133
13 Feb 01	73.0	3.0	76	7.0	1110	43	1160
5 Apr 01	77.0	3.0	80	5.0	1100	55	1160
5 Jun 01	88.0	2.0	82	6.0	1230	14	1250
17 Sep 01	81.0	negl	81	8.0	1380	negl	1388
27 Nov 01	74.0	negl	74	8.0	986	-	-
22 Feb 02	74.0	negl	74	5.0	1070	15	1090
9 May 02	84.0	negl	84	7.0	1140	13	1160
2 Sep 02	81.0	2.0	83	7.0	1140	33	1180
22 Oct 02	76.0	3.0	79	7.0	1060	33.0	1100
19 Dec 02	72.0	6.0	78	7.0	1020	123.0	1150
6 Mar 03	72.0	negl	72	3.0	1060	17.0	1080
1 May 03	80.0	6.0	86	1.0	1090	29	1120
10 Jun 03	96.0	4.0	100	9.0	1120	21	1150

DRP, dissolved reactive P; DOP, dissolved organic P; TDP, total dissolved P; NH_4-N, ammonium-N; NO_3-N, nitrate-N; DON, dissolved organic N; TDN, total dissolved N; negl, negligible

nutrient uptake might have been expected above the sampling site. This concentration range was consistent with the range recorded from 1979 to 1995 (Howard-Williams & Pickmere 1999a), indicating little change in spring water nitrate concentration over the last two decades.

Nitrate concentration in the stream itself is shown for the study period and back to 1995 in Fig. 6. While there was limited seasonality in the 1996–1999 period, there were clear reductions in nitrate, especially at the Bottom Site in the summers of 2000/01, 2001/02, and 2002/03 (Fig. 6). Mass flow of nitrate (Fig. 7) declined markedly since the winter of 1999, in line with discharge changes (Fig. 3), and the differences between Top and Bottom sites in mass flow were small.

Figure 6.
Nitrate-N concentrations at Top and Bottom sites, Whangamata Stream, 1995–2003.

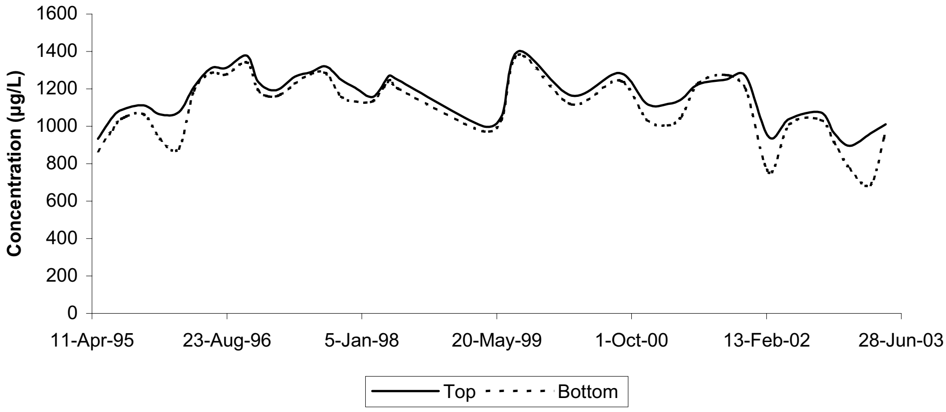
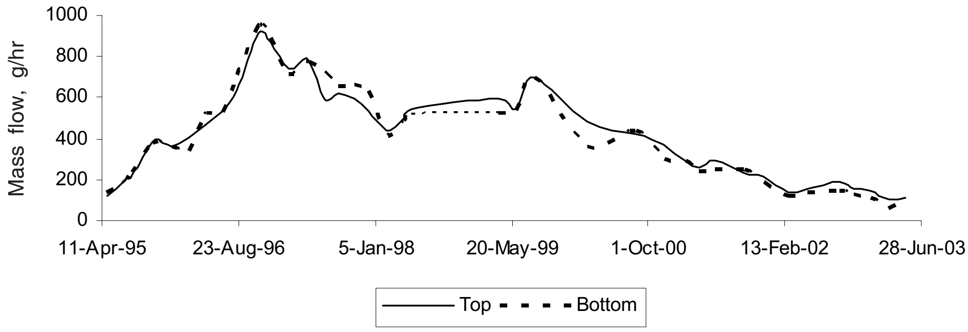


Figure 7.
Mass flows of nitrate-N at Top and Bottom sites, Whangamata Stream, 1995–2003.



Dissolved reactive phosphorus

DRP concentrations in the spring waters varied from 66 µg/L to 84 µg/L (Table 1), with a clear indication of seasonal variability in concentration, such that slightly lower values were recorded in summer months. The stream concentrations (Fig. 8) also showed a marked seasonality, with lower values at both Top and Bottom sites in summer. Bottom Site showed a proportionately greater decrease in summer than Top Site, which indicates nutrient stripping. The mass flows (Fig. 9) showed that, from 1998, DRP had been consistently lost between Top and Bottom sites.

Ammonium-N

Ammonium-N concentrations (Appendix 1) remained low, with summer concentrations at both sites generally between 6 µg/L and 10 µg/L, while winter concentrations were in the range 13–25 µg/L . Bottom Site had slightly higher ammonium-N concentrations than Top Site.

Dissolved organic nutrients

Dissolved organic phosphorus concentrations were extremely low, ranging between 1 µg/L and 8 µg/L (Appendix 1), with no clear seasonal pattern or difference between Top and Bottom Sites. Dissolved organic nitrogen levels likewise showed no clear seasonality or downstream difference; values over the period 1998–2003 ranged from 385 µg/L (March 1999) to 22 µg/L (February 2000).

Figure 8.
Concentrations of DRP at Top and Bottom sites, Whangamata Stream, 1995–2003.

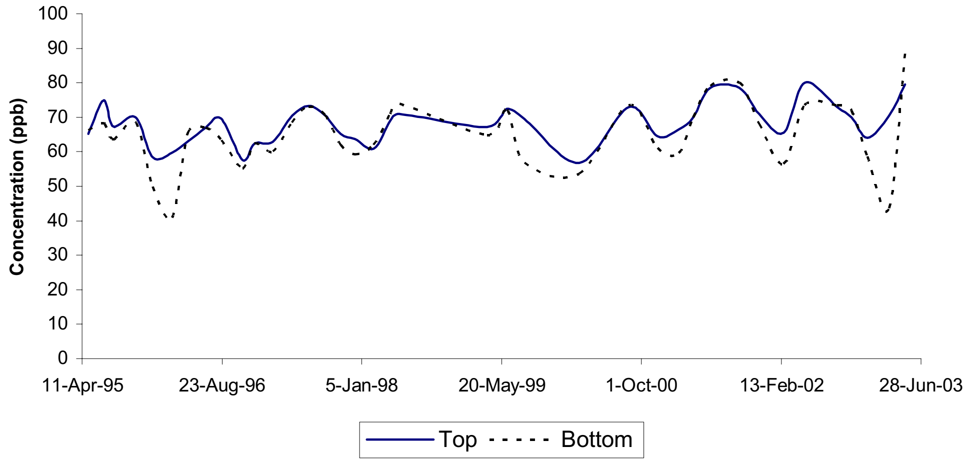
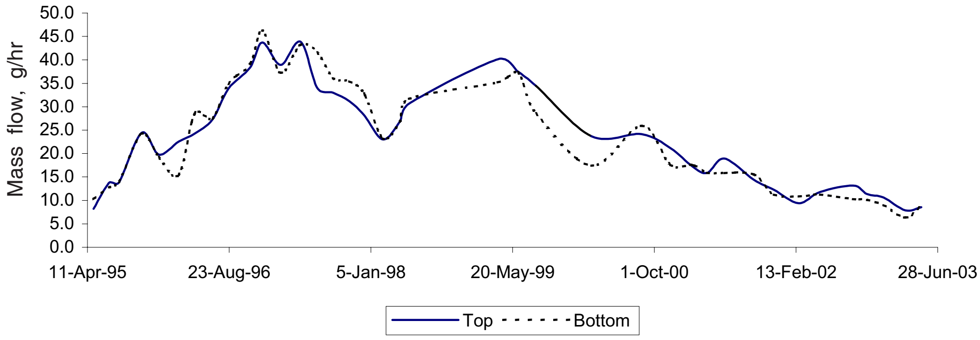


Figure 9.
Mass flows of DRP at Top and Bottom sites, Whangamata Stream, 1995–2003.



