



The Styx

Pūrākaunui

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May 2004

Styx Report: 2004/2
AEL23

**The Aquatic Ecology of the Upper Kaputone Stream
and the Effects of Reduced Flows**



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Executive Summary

Aquatic invertebrate and fish communities from sites in the upper reaches of Kaputone Stream, last surveyed in 1996 and 1998, were resurveyed in 2004 using similar collection methods.

The instream fauna of the Kaputone Stream upstream of the Main North Road has been compromised by lack of permanent flow. This is evident by the absence of invertebrate taxa requiring permanent water, significant loss of species diversity, and drop in UCI scores upstream compared to downstream of the Main North Road.

Comparison of invertebrate community composition between 1996 and this study indicates that Kaputone Stream upstream of the Main North Road is becoming increasingly dominated by oligochaetes and microcrustaceans; species tolerant of ephemeral conditions. This trend is consistent with the hypothesis that periods of dewatering in this reach have increased since 1996.

The fish fauna has declined from two species in 1996, shortfin eel and upland bully, to just shortfin eels in 2004. Shortfin eel abundance was relatively low upstream of the Main North Road, in ephemeral, but otherwise suitable aquatic habitats, compared to more permanent aquatic habitats downstream.

It is concluded that the frequent and protracted dewatering of ephemeral habitats is compromising both fish and aquatic invertebrate community health in the upper reaches of Kaputone Stream.

1. Background and objective

The upper reaches of Kaputone Stream, one of the two principal tributaries of the Styx River, have incurred a significant loss of surface flow in recent years (Taylor, 2002). Temporary loss of surface flow has been associated with local groundwater pumping during subdivision development, with surface flows returning when groundwater pumping ceased. However, there have also been protracted periods of time where the channel has little or no water, in the absence of groundwater pumping. While groundwater levels, rainfall, and Waimakariri River flows are associated with base flows in the upper Kaputone Stream, periods of dewatering appear to be becoming more frequent (Nikora, 2004). Clearly, dewatering will have implications for the aquatic ecology, but to date these changes have not been monitored.

AEL (Aquatic Ecology Limited) was commissioned by the CCC (Christchurch City Council) to compare the aquatic ecology of the upper reaches of the Kaputone Stream, with that in 1996 and 1998, prior to the intensive residential development of the upper catchment. The historical data was collected as part of the NIWA (National Institute of Water and Atmospheric Research) USHA (Urban Streams Habitat Assessment) field programme.

For the purposes of this report the upper reaches of the Kaputone Stream extend from Englefield Reserve Belfast, to a point 320m downstream of the Main North Railway Bridge (Fig. 1).



Figure 1. Aquatic ecology sampling sites on the upper Kaputone Stream (yellow icons). Invertebrate kicknet samples were obtained at all sites except Sites 2a and 2b. Red icons indicate unsampled or dry habitats.

2. Methods

Six sites were surveyed during the autumn of 2004, and involved the assessment of macrophyte, invertebrate, and/or fish communities (Fig. 1). These sites were those surveyed in the past for either aquatic invertebrates or fish:

- **Sites 1, 3-4:** Benthic invertebrate surveys conducted during January/February 1996 (McMurtrie and McNickel 1996).
- **Sites 2a -2b:** Fish surveys conducted during 1998 (NIWA raw data)

Two additional sites (Fig. 1) surveyed by McMurtrie and McNickel (1996) were dewatered at the time of this survey, and could not be resampled.

Aquatic invertebrates were sampled at four sites along Kaputone Stream (namely sites 1, 3, 4 and 5) by collecting two replicate kicknet samples from transects spaced 5 m apart. Where these sites coincided with electric-fishing areas