Return to previous file: sfc300

TABLE 1. SPECIES NOT RECORDED IN 2008 THAT HAD BEEN RECORDED PREVIOUSLY FROM WHANGAMATA STREAM.

Bold = species lost since 2003. (Data taken from Beadel 1993, 1998; Wildland Consultants Ltd 2003, 2008.)

SPECIES	YEAR RECORDED AS PRESENT
Acaena agnipila	2003
Azolla filiculoides	1982, 1986
Berberis glaucophylla	2003
Carduus nutans	2003
Carex maorica*	1986, 1993, 2003†
Castanea sp.	1986, 1993, 1998
*Cortaderia toetoe**	1986, 1993, 1998
Cryptomeria japonica	2003
Cyathea smithii*	2003
Digitalis purpurea	1993
Eleocharis gracilis	1986
*Elymus rectisetus**	1986, 1993
*Epilobium nummulariifolium**	1986, 1993
Epilobium obscurum	1986, 1993
Epilobium pallidiflorum	2003
*Epilobium pedunculare**	1986, 1993, 1998
*Euchiton audax (Gnaphalium audax)**	1998
*Euchiton involcratus (Gnaphalium involucratum)**	1986, 1993
*Euchiton limosus (Gnaphalium limosum)**	1986, 1993
Euonymus oxyphyllus	2003
*Geranium potentilloides**	1986, 1993
Glyceria fluitans	1998, 2003
Glyceria maxima	1998
Hebe sp. (cultivar)	1986, 1993, 1998
Hypericum perforatum	2003
Juncus acuminatus	1986, 1993
Juncus dichotomus	1986, 1993
Lemna minor	2003
Ludwigia peploides	1982,1986
Ludwigia palustris	1982,1986
Luzula picta	2003
Medicago sativa	1998
*Microtis unifolia**	1986, 1993
Mimulus moschatus	1998
Myosotis scorpioides	1986, 1993, 1998, 2003‡
Myriophyllum propinquum	1982, 1986
Myriophyllum triphyllum	1982, 1986
Orobanche minor	1986, 1993
Paspalum distichum	1986, 1993
Persicaria decipiens	2003
Plantago major	1998, 2003
Polystichum richardii	1993
Pteris macilenta*	2003
Pteris tremula*	2003
*Pseudognaphalium luteoalbum**	1998
Ranunculus acaulis	1986
Rorippa (Nasturtium) microphylla	2003
Senecio minimus	2003
Senecio sylvaticus	1998
Solanum tuberosum	1998
Typha orientalis	1982, 1986
Ulex europaeus	1998
Urtica incisa	2003
***Ulmus* sp.**	2003

* Native species.

† Incorrectly recorded as *Carex fascicularis* in 1986 and 1993.

‡ The *Myosotis* present in 1986, 1993, 1998 and 2003 may have been incorrectly identified and may in fact have been *Myosotis laxa*. *Myosotis laxa* and *M. scorpioides* are 'extremely difficult to distinguish' based on vegetative parts (Wildland Consultants Ltd 2008).

were recorded as lost between 1998 and 2003 were later recorded in the 2008 survey, and five species that were recorded as lost between 1998 and 2008 were originally mis-identified. Table 1 is the most up-to-date list of lost species. If the lost species are added to the existing species list, then over 240 vascular plant species have been present in the riparian area of Whangamata Stream over the last 32 years.

Table 2 provides a breakdown of the total number of species found at Whangamata Stream in 2008, arranged in a downstream sequence by stream survey section. The highest number of species was found in Section G. The largest increases since 1998 were in the middle sections (D–E) and in the lower section (G) (Fig. 4). The number of woody trees and shrubs was lowest in Sections C and E, and the proportion of woody species varied from 18% to 51%. The number of native species was highest in Sections A and B and lowest in Sections E and F. Significant increases in native species had occurred in Section G, while a decline in native species since 2003 was recorded in Sections A and C.

TABLE 2. TOTAL NUMBER OF SPECIES OF WOODY PLANTS PRESENT IN EACH OF THE SEVEN SECTIONS OF WHANGAMATA STREAM IN 2008.

See Fig. 1 for locations of each section. Numbers in brackets are assisted plantings.