3.4 NUTRIENT REMOVAL

Nutrient removal from the stream water was calculated as the mass flow of nutrient that disappeared from the stream between Top and Bottom sites. With decreasing flows over the last few years, musk and cress beds have been able to more successfully colonise some of the more open shallow areas of the lower stream channel. During the low flows in the summer of 2002/03, these plants were able to choke parts of the lower stream channel; this is reflected in the stripping of nitrate and DRP between Top and Bottom sites at this time (Table 2). On 6 March, nitrate-N and DRP were reduced from 963 µg/L and 71 µg/L to 688 µg/L and 44 µg/L, respectively. This was reflected in the broad calculations for mass removal of an extra 80 kg/year of nitrate-N and 5 kg/year of DRP in 2002/03 compared to 2000–2002.

At face value this nutrient loss could be attributed to biological nutrient stripping. Certainly the drop in concentration suggests this. However, there was also a loss of water between Top and Bottom sites, so some of the nutrient recorded as mass flow might have disappeared with the water. This needs investigation, as it appears from Table 2 that nutrient removal rates from the stream increased markedly since the 1990s.

TABLE 2. MASS NUTRIENTS REMOVED (kg/year) BETWEEN TOP AND BOTTOM SITES IN WHANGAMATA STREAM, 1986/87 TO 2002/03.

YEAR	NO3-N	DRP
1986/87	475	47.4
1987/88	787	71.7
1988/89	558	48
1989/90	413	33.8
1990/91	239	14.6
1991/92	234	20.7
1992/93	124	10.7
1993/94	-	-
1994/95	-	-
1995/96	73	5.5
1996/97	negl	negl
1997/98	negl	negl
1998/99	-	-
1999/00	165	32.2
2000/01	167	4.4
2001/02	169	5
2002/03	250	10.7

negl negligible, - no calculation

3.5 VEGETATION

Biodiversity changes

A total of 172 vascular plant species were recorded for the study area. The total species pool has increased by 24 (16%) since 1998 and by 46% over the last decade. However, 29 species that were recorded in 1998 were not found in this survey (lost species), and 41 of the species recorded in 2003 were not found there before (new species). With increasing maturity of the riparian area, the number of indigenous species rose steadily (Fig. 10) and by 2003 was 70 species, which was 41% of the total flora. This is the same percentage as was recorded in 1998.

Figure 10 shows the trend in the number of species in the study area over time. A cumulative total of 45 species had been 'lost' from the stream since 1982. All the species lost since 1998, with the exception of *Senecio sylvaticus,* were listed as having a percentage cover of < 1%. All the species 'lost' (see Table 3), except *Mimulus moschatus* (2 survey areas), were recorded in only one of the survey areas. Therefore, with the exception of the two species mentioned, the lost species probably had occurred only as single specimens and could probably have still been in the area.

Thus, as the flora matured, there was a continual exchange of species invading, and species disappearing. It is likely that many of the invaders moved into the area but did not succeed in establishing themselves. This exchange accounted for 10% over the last five years of the study (average of 2% per year).

Table 4 provides a breakdown of the total number of species, arranged in a downstream sequence by stream survey area. The highest number of species was found in Section A. The largest increases since 1998 (Fig. 11) were in the middle sections (C–E) and in the lower Section G. The number of woody trees and shrubs was

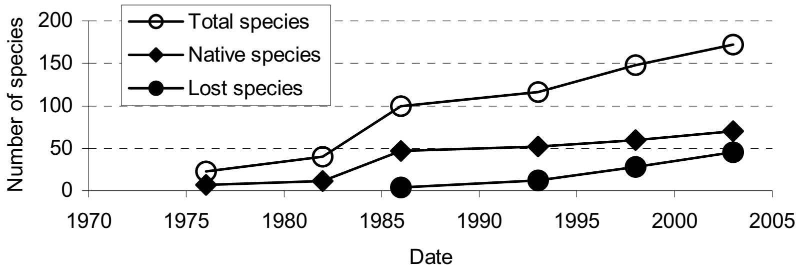


Figure 10. Vascular plant biodiversity (number of species) since 1976 following protection of the Whangamata Stream. Lost species are the cumulative totals of those species formerly recorded but no longer present.

TABLE 3. SPECIES LOST IN THE PERIOD 1998–2003 (SPECIES RECORDED IN 1998 THAT WERE NOT FOUND IN 2003).

SPECIES	RECORDED IN
*Blechnum penna-marina**	1993, 1998
*Carex lessoniana**	1986, 1993, 1998
Castanea sp.	1986, 1993, 1998
Cortaderia toetoe *	1986, 1993, 1998
*Epilobium pedunculare**	1986, 1993, 1998
Euchiton audax (*Gnaphalium audax*)*	1998
Gamochaeta spicata (*Gnaphalium coarctatum*)	1998
Glyceria maxima	1998
Haloragis erecta subsp. *erecta**	1986, 1993, 1998
Hebe sp. (cultivar)	1986, 1993, 1998
Medicago sativa	1998
Mimulus moschatus	1998
Polygonum prostratum	1998
*Pseudognaphalium luteoalbum**	1998
Senecio sylvaticus	1998
Solanum tuberosum	1998
Ulex europaeus	1998

* Indigenous species

TABLE 4. TOTAL SPECIES NUMBERS AND DISTRIBUTION OF WOODY PLANTS IN THE FLORA AT SEVEN SECTIONS OF WHANGAMATA STREAM IN 2003 (SEE FIG. 1 FOR MAP OF SECTIONS).

STREAM AREA	TOTAL NO. OF SPECIES	NO. OF NATIVE SPECIES	NO. OF TREES AND SHRUBS	TREES AND SHRUBS, %	NATIVE TREES AND SHRUBS, %
A	101	55	33	33	48
B	76	35	33	43	45
C	75	38	23	31	70
D	84	33	30	36	43
E	57	12	11	19	36
F	47	12	20	42	25
G	85	27	27	32	48

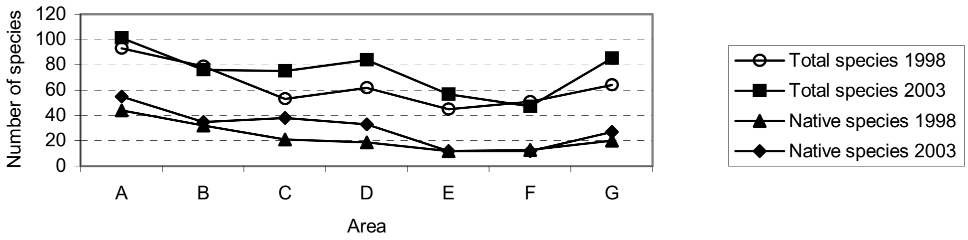


Figure 11. Total number of species and number of native species in 1998 and 2003 in each of the survey sections, Whangamata Stream.

lowest in sections E and F with the proportion of woody species varying between 19% and 42 %. Figure 11 shows that the number of native species was lowest in sections E and F and that significant increases in native species occurred in sections C and D.

Upper reach (Sections A and B)

The 2003 photograph of the top part of Section B is Fig. 2 and that taken of Section A is Fig. 12. These can be compared with the photographic history of the site presented in Howard-Williams & Pickmere (1999). The Frontispiece contrasts the pre-retirement pasture landscape with the situation in 1998. By 2003, there were 122 species in the upper reach, of which 45 (37%) were classed as trees and shrubs. Within the total species assemblage for the reach there were 61 native species, which made up 50% of the flora. The following native species were recorded as having cover classes of 3 (6–25% cover, see Appendix 2) or greater: *Phormium tenax, Hebe stricta, Pteridium esculentum, Carex secta, Carex* sp. *(C. geminata* agg.*)*. By 2003 also, *Cortaderia fulvida*, a streambank dominant between 1982 and 1992, which was still in cover class 3 in 1998, had a percentage cover of less than 6% in this reach of the stream; it did not survive the competition from *Phormium tenax*. Other former dominants such as watercress and musk had also become uncommon in this reach. Four species of tree fern were recorded, with *Dicksonia fibrosa* having a cover class of 2. Tall groves of cabbage tree were well established.

Middle reaches (Sections C, D and E)

The middle reaches showed the greatest increase in biodiversity over the last five years of the study, with increases in total species numbers of 22, 22 and 12 for Sections C, D and E, respectively (Fig. 11). In Sections C and D, these increases were made up of a significant number of native species (17 and 14 new native species, respectively). New woody species in Section C included: *Brachyglottis repanda, Geniostoma rupestre, Leptospermum scoparium, Leucopogon fasciculatus*, and *Pittosporum colensoi*. In Section D, new woody species were *Aristotelia serrata, Kunzea ericoides* var. *ericoides, Leucopogon fasciculatus, L. fraseri,* and *P. tenuifolium*. Of these, *K. ericoides* and *P. tenuifolium* were likely to have spread from Section C in the previous three years. *Acacia melanoxylon* was still the main tree species in the middle reaches, and dense grassy swards of the original pasture grasses *Agrostis capillaris, Dactylis glomeratus,* and *Holcus lanatus* still covered significant areas. Invasion by new woody species might in the long term reduce this persistent grass cover.

Lower reaches (Sections F and G)

The lower reaches, particularly Section G showed significant increases in biodiversity in the last five years of the study. These increases included 21 new species, of which nine were indigenous. The woody species C*oprosma propinqua* subsp. *propinqa* and *Plagianthus regius* were new to the lower reaches; the latter had been deliberately planted with *Leptospermum scoparium*. *Carex secta* had moved downstream from Section F to Section G, and a new species likely to spread further was *Persicaria decipiens.* Plantings in the lower stream area off the end of Ogilvie Terrace had become well established and restricted access to much of this area, although there were some walking tracks maintained. The vegetation of the lower reaches had become very dense, and foot access to the stream channel was restricted to places where the formed tracks allowed it. The stream banks now dominated by *Cortaderia fulvida* and *Phormium tenax*.

4. Discussion and conclusions

The inter-annual (and inter-decadal) fluctuations in discharge rates for the Whangamata Stream are not yet fully understood. Discharge is closely linked to stream nutrient concentrations, and influences plant nutrient uptake. It also affects trout spawning habitat and the ability of large spawning trout to move upstream. During 2002/03, spawning trout were barely able to remain below the water surface in transit between deeper lies, a situation that had not been seen since the low-discharge period of the late 1980s. The spring waters feeding the Whangamata catchment are old (Dr W Vant, Environment Waikato, pers. comm.), with only 10% being younger than 35 years (Hadfield et al. 2001). These spring discharges (and hence stream discharge) may be a function of changes to the groundwater reservoirs of up to three decades ago or an alteration to the geomorphology of the springs. It appears that Left Hand Spring was the more variable of the two tributaries; the decline in discharge principally from here could also have been a result of land use (e.g. water extraction) from this tributary between the spring itself and Whangamata Road. This was not investigated.

Because of the age of the spring water, 2002/03 nutrient concentrations in the springs reflect catchment changes of the 1960s and 1970s. More recent changes to land use would take some time to show up in the springs. Once these spring waters joined the stream, they were modified *in situ* by day-to-day ecological nutrient processing; there were no significant inputs of nutrients to the stream other than those arriving from the springs. Therefore the observed inter-annual changes to the stream's nutrient concentrations were a consequence of on-going changes to the vegetation of the stream channel and riparian zone as well as to changing discharges from the springs. Preliminary analyses by Environment Waikato have indicated a long-term relationship between a time lag in annual rainfall and spring discharge (W. Vant, pers. comm.). This will need to be confirmed with additional data.

With decreasing discharges over the past few years, the musk and cress beds have been able to more successfully colonise some of the more open shallow areas of the lower stream channel (Fig. 13). During the low flows of 2002/03, these plants were able to choke parts of the lower stream channel, thereby increasing the mass of plant material in contact with the water. The result was an increased removal of nutrients from the water, and this was reflected in the stripping of nitrate and DRP between Top and Bottom sites. For example, on 6 March 2003 nitrate-N and DRP were reduced from 963 µg/L and 71 µg/L to 688 µg/L and 44 µg/L, respectively (Fig. 6 and Appendix 1). This is also indicated by the broad calculations for biological removal (Table 2) of an extra 80 kg/year of nitrate-N and 5 kg/year of DRP in 2002/03 compared with 2001/02. The high plant biomass in the stream channel itself may have increased nutrient stripping efficiency, but it had undesirable consequences for trout spawning. For example, a stream channel-clearing programme was needed in May 2002 to remove musk and watercress from regions of the stream where plant growth was not inhibited by stream bank shading (Hart 2002). The difference when the stream was clear is shown in Fig. 14.

Of interest, and potential concern, is the apparent loss of water between Top and Bottom sites. Until 1998, Bottom Site consistently had a slightly (6.1%) higher discharge than Top Site (Howard-Williams & Pickmere 1998). The 2002/03 situation, with a loss of water down the stream reach, means either increased evapo-transpiration or that water is being lost in some other way (e.g. to groundwater or to extraction). Given the influence of low discharges on the system, it would be prudent to investigate this downstream loss in more detail.

Of some concern is the spread of invasive weeds into the riparian protected area and especially along the stream banks. For instance, Himalayan honeysuckle (*Leycesteria formosa*) had increased its cover in Section C from 1% to 5% in five years, while blackberry (*Rubus fruticosus* agg.) had become established along the length of the stream since 1998 (Wildland Consultants 2003). These species have the potential to dominate significant sections of the protected area and may need control.

Changes to the land use in the catchment accelerated during the last five years of the study, with development of forestry in the upper catchment (Fig. 15), of 'Kinloch Park' life-style blocks in the middle catchment, and the new 'Holy Oaks' urban subdivision at the bottom end of the catchment (Fig. 16). The development work for Kinloch Park was completed in 2001 and a number of dwellings were in place by 2003, while the first stage of Holy Oaks was completed with the issuing of a subdivision prospectus and the construction of a new bridge across the stream. During bridge building, the stream was protected from sediment runoff by the construction of coffer dams, and no visible effects were observed in the lower stream. The plan of this substantial subdivision shows over 100 sections that have the potential to influence the Whangamata Stream.