	TOTAL SPECIES			NATIVE SPECIES		
STREAM SECTION	TOTAL SPECIES NUMBER	NUMBER OF TREE AND SHRUB SPECIES	% TREES AND SHRUBS	NUMBER OF NATIVE SPECIES	NUMBER OF NATIVE TREES AND SHRUBS	% NATIVE SPECIES THAT ARE TREES AND SHRUBS
A	79	40	51	45	22 (9)	55
B	84	35	42	39	19 (8)	54
C	50	16	32	24	11 (7)	69
D	84	29	35	33	17 (6)	59
E	62	11	18	10	4 (1)	36
F	58	20	34	16	12 (8)	60
G	114	31	27	36	18 (14)	58

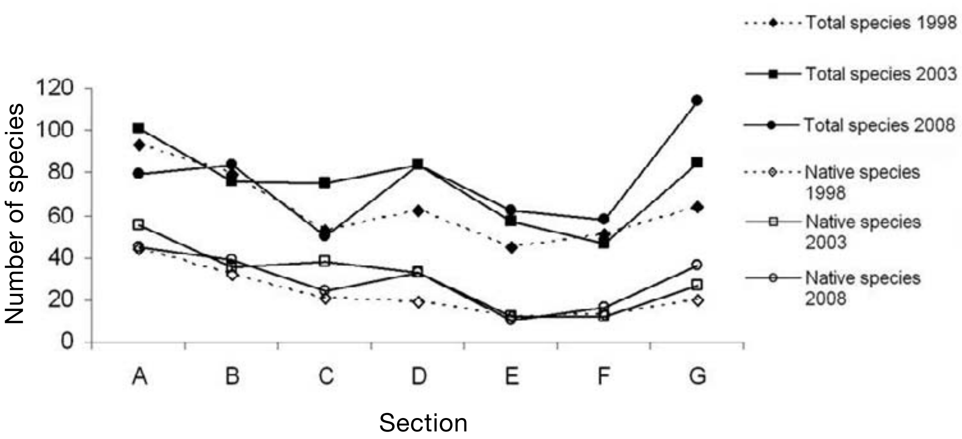

Figure 4. Total number of species and number of native species in 1998, 2003 and 2008 in each of the Whangamata Stream survey sections.

4.1.1 Upper reach (Sections A and B)

There were 110 species in the upper reach of the stream, of which 50 (45%) were classed as trees and shrubs. Within the total species assemblage for the reach, there were 55 native species, equivalent to 50% of the flora. The total number of species recorded decreased in Section A from 101 in 2003 to 79 in 2008, but increased in Section B from 76 in 2003 to 84 in 2008. The observed decrease in Section A may in part be attributed to the significant expansion of *Prunus serotina*, along with the growth of other woody species, particularly *Quercus* spp., that appear to have outcompeted the native species. Two native species (*Phormium tenax* and *Muhlenbeckia australis*) were particularly abundant, having cover classes of 3 (6–25% cover) or greater (see Appendix 2). It is of interest that *Cortaderia fulvida*, which was a stream bank dominant between 1982 and 1992 and was still in cover class 3 in 1998, had a percentage cover of less than 6% in this reach of the stream in 2003 and 2008, having been replaced by competition from *Phormium.* Other former dominants, such as watercress (*Rorippa nasturtium-aquaticum*) and musk (*Mimulus guttatus*), were also uncommon in this reach in 2008. Three species of tree fern were recorded, with *Dicksonia fibrosa* the most common, having a cover class of 2. *Cyathea smithii*, which was present in 2003, was not recorded in 2008. Tall groves of cabbage tree (*Cordyline australis*) are now well established. The only new woody species to enter Sections A and B in the last 5 years were *Schefflera digitata* and *Ilex aquifolium.*

4.1.2 Middle reaches (Sections C, D and E)

The middle reaches showed the greatest increase in number of plant species between 1998 and 2003 (Howard-Williams & Pickmere 2005). However, between 2003 and 2008 the number of species recorded in these middle section areas remained constant overall (83 and 84 species, respectively). Blackwood (*Acacia melanoxylon*) has remained the main tree species in the middle reaches, and the dense grassy swards of the original pasture grasses *Agrostis capillaris*, *Dactylis glomeratus* and *Holcus lanatus* reported in 2003 still covered significant areas. Blackwood and broom (*Cystisus scoparius*) were aggressively colonising the grassy area. It is anticipated that the invasion of new woody species may, in the long term, reduce the persistent grass cover; however, this is taking longer than expected.

4.1.3 Lower reaches (Sections F and G)

The lower reaches, particularly Section G, again showed significant increases in species diversity between 2003 and 2008. These increases included 11 new species in Section F and 29 in Section G. These were mostly herbaceous species, with only four new tree species identified: *Erica lusitanica*, *Coprosma propinqua* subsp. *propinqua* × *C. robusta*, *Hebe stricta* and *Leucopogon fasiculatus.* Vegetation in the lower stream section (G) off the end of Ogilvie Terrace had become very dense, restricting access to the maintained footpaths. Stream banks in the lower reaches were dominated by assisted plantings of toetoe, flax, manuka and hebe (*Hebe* spp.) species. Much of the stream channel was lined with *Carex* spp. (Fig. 5) and musk was a prevalent in-stream plant.

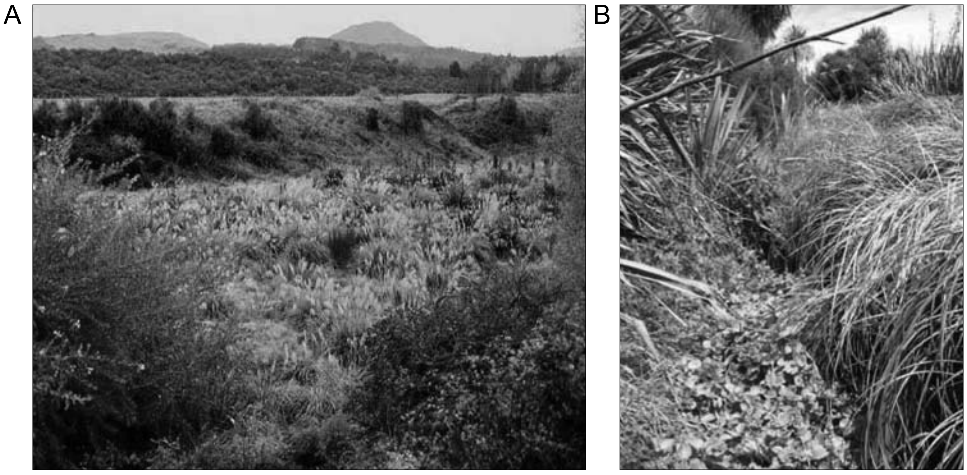

Figure 5. Vegetation at the Bottom Site, Whangamata Stream. A. Overview of the lower stream Section G from Kinloch on the left bank in 1998, showing assisted plantings of toetoe (*Cortaderia fulvida*) and flax (*Phormium tenax*) across the riparian strip. B. Downstream view from the Bottom Site in February 2006, showing development of musk beds covering the stream channel.

4.2 FLOW RATES

Recent evidence from Environment Waikato (Hadfield et al. 2001; Vant & Smith 2002) indicates long groundwater residence times in the Whangamata Stream catchment, with only 10% of the catchment groundwaters being younger than 35 years (Hadfield et al. 2001). At base flows, all of the Whangamata Stream water arises from the two groundwater-fed springs. Inter-annual and inter-decadal fluctuations in flows from these springs result in the cyclical pattern of flow rates in the stream shown in Fig. 6. It is not known what causes these fluctuations, but most of the variability in the long-term pattern of stream discharge for the study reach is due to variability in the Left Hand Spring and Tributary. Peaks in flow occurred in 1977, 1999 and 2007 (Fig. 6). Following a low-flow period (0.05 m^3/s) in the mid-1980s (Howard-Williams & Pickmere 1999), the maximum base flow over the whole record was reached in March 1999 (0.166 m^3/s); flows then generally stayed above 0.11 m^3/s from June 1999 to February 2000. From that time, stream flows gradually declined, so that from November 2001 to June 2003 stream discharges were less than 0.05 m^3/s. Flows began to rise again in June 2004 and reached a peak of 0.1 m^3/s in November 2007. By the end of the record in June 2008, flows had again reduced to 0.06 m^3/s.