The fate of street and garden stormwater runoff needs to be determined where this enters the riparian strip. Also of potential significance will be the enhanced loading on the sewage treatment plant when the new subdivision is connected to the scheme. Taupo District Council plans to promote increased denitrification of the effluent from this plant in the near future by establishing a trial denitrification bed, which, if successful, will replace the soakage trench facility. This bed is on relatively high ground between the treatment plant and the road (Colin Light, Taupo District Council, pers. comm.) and little, if any, contamination of the stream is expected.

This long-term monitoring programme continues to be of value in showing the state of the environment, especially with the rapid changes occurring in the Whangamata catchment.

5. Acknowledgements

This work has been funded on an equal-share basis by DOC (Science Investigation Number 356) and Environment Waikato.

We are grateful to Dr Harry Keys, Dr Rob McColl, and John Gibbs of DOC and to Bill Vant of Environment Waikato for supporting this project.

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Appendix 1

Whangamata Stream nutrient concentration database 1995–2003

SAMPLE	DATE COLLECTED	LAB ID	DRP µg/L	TDP µg/L	DOP µg/L	NH_4-N µg/L	NO_3-N µg/L	TDN µg/L	DON µg/L	SS mg/L	FLOW m^3/sec	TEMP °C
Top 1	03 May 95	TF 1	66.5	70.2	3.8	2.8	931	1035	101	1.884	0.035	11.2
Top 2	03 May 95	TF 2	33.8	72.5	38.7	6.1	936	1036	94	1.326		
Bot 1	03 May 95	TF 3	66.0	73.6	7.6	8.3	868	1008	132	7.281	0.043	13.0
Bot 2	03 May 95	TF 4	66.5	77.1	10.7	7.6	867	995	121	7.062		
LH Spring	03 May 95	TF 5	54.5	57.3	2.8	6.4	750	868	111			
RH Spring	03 May 95	TF 6	78.1	76.0	2.1	0.5	1053	1106	53			
Top 1	27 Jun 95	TF 7	75.9	83.8	8.0	8.3	1064	1180	107	4.610	0.051	10.3
Top 2	27 Jun 95	TF 8	74.1	82.0	7.8	4.0	1035	1264	225	4.450		
Bot 1	27 Jun 95	TF 9	72.2	77.9	5.7	8.5	996	1163	159	8.870	0.052	11.0
Bot 2	27 Jun 95	TF 10	64.4	68.4	4.0	11.8	971	1284	301	9.680		
LH Spring	27 Jun 95	TF 11	63.7	68.7	5.0	10.1	1004	1163	149			
RH Spring	27 Jun 95	TF 12	81.5	88.0	6.5	3.7	1114	1215	97			
Top 1	31 Jul 95	TF 13	66.4	72.0	5.6	9.0	1117	1233	107	7.302	0.057	
Top 2	31 Jul 95	TF 14	68.2	70.3	2.1	8.9	1059	1203	135	10.190		
Bot 1	31 Jul 95	TF 15	67.4	69.3	1.8	10.3	1037	1170	122	11.690	0.061	
Bot 2	31 Jul 95	TF 16	59.6	68.2	8.5	10.1	1043	1198	145	10.630		
LH Spring	31 Jul 95	TF 17	55.9	64.2	8.2	12.2	1058	1178	107			
RH Spring	31 Jul 95	TF 18	78.8	81.4	2.6	4.1	1129	1221	88			
Top 1	19 Oct 95	YV1	70.1	70.6	0.5	10.2	1115	1181	57	16.022	0.097	11.5
Top 2	19 Oct 95	YV2	69.8	70.0	0.2	9.3	1111	1217	97	14.821		
Bot 1	19 Oct 95	YV3	68.1	68.2	0.1	10.8	1061	1167	96	18.108	0.098	12.2
Bot 2	19 Oct 95	YV4	69.0	69.7	0.7	10.9	1070	1164	82	16.622		
RH Spring	19 Oct 95	YV5	81.0	82.3	1.3	5.9	1017	1121	99	3.304		
LH Spring	19 Oct 95	YV6	64.6	65.5	0.9	11.2	1147	1272	113	20.324		
Top 1	19 Dec 95	YV7	58.7	61.1	2.4	9.8	1060	1165	95	0.908	0.094	11.3
Top 2	19 Dec 95	YV8	58.1	59.5	1.4	6.0	1067	1190	118	1.573		
Bot 1	19 Dec 95	YV9	49.3	51.3	2.0	9.3	932	1033	91	0.583	0.107	13
Bot 2	19 Dec 95	YV10	50.4	51.2	0.8	16.4	932	1033	85	0.689		
Top 1	27 Feb 96	YV11	59.0	59.0	0.1	14.1	1073	1177	90	0.764	0.105	11
Top 2	27 Feb 96	YV12	60.3	59.6	0.7	7.3	1079	1174	87	1.01		
Bot 1	27 Feb 96	YV13	41.5	43.1	1.5	6.4	878	994	110	0.137		11
Bot 2	27 Feb 96	YV14	40.9	42.3	1.4	6.8	884	1002	111	0.128		
Top 1	23 Apr 96	YV15	63.0	63.0	0.0	8.0	1206	1337	123	2.264	0.107	10.2
Top 2	23 Apr 96	YV16	63.0	64.0	1.0	7.0	1216	1358	135	2.234		
Bot 1	23 Apr 96	YV17	66.0	68.0	2.0	11.0	1189	1384	184	8.862	0.121	11
Bot 2	23 Apr 96	YV18	65.0	67.0	2.0	10.0	1192	1410	208	8.304		
RH Spring	23 Apr 96	YV19	80.0	81.0	1.0	7.0	1103	1274	164	2.035		
LH Spring	23 Apr 96	YV20	58.0	59.0	1.0	10.0	1290	1464	164	3.183		
Top 1	25 Jun 96	YV20a	67.0	68.0	1.0	12.0	1310	1487	165	25.05	0.113	10.5
Top2	25 Jun 96	YV21	67.0	68.0	1.0	8.0	1312	1475	155	23.711		
Bot 1	25 Jun 96	YV22	67.0	69.0	2.0	14.0	1280	1403	109	38.19	0.114	11
Bot 2	25 Jun 96	YV23	67.0	70.0	3.0	13.0	1291	1465	161	40.77		
Top	20 Aug 96	GK 1	68.7	71.6	2.9	6.3	1307	1350	37	53.9	0.135	
Top	20 Aug 96	GK 2	70.6	72.8	2.2	4.9	1318	1361	38	63.0		
Bottom	20 Aug 96	GK 3	62.0	66.1	4.1	2.3	1271	1310	37	72.8	0.153	

DRP, dissolved reactive P; TDP, total dissolved P; DOP, dissolved organic P; NH_4-N, ammonium-N; NO_3-N, nitrate-N; TDN, total dissolved N; DON, dissolved organic N; SS, suspended solids

Appendix 1 (*continued*)

SAMPLE	DATE COLLECTED	LAB ID	DRP µg/L	TDP µg/L	DOP µg/L	NH_4-N µg/L	NO_3-N µg/L	TDN µg/L	DON µg/L	SS mg/L	FLOW m^3/sec	TEMP °C
Bottom	20 Aug 96	GK 4	64.8	68.5	3.7	7.7	1281	1361	72	80.4		
Top	05 Nov 96	GK 5	58.2	62.4	4.2	4.4	1380	1457	73	13.7	0.185	11.3
Top	05 Nov 96	GK 6	57.1	61.8	4.7	2.8	1374	1411	34	15.8		
Bottom	05 Nov 96	GK 7	56.0	65.5	9.5	4.9	1337	1405	63	25.4	0.197	12.1
Bottom	05 Nov 96	GK 8	54.4	64.9	10.5	9.9	1345	1412	57	24.5		
Top	18 Dec 96	GK 9	61.8	62.9	1.0	6.5	1236	1367	124	2.8	0.195	11
Top	18 Dec 96	GK 10	62.8	62.9	0.1	6.5	1236	1354	111	3.0		
Bottom	18 Dec 96	GK 11	62.2	62.6	0.4	6.9	1191	1365	168	14.1	0.206	11.9
Bottom	18 Dec 96	GK 12	62.6	62.6	0.0	7.5	1192	1335	136	16.0		
Top	21 Feb 97	GK 13	63.2	63.4	0.2	7.2	1195	1352	150	4.1	0.172	
Top	21 Feb 97	GK 14	62.7	63.4	0.7	8.4	1191	1363	164	3.3		
Bottom	21 Feb 97	GK 15	60.4	61.4	1.1	6.0	1153	1310	150	5.5	0.172	
Bottom	21 Feb 97	GK 16	59.9	60.8	0.9	6.3	1164	1315	145	4.9		
Top	02 May 97	NV1	70.4	70.6	0.3	10.9	1256	1385	117	10.5	0.173	10.2
Top	02 May 97	NV2	70.5	70.6	0.1	9.1	1273	1416	133	10.7		
Bottom	02 May 97	NV3	68.1	68.0	0.1	8.7	1231	1372	131	9.6	0.175	10.4
Bottom	02 May 97	NV4	69.0	69.6	0.6	11.6	1224	1378	142	9.1		
LH Spring	02 May 97	NV5	82.8	82.7	0.1	4.0	1016	1165	145	13.5		
RH Spring	02 May 97	NV6	66.2	67.0	0.8	10.9	1346	1505	148	2.6		
Top	30 Jun 97	NV7	73.5	74.0	0.4	17.4	1284	1439	137	23.1	0.129	10.0
Top	30 Jun 97	NV8	73.0	73.7	0.7	15.9	1296	1450	138	22.8		
Bottom	30 Jun 97	NV9	73.6	73.7	0.1	14.2	1281	1414	119	23.9	0.158	9.7
Bottom	30 Jun 97	NV10	72.6	73.7	1.2	14.2	1277	1430	139	23.3		
Top	25 Aug 97	RM1	70.2	72.8	2.6	20.9	1308	1390	61		0.13	10.3
Top	25 Aug 97	RM2	70.9	72.6	1.7	21.2	1330	1419	68	45.17		
Bottom	25 Aug 97	RM3	69.9	71.7	1.8	24.0	1273	1373	76	38.48	0.142	10.2
Bottom	25 Aug 97	RM4	71.3	72.6	1.3	19.5	1294	1371	58	35.92		
RH Spring	25 Aug 97	RM5	78.8	80.4	1.6	6.9	1094	1142	41	4.24		
LH Spring	25 Aug 97	RM6	66.6	68.1	1.5	30.9	1355	1451	65	37.29		
Top	21 Oct 97	RM7	65.4	66.4	1.0	15.6	1254	1323	53	10.22	0.133	10.6
Top	21 Oct 97	RM8	64.8	65.9	1.1	13.4	1243	1339	83	14.99		
Bottom	21 Oct 97	RM9	62.4	66.2	3.8	19.2	1140	1234	75	25.55	0.159*	10.9
Bottom	21 Oct 97	RM10	61.3	66.1	4.8	13.2	1179	1207	15	23.61		
Top	12 Dec 97	RM11	63.7	69.2	5.5	10.8	1203	1249	35	3.71	0.123	12.1
Top	12 Dec 97	RM12	63.7	66.1	2.4	10.9	1208	1259	40	2.703		
Bottom	12 Dec 97	RM13	60.0	61.8	1.8	9.4	1125	1167	33	2.236	0.154	12.8
Bottom	12 Dec 97	RM14	58.6	61.9	3.3	58.6	1143	1180	22	2.265		
Top	16 Feb 98	RM15	61.1	63.8	2.7	9.9	1148	1223	65	1.358	0.105	
Top	16 Feb 98	RM16	60.8	60.9	0.1	6.3	1167	1220	47			
Bottom	16 Feb 98	RM17	61.6	62.7	1.1	7.0	1133	1180	40	7.76	0.104	
Bottom	16 Feb 98	RM18	62.5	62.9	0.4	7.7	1136	1167	23	8.33		
Top	17 Apr 98	RM19	67.0	71.0	4.0	11.0	1272	1241	0	5.758	0.108	10.6
Top	17 Apr 98	RM20	71.0	73.0	2.0	10.7	1271	1273	0	5.516		
Bottom	17 Apr 98	RM21	69.0	72.0	3.0	11.3	1241	1219	0	12.747	0.105	10.8
Bottom	17 Apr 98	RM22	73.0	73.0	0.0	10.4	1251	1193	0	11.67		
Top	20 May 98	RM23	74.5	75.2	0.7	15.2	1276	1304	0	13.99	0.12	10
Top	20 May 98	RM24	74.9	77.1	2.2	14.5	1219	1406	173	14.92		
Bottom	20 May 98	RM25	74.5	75.7	1.2	15.2	1214	1207	0	17.174	0.119	10
Bottom	20 May 98	RM26	73.5	76.1	2.6	15.8	1188	1156	0	18.891		
LH Spring	20 May 98	RM27	70.2	72.3	2.1	20.2	1298	1336	18	18.12		
RH Spring	20 May 98	RM28	88.3	88.5	0.2	6.2	1106	1078	0	3.984		
Top	29 Mar 99	KG1	66.6	66.8	0.2	9.6	1002	1397	385	2.86	0.166	12.7
Top	29 Mar 99	KG2	67.7	67.7	0.0	7.0	1002	1347	338	2.88		
Bottom	29 Mar 99	KG3	63.8	66.3	2.5	9.5	975	1292	308	11.95	0.151	12.6
Bottom	29 Mar 99	KG4	65.7	66.0	0.3	7.7	975	1295	312	10.24		
Top	08 Jun 99	KG5	72.4	74.1	1.7	17.2	1055	1394	322	13.1	0.144	10.7
Top	08 Jun 99	KG6	72.3	72.3	0.0	13.8	1055	1380	311	12.95		
Bottom	08 Jun 99	KG7	71.8	72.6	0.8	12.8	1028	1370	329	17.04	0.144	10.6
Bottom	08 Jun 99	KG8	72.4	73.0	0.6	13.4	1041	1376	322	16.83		

Appendix 1 (*continued*)