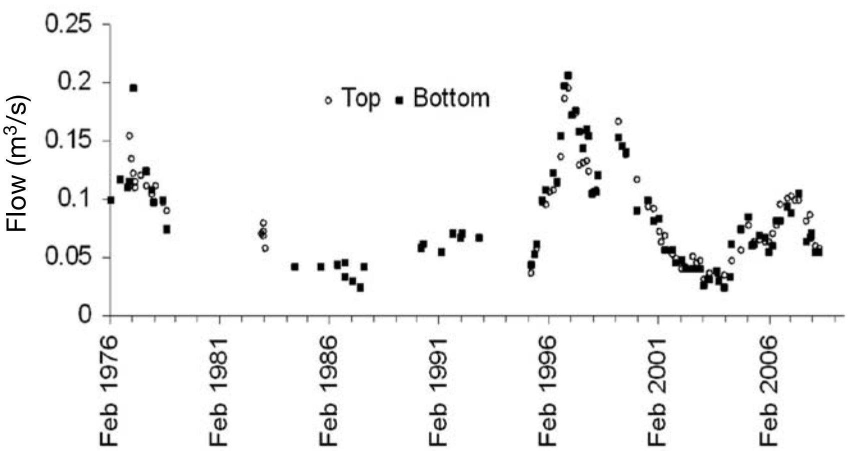

Figure 6. Whangamata Stream flows (m^3/s) at the Top and Bottom Sites from 1976 to 2008. (Note that in period 1984–1993, Top and Bottom Site flow symbols overlap.)

Since 1999, flows at the Bottom Site have often been up to 10% lower than those at the Top Site, and from November 2007 to June 2008 flows were consistently lower at the Bottom Site (mean reduction = 0.011 m^3/s). This is a reversal of the situation that prevailed through the 1980s up to 1998.

4.3 TOTAL SUSPENDED SOLIDS (TSS)

Concentrations of total suspended solids (TSS) followed a strongly seasonal pattern, with low values in the summer months that increased to a peak in late winter each year (Fig. 7). Values at the Bottom Site were consistently higher than those at the Top Site, with the exception of occasional single samples usually in summer or autumn in most years. The very high values in 1996 and 1997 followed the eruption of Mount Ruapehu, which resulted in considerable ash fall coating this area. During the low-flow period from 2002 to 2004, the typical winter maxima were less than 20 g/m^3 and summer values at the Top Site were frequently less than 1 g/m^3. TSS increased in 2005, 2006 and 2007, which corresponded with increasing stream flows. A relatively high value of 35 g/m^3 in November 2006 corresponded with a high TSS value in the Left Hand Tributary (26 g/m^3). This presumably resulted from land clearance upstream in the Left Hand Tributary.

Peaks in TSS mass flow (kg/h) in 1996 and 1997 also followed the Mt Ruapehu eruption. The mass flow of suspended solids declined with declining discharge from 1999 to 2003 (Fig. 8), so that the values in May 2003 were only 0.12 kg/h. As with suspended solids concentration, mass flow increased with increasing stream flow to 2006 and then appeared to decline again.

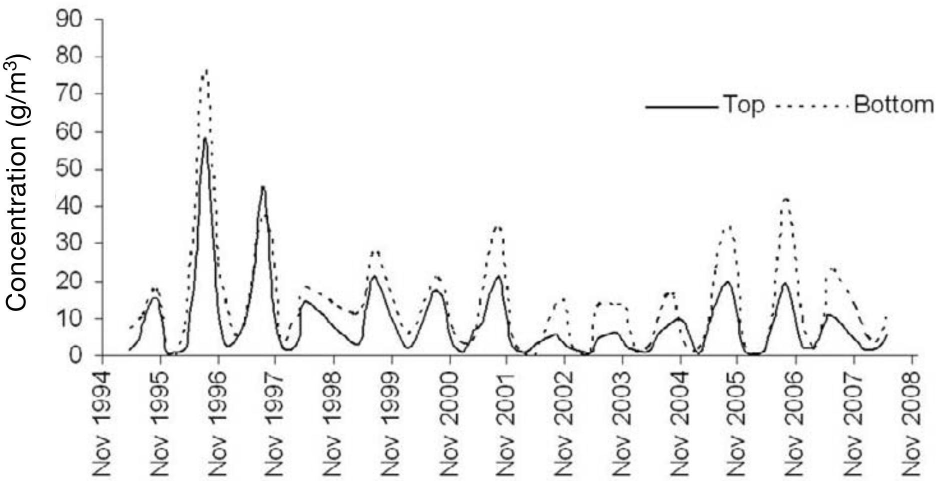

Figure 7. Concentration of suspended solids (g/m^3) in the Whangamata Stream.

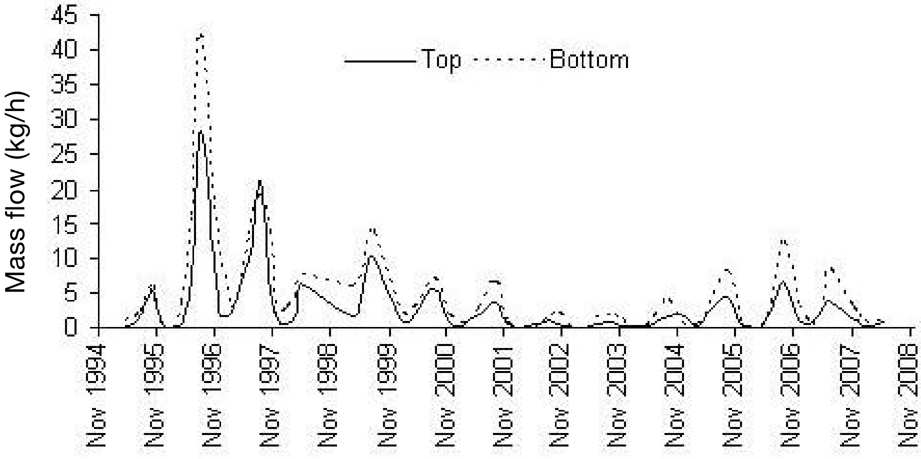

Figure 8. Mass flow of suspended solids (kg/h) in the Whangamata Stream.

4.4 NUTRIENTS IN THE RIGHT HAND SPRING AND LEFT HAND TRIBUTARY

The Right Hand Spring has the oldest groundwater in the catchment, identified as being 80 years old (Vant & Smith 2002). Nutrient concentrations in the springs may therefore now reflect land use practices in the 1930s and 1940s. Nitrate-N concentrations were not as high in the Right Hand Spring as in the Left Hand Tributary, but the Right Hand Spring was characterised by higher DRP concentrations. There was an increase in nitrate-N concentrations between 1979 and 1985, after which the values fell to a low of 700 mg/m^3 in 1986 (Fig. 9). Nitrate-N concentrations subsequently increased steadily to reach almost double the 1986 value in 2008 (Fig. 9; Appendix 1). In contrast, DRP in the Right Hand Spring increased only very slightly, from c. 70 mg/m^3 in 1980 to c. 80 mg/m^3 in 1995, and then remained relatively constant (Fig. 10; Appendix 1).

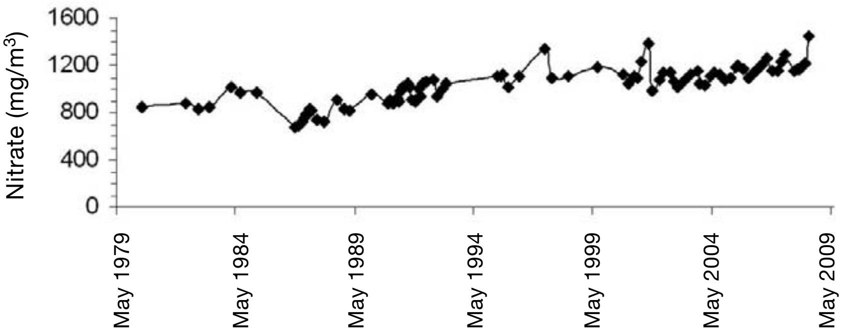

Figure 9. Nitrate-N concentrations (mg/m^3) in the Right Hand Spring, Whangamata Stream, 1979–2008.