SAMPLE	DATE COLLECTED	LAB ID	DRP µg/L	TDP µg/L	DOP µg/L	NH_4-N µg/L	NO_3-N µg/L	TDN µg/L	DON µg/L	SS mg/L	FLOW m^3/sec	TEMP °C
Top	10 Aug 99	ZY54*	70.1	71.7	1.6	12.1	1402	1449	35	19.81	0.138	10
Top	10 Aug 99	ZY55	68.6	70.8	2.2	11.8	1400	1438	26	21.66		
Bottom	10 Aug 99	ZY56	68.6	70.7	2.1	14.0	1383	1412	15	26.18	0.14	10.1
Bottom	10 Aug 99	ZY57	70.1	71.1	1.0	12.8	1383	1431	35	28.83		
LH Spring	10 Aug 99	ZY52*	65.6	67.7	2.1	15.1	1491	1533	27	31.63		
RH Spring	10 Aug 99	ZY53	80.6	82.3	1.7	7.3	1179	1203	17	1.345		
Top	22 Feb 00	ZY58	56.7	59.6	2.9	6.8	1213	1242	22	2.17	0.116	11.6
Top	22 Feb 00	ZY59	56.7	57.2	0.5	7.8	1112	1152	32	2.23		
Bottom	22 Feb 00	ZY60	53.7	55.3	1.6	8.6	1121	1152	22	10.58	0.09	12.4
Bottom	22 Feb 00	ZY61	53.7	55.5	1.8	8.8	1112	1162	41	11.13		
Top	17 Aug 00	PF1	73	77	4.0	21	1270	1350	59	17.56	0.092	10.2
Top	17 Aug 00	PF2	73	78	5.0	20	1300	1390	70	17.36		
Bottom	17 Aug 00	PF3	73	79	6.0	20	1250	1350	80	20.99	0.098	10.2
Bottom	17 Aug 00	PF4	74	81	7.0	22	1240	1370	108	20.35		
LH Spring	17 Aug 00	PF5	68	73	5.0	25	1360	1510	125	18.65		
RH Spring	17 Aug 00	PF6	80	87	7.0	9	1120	1200	71	6.24		
Top	27 Nov 00	PF7	65	71	6.0	15	1120	1200	65	3.18	0.091	11.6
Top	27 Nov 00	PF8	64	70	6.0	15	1120	1200	65	3.59		
Bottom	27 Nov 00	PF9	61	68	7.0	12	1040	1110	58	6.65	0.08	12.4
Bottom	27 Nov 00	PF10	61	69	8.0	12	1030	1110	68	6.36		
LH Spring	27 Nov 00	PF11	61	68	7.0	22	1160	1260	78	4.33		
RH Spring	27 Nov 00	PF12	70	77	7.0	5	1050	1090	35	2.52		
Top	13 Feb 01	PF13	66	75	9.0	11	1120	1220	89	0.97	0.072	13
Top	13 Feb 01	PF14	67	71	4.0	10	1120	1210	80	1.25		
Bottom	13 Feb 01	PF15	60	67	7.0	10	1000	1130	120	3.2	0.082	12.4
Bottom	13 Feb 01	PF16	59	65	6.0	10	1010	1140	120	3.24		
LH Spring	13 Feb 01	PF17	61	68	7.0	14	1160	1270	96	1.31	0.038	
RH Spring	13 Feb 01	PF18	73	76	3.0	7	1110	1160	43	0.89	0.034	
Top	05 Apr 01	PF19	69	74	5.0	8	1150	1200	42	4.91	0.063	11
Top	05 Apr 01	PF20	71	78	7.0	8	1140	1230	82	8.23		
Bottom	05 Apr 01	PF21	70	77	7.0	10	1050	1130	70	5.6		11.2
Bottom	05 Apr 01	PF22	70	76	6.0	10	1060	1110	40	3.19		
LH Spring	05 Apr 01	PF23	62	70	8.0	8	1140	1220	72	17.37		
RH Spring	05 Apr 01	PF24	77	80	3.0	5	1100	1160	55	11.66		
Top	05 Jun 01	RE3	78.0	77.0	1.0	10.0	1180	1330	140	8.67	0.067	9.4
Top	05 Jun 01	RE4	79.0	79.0	0.0	10.0	1270	1310	30	8.4		
Bottom	05 Jun 01	RE5	80.0	84.0	4.0	14.0	1230	1260	16	14.24	0.056	8.5
Bottom	05 Jun 01	RE6	78.0	79.0	1.0	12.0	1230	1300	58	14.77		
LH Spring	05 Jun 01	RE1	72.0	77.0	5.0	23.0	1340	1410	47	10.6		
RH Spring	05 Jun 01	RE2	88.0	90.0	2.0	6.0	1230	1250	14	2.97		
Top	17 Sep 01	YL1	77.0	75.0	0.0	20.0	1260			23.98	0.051	11.2
Top	17 Sep 01	YL2	80.0	77.0	0.0	21.0	1240			18.81		
Bottom	17 Sep 01	YL3	80.0	80.0	0.0	28.0	1250			35.11	0.055	11.8
Bottom	17 Sep 01	YL4	80.0	80.0	0.0	28.0	1300			33.1		
LH Spring	17 Sep 01	YL5	73.0	74.0	1.0	34.0	1380			32.5		
RH Spring	17 Sep 01	YL6	81.0	80.0	0.0	8.0	1380			11.62		
Top	27 Nov 01	YL7	71.0	71.0	0.0	12.0	1270			3.93	0.048	11.3
Top	27 Nov 01	YL8	71.0	70.0	0.0	12.0	1270			3.97		
Bottom	27 Nov 01	YL9	68.0	70.0	0.0	13.0	1200			5.68	0.044	12.1
Bottom	27 Nov 01	YL10	68.0	70.0	2.0	12.0	1200			5.24		
LH Spring	27 Nov 01	YL11	64.0	65.0	1.0	18.0	1230			5.86		
RH Spring	27 Nov 01	YL12	74.0	74.0	0.0	8.0	986			4.55		
Top	22 Feb 02	GD1	65	67.0	2.0	6	943	1000	51	0.78	0.04	11.5
Top	22 Feb 02	GD2	66	69.0	3.0	6	943	992	43	0.77		
Bottom	22 Feb 02	GD3	56	62.0	6.0	6	749	821	66	0.68	0.046	12.4
Bottom	22 Feb 02	GD4	57	62.0	5.0	8	756	838	74	0.76		
LH Spring	22 Feb 02	GD6	50	54.0	4.0	7	719	816	90	0.45		
RH Spring	22 Feb 02	GD5	74	73.0	1.0	5	1070	1090	15	0.79		
Top	09 May 02	GD7	80	82.0	2.0	8	1030	1100	62	3.14	0.041	10.8

Appendix 1 (*continued*)

SAMPLE	DATE COLLECTED	LAB ID	DRP µg/L	TDP µg/L	DOP µg/L	NH_4-N µg/L	NO_3-N µg/L	TDN µg/L	DON µg/L	SS mg/L	FLOW m^3/sec	TEMP °C
Top	09 May 02	GD8	80	82.0	2.0	8	1050	1070	12	3.04		
Bottom	09 May 02	GD9	73	75.0	2.0	27	998	1080	55	196.6*	0.039	11
Bottom	09 May 02	GD10	74	79.0	5.0	25	1020	1110	65	191.1*		
LH Spring	09 May 02	GD12	69	71.0	2.0	11	863	916	42	1.21		
RH Spring	09 May 02	GD11	84	84.0	0.0	7	1140	1160	13	3.59		
Top	02 Sep 02	LH1	73.0	74.0	1.0	4.0	1080	1120	36	5.52	0.05	10.5
Top	02 Sep 02	LH2	73.0	74.0	1.0	8.0	1070	1140	62	6.07		
Bottom	02 Sep 02	LH3	74.0	76.0	2.0	16.0	1030	1120	74	12.95	0.039	9.8
Bottom	02 Sep 02	LH4	73.0	78.0	5.0	15.0	1040	1110	55	12.68		
LH Spring	02 Sep 02	LH5	59.0	62.0	3.0	7.0	989	1070	74	11.94	0.017	9.5
RH Spring	02 Sep 02	LH6	81.0	83.0	2.0	7.0	1140	1180	33	4	0.033	11.2
Top	22 Oct 02	NB1	70.0	71.0	1.0	8.0	964	1050	78	3.21	0.045	11.8
Top	22 Oct 02	NB2	70.0	73.0	3.0	8.0	962	1020	50	3.71		
Bottom	22 Oct 02	NB3	72.0	79.0	7.0	22.0	916	1010	72	15.83	0.04	13.7
Bottom	22 Oct 02	NB4	72.0	76.0	4.0	22.0	915	1020	83	15.62		
LH Spring	22 Oct 02	NB5	57.0	61.0	4.0	10.0	769	849	70	8.13		12.1
RH Spring	22 Oct 02	NB6	76.0	79.0	3.0	7.0	1060	1100	33	3.57		11.7
Top	19 Dec 02	PQ1	64.0	70.0	6.0	9.0	895	1000	96	1.91	0.046	12
Top	19 Dec 02	PQ2	64.0	68.0	4.0	10.0	895	1010	105	2.4		
Bottom	19 Dec 02	PQ3	58.0	66.0	8.0	10.0	782	892	100	3.1	0.039	14
Bottom	19 Dec 02	PQ4	59.0	67.0	8.0	10.0	764	876	102	3.07		
LH Spring	19 Dec 02	PQ5	49.0	59.0	10.0	20.0	641	970	309	0.84		
RH Spring	19 Dec 02	PQ6	72.0	78.0	6.0	7.0	1020	1150	123	3.65		
Top	06 Mar 03	SZ1	71.0	74.0	3.0	5.0	964	978	9	0.91	0.031	11.4
Top	06 Mar 03	SZ2	70.0	75.0	5.0	3.0	961	971	7	0.91		
Bottom	06 Mar 03	SZ3	44.0	44.0	0.0	5.0	696	745	44	0.24	0.025	11.9
Bottom	06 Mar 03	SZ4	43.0	44.0	1.0	1.0	680	729	48	0.21		
LH Spring	06 Mar 03	SZ5	56.0	56.0	0.0	0.0	567	616	49	0.36		
RH Spring	06 Mar 03	SZ6	72.0	72.0	0.0	3.0	1060	1080	17	1.19		
Top	01 May 03	VL1	79.0	84.0	5.0	2.0	1010	1060	48	1.121	0.03	10.9
Top	01 May 03	VL2	80.0	84.0	4.0	3.0	1010	1060	47	1.109		
Bottom	01 May 03	VL3	89.0	97.0	8.0	6.0	974	1050	70	0.93	0.031	10.4
Bottom	01 May 03	VL4	89.0	98.0	9.0	6.0	974	1050	70	0.852		
LH Spring	01 May 03	VL5	67.0	74.0	7.0	4.0	663	722	55	0.368		
RH Spring	01 May 03	VL6	80.0	86.0	6.0	1.0	1090	1120	29	1.185		
Top	10 Jun 03	XI1	82.0	86.0	4.0	10.0	1020	1070	40	5.395	0.036	10.5
Top	10 Jun 03	XI2	82.0	86.0	4.0	10.0	1020	1060	30	4.425		
Bottom	10 Jun 03	XI3	85.0	90.0	5.0	18.0	962	1040	60	12.382	0.031	10
Bottom	10 Jun 03	XI4	84.0	91.0	7.0	16.0	958	1040	66	13.866		
LH Spring	10 Jun 03	X15	71.0	75.0	4.0	11.0	684	769	74	3.671		
RH Spring	10 Jun 03	X16	96.0	100.0	4.0	9.0	1120	1150	21	3.678		

*Hand weeding above bottom site

Appendix 2

Vascular plant species of Whangamata Stream 2003*

(Wildland Consultants Ltd 2003) (Grid reference NZMS260 T17 649806)

COVER CLASS ABUNDANCE FOR SPECIES ON DIFFERENT SURVEY SECTIONS

VASCULAR PLANTS	SURVEY SECTION						
	A	B	C	D	E	F	G
Gymnosperms							
Dacrycarpus dacrydioides[1]		1	2	1			1
Monocot. trees and shrubs							
Cordyline australis	2	2	2	2	1	1	1
Phormium tenax	4	2	2	3	2	2	3
Dicot. trees and shrubs							
Aristotelia serrata[3]				1			
Brachyglottis repanda var. *repanda*[1]	1		1				
Coprosma propinqua subsp. *propinqua*[3]						1	1
C. propinqua subsp. *propinqua* × *C. robusta*[3]		1					
C. robusta	1	1	1	1		1	1
Coriaria arborea	1			1			
Fuchsia excorticata	2						
Gaultheria antipoda[2]		1					
Geniostoma rupestre var. *ligustrifolium*[2]	1		1				
Griselinia littoralis[1]	1						
Hebe stricta[1]	4	3	1	2			
Kunzea ericoides var. *ericoides*[1]	1	2	1	1	1	2	2
Leptospermum scoparium	1		1	1	1	2(p)	2(p)
Leucopogon fasciculatus[3]			1	1			
L. fraseri[1]		1		1			

***KEY**

[1] Not recorded in 1986; but recorded in 1993 and 1998
[2] New record 1998
[3] New record 2003
(p) Planted

Percentage cover class scale (from Allen 1992)

Percentage cover	Cover class
< 1	1
1–5	2
6–25	3
26–50	4
51–75	5
76–100	6

Appendix 2 (*continued*)

VASCULAR PLANTS	SURVEY SECTION						
	A	B	C	D	E	F	G
Dicot. trees and shrubs							
Melicytus ramiflorus subsp. *ramiflorus*[1]	1	1					
Nothofagus fusca[1]	2(p)	1					
Pittosporum colensoi[1]	1	1	1				1
P. eugenioides[2]							1
P. tenuifolium[1]		1	2	1		2	1
Plagianthus regius[3]							1(p)
Pseudopanax arboreus[2]	1	1	2	1			1
Sophora tetraptera[1]	2	1	1				1
Dicot. lianes							
Calystegia sepium[1]	2		1	1			1
Muehlenbeckia australis	2		1	1		2	1
Ferns							
Asplenium bulbiferum s.s.[3]	1						
A. flaccidum subsp. *flaccidum*	1	1	1				
A. oblongifolium[3]	1	1	1				
A. polyodon[2]	1	1	1	1			
Blechnum chambersii[3]		1					
B. fluviatile[2]			1				
B. novae-zelandiae s.s.	1	1	1	1			
B. novae-zelandiae (wetland form)	1	1	2	2	1		1
Cyathea dealbata[2]	1						
C. smithii[3]	1			1			
Deparia petersenii							1
Dicksonia fibrosa[3]	2	1	1	1			
D. squarrosa	1	1	1	1	1		
Diplazium australe	1	1	1	1			
Histiopteris incisa	1	1	1	1			
Hypolepis ambigua	1	1	1	1			1
Paesia scaberula	1	1	1	1			
Pellaea rotundifolia	1						
Phymatosorus pustulatus[1]	1	1	1	1			
Polystichum richardii	1	1					
P. vestitum	1	1	1	1			
Pteridium esculentum	3	2	2	2	1	3	2
Pteris macilenta[3]							1
P. tremula[3]	1						
Pyrrosia eleagnifolia[3]	1						
Grasses							
Cortaderia fulvida	1	2	2	2	1	3	4
Deyeuxia avenoides[3]	1						
Poa anceps[3]	1						
Rytidosperma sp.[1]	1	1	1	1			
Sedges							
Carex maorica[3]	1						
C. secta	3	1	1	1	1	1	1
C. virgata	2	1	1	1	1		1
Carex sp. (*C. geminata* agg.)	3		1		1	3	2
Eleocharis acuta	1						1
Rushes							
Luzula picta[2]	1						