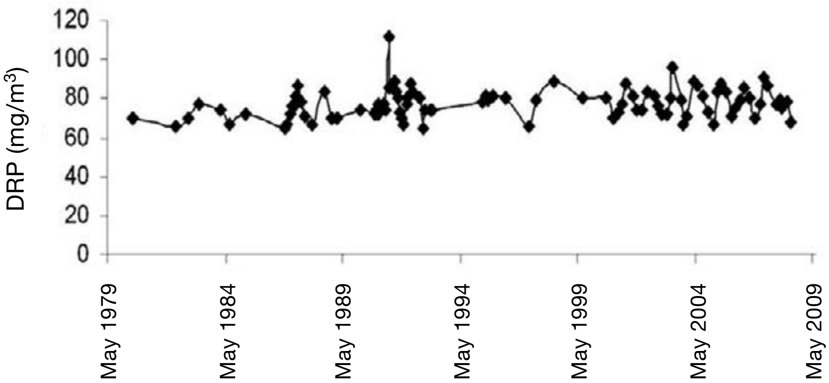

Figure 10. Dissolved reactive phosphorus (DRP) concentrations (mg/m^3) in the Right Hand Spring, Whangamata Stream, 1979–2008.

There appeared to be slightly lower nutrient values in the summer months (Appendix 1). This probably resulted from the fact that these springs emerge in dense watercress- and musk-dominated wetland, so some nutrient uptake may be expected above the sampling sites at the bases of the springs.

Nutrient concentrations in the Left Hand Tributary have fluctuated considerably since 1995, from a low of 499 mg/m^3 on 29 April 2004 (Howard-Williams & Pickmere 2005) to a high of 1650 mg/m^3 in June 2007; they then decreased again to 1360 mg/m^3 in April 2008 (Appendix 1).

4.5 NUTRIENTS IN THE STREAM CHANNEL

4.5.1 Nitrate-N

Nitrate-N concentrations at the Top Site and Bottom Site of Whangamata Stream are shown for the whole monitoring period in Fig. 11. Earlier data are available from Vincent & Downes (1980) and Schouten et al. (1981). Over the whole study period, nitrate-N concentrations showed a steady rise at the Top Site, from c. 700 mg/m^3 in 1979 to almost double that in 2008. The general long-term trend reflects the increase in nitrate-N in the Right Hand Spring (Fig. 9). The apparent inter-decadal periodicity that overlies this trend generally follows the same pattern as that of the stream flows shown in Fig. 6 (although not quite as marked), with rises in 1979–1981, 1989–1992, 1995–2001 and 2004–2007, illustrating some dependence of concentration on flow. However, the general trend of increasing concentration over the study period and the marked variability in concentrations at the Bottom Site indicate that flow is only one of the factors affecting nitrate-N concentration. This is discussed in section 5.2.

The relationship between nitrate-N concentration and mass flow can be better gauged from a comparison of trends in each between 1994 and 2008. Comparison of Figs 12 & 13 illustrates that there was a relatively small change in concentration of nitrate-N with associated seasonal and inter-decadal periodicity over this period, whereas there was large inter-decadal periodicity in mass flow. Note that mass flow of nitrate-N was often lower at the Bottom Site, which is a function of both the decrease in flow at the Bottom Site referred to in section 4.2 and the attenuation processes for nitrate in the stream.

The concentration (and then mass flow) records have been divided into a number of qualitatively assigned 'Phases' that reflect characteristics of the nutrient record (Figs 11, 12 & 13 for nitrate-N). The full description of the Phases is provided in the Discussion (section 5.4).

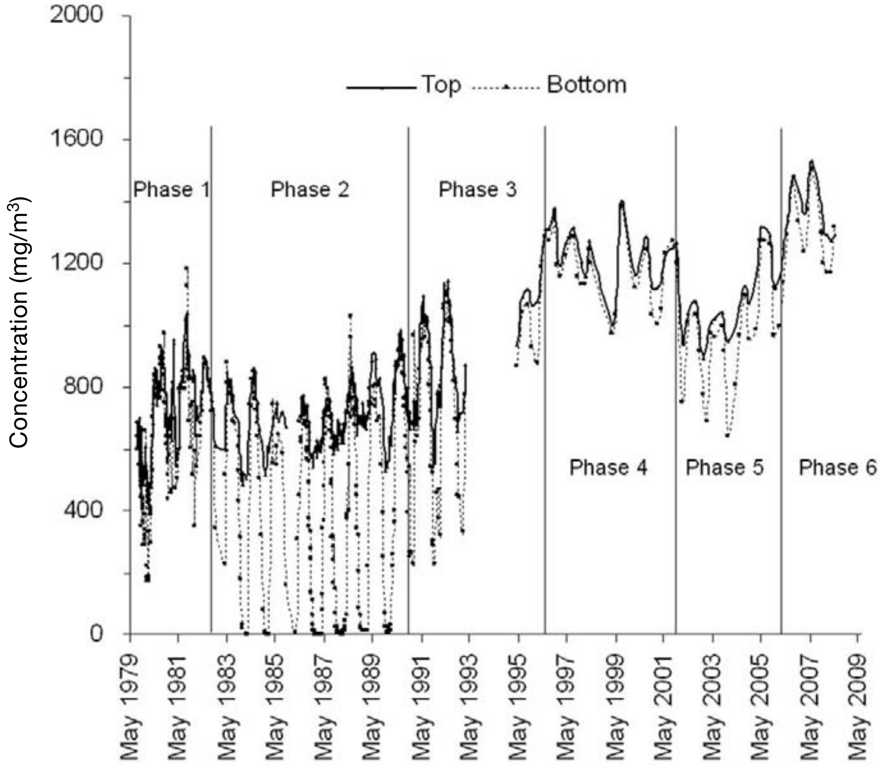

Figure 11. Nitrate-N concentrations (mg/m^3) at the Top and Bottom Sites, Whangamata Stream, 1979–2008. Phases 1–6 are described in section 5.4.

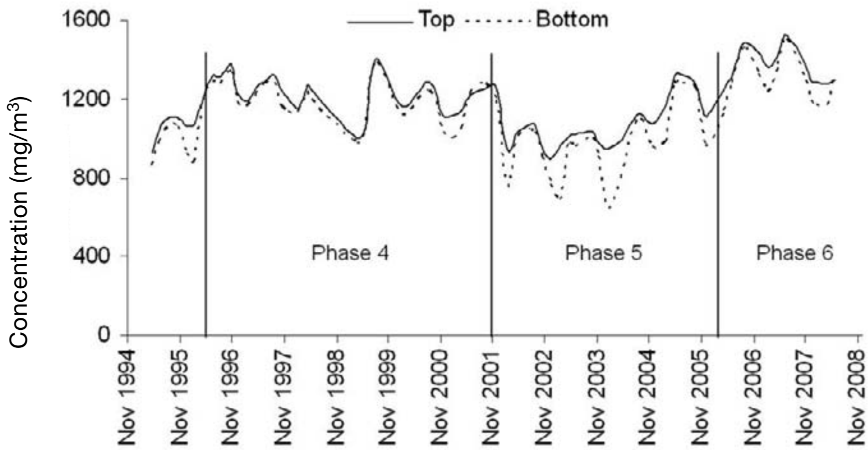

Figure 12. Nitrate-N concentrations (mg/m^3) at the Top and Bottom Sites, Whangamata Stream, 1995–2008.

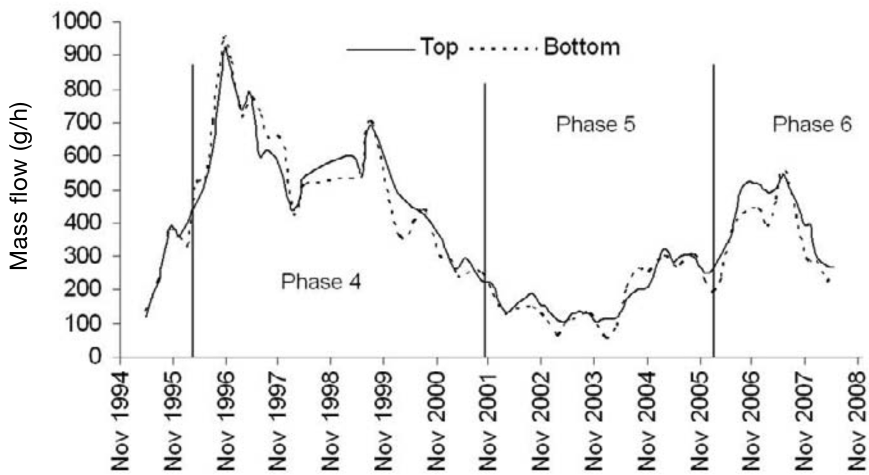

Figure 13. Mass flows of nitrate-N (g/h) at the Top and Bottom Sites, Whangamata Stream, 1995–2008.

Continue to next file: sfc300b