Appendix 2 (*continued*)

VASCULAR PLANTS	SURVEY SECTION						
	A	B	C	D	E	F	G
Monocot herbs (other than orchids, grasses, sedges and rushes)							
Lemna minor[2]	1						
Composite herbs							
Senecio minimus[1]	1		1				
Dicot. herbs (other than composites)							
Epilobium pallidiflorum[3]	1			1			1
Persicaria decipiens+ (*= Polygonum salicifolia)*	1		1		1		1
Pratia angulata[2]	1						
Urtica incisa	1						

ADVENTIVE PLANTS	SURVEY SECTION						
	A	B	C	D	E	F	G
Gymnosperms							
Pinus pinaster[3]		1		1			
P. radiata[2]		1				1	
Pseudotsuga menziesii[2]	1	1	1	1		1	
Dicot. trees and shrubs							
Acacia melanoxylon	*2*	*3*	*4*	*3*			
A. verticillata[3]	1						
Acer sp.[2]							
Berberis glaucocarpa[3]	1						
Betula pendula[2]	1	1			1		1
Buddleia davidii[2]				1		1	1
Chaemaecytisus palmensis[1]		3	2	1		1	2
Cotoneaster franchetti[3]				1		1	
C. glaucophyllus[3]							1
Cryptomeria japonica[3]				1			
Cytisus scoparius	2	2	2	2	1	2	
Erica lusitanica[1]	1	1		1			
Eucalyptus globulus[2]		2	2	1			
Euonymus oxyphyllus[3]	1						
Larix sp.[2]				3			
Leycesteria formosa[2]			2	1			
Liquidambar styraciflua[3]	1						
Lupinus arboreus				1	1	2	1
Malus domestica[2]		1				1	1
Populus sp.[3]					2		
Populus nigra cv. *italica*[1]	1						2
Prunus sp. (ornamental cherry)[3]						1	1
Prunus sp.	2	2	1	1			1
P. persica[3]						1	
Quercus palustris	1	2					
Q. robur[3]	1	1					
Q. subar		1					
Rosa rubiginosa	1	1	1	1	1	1	1
Rubus sp. (*R. fruticosus* agg.)	4	3	2	2	1	3	2
Salix babylonica[3]						1	1
S. cinerea[1]		1		2			1
S. fragilis[1]	2						1
Sorbus aucuparia[3]	1	1					
Ulmus sp.					1		
Ferns							
Dryopteris filix-mas[3]		1	1				

Appendix 2 (*continued*)

ADVENTIVE PLANTS	SURVEY SECTION						
	A	B	C	D	E	F	G
Dicot. lianes							
Lonicera japonica[3]				1			2
Grasses							
Agrostis capillaris	3	2	2	3	4	2	3
Anthoxanthum odoratum	1	2	1	1	1		1
Bromus willdenowii[2]				1	1		1
Dactylis glomeratus	2	2	4	3	3	4	3
Glyceria declinata							1
G. fluitans[2]							1
Holcus lanatus	2	3	3	2	2	2	2
Lolium perenne					2		1
Paspalum dilatatum					1		
Phleum pratense[1]						1	
Poa sp. [2]							1
Schedonorus phoenix[3]							1
Sedges							
Carex ovalis		1					1
Rushes							
Juncus articulatus							1
J. bufonius							1
J. effusus	1						1
J. tenuis							1
Composite herbs							
Bidens frondosa							1
Carduus nutans[3]	1	1		1	1	1	
Cirsium arvense	1	1	1		1		1
C. vulgare	1	1	1	1	1	1	1
Conyza albida	1	1	1	1	1		1
Crepis capillaris		1	1	1	1		1
Hypochaeris radicata					1	1	1
Leontodon taraxacoides[3]					1		
Mycelis muralis	1	1	1	1	1		
Senecio bipinnatisectus			1				
S. jacobaea	1	1		1	1	1	1
Sonchus oleraceus		1	1	1			1
Taraxacum officinale[1]	1				1	1	1
Dicot. herbs (other than composites)							
Acaena agnipila[3]					1		
Acaena novae-zelandiae	1	1	1	1			
Achillea millefolium		1	1	1	2	3	2
Callitriche stagnalis							1
Capsella bursa-pastoris[3]					1		
Cerastium fontanum subsp. *triviale*	1						1
Digitalis purpurea			1				
Duchesnea indica[3]	1						
Epilobium ciliatum	1						
Galium aparine	1	1	1	1		1	1
Geranium molle[3]				1	1		1
Geranium robertianum[2]		1	1	1			
Hypericum perforatum				1			
Lactuca serriola[1]	1		1	1	1	1	1
Lotus pedunculatus	1	2	1	2	2	1	2
Mentha spicata subsp. *spicata*						1	1

ADVENTIVE PLANTS	SURVEY SECTION						
	A	B	C	D	E	F	G
Dicot. herbs (other than composites)							
Mimulus guttatus	2	2	2	2	1	1	1
Myosotis scorpioides				1			1
Plantago lanceolata[1]		1		1	1	1	
P. major[2]					1		
Polygonum hydropiper			1	1	1	1	1
Prunella vulgaris	1						
Ranunculus acris[1]		1	1	1			1
R. repens			1	1	1	1	1
Rorippa microphylla[3]			1				
R. nasturtium-aquaticum	2		1	1	1		1
Rumex acetosella[1]	1		1	1	2	1	1
R. conglomeratus	1			1	1		
R. obtusifolius	1	1			1	1	1
Solanum nigrum[1]	1		1	1	1		
Stachys sylvatica[3]			1				
Stellaria media	1			1	1	1	1
Trifolium arvense					1		
T. pratense				1	2	2	1
T. repens	1			1	2	2	1
Verbascum virgatum[1]	1				1		

Species not recorded 2003 but recorded previously

*Blechnum penna-marina**	(recorded 1993, 1998)
*Carex fascicularis**	(recorded 1986, 1993)
*C. lessoniana**	(recorded 1986, 1993, 1998)
Castanea sp.	(recorded 1986, 1993, 1998)
Cortaderia toetoe *	(recorded 1986, 1993, 1998)
*Elymus rectisetus**	(recorded 1986, 1993)
*Epilobium nummulariifolium**	(recorded 1986, 1993)
E. obscurum	(recorded 1986, 1993)
*E. pedunculare**	(recorded 1986, 1993, 1998)
*Euchiton audax (Gnaphalium audax)**	(recorded 1998)
*E. involcratus (G. involucratum)**	(recorded 1986, 1993)
*E. limosus (G. limosum)**	(recorded 1986, 1993)
Gamochaeta spicata (Gnaphalium coarctatum)	(recorded 1998)
*Geranium potentilloides**	(recorded 1986, 1993)
Glyceria maxima	(recorded 1998)
Haloragis erecta subsp. *erecta**	(recorded 1986, 1993, 1998)
Hebe sp. (cultivar)	(recorded 1986, 1993, 1998)
Juncus acuminatus	(recorded 1986, 1993)
J. dichotomus	(recorded 1986, 1993)
Medicago sativa	(recorded 1998)
*Microtis unifolia**	(recorded 1986, 1993)
Mimulus moschatus	(recorded 1998)
Orobanche minor	(recorded 1986, 1993)
Paspalum distichum	(recorded 1986, 1993)
Polygonum prostratum	(recorded 1998)
*Pseudognaphalium luteoalbum**	(recorded 1998)
Senecio sylvaticus	(recorded 1998)
Solanum tuberosum	(recorded 1998)
Ulex europaeus	(recorded 1998)

* Indigenous species

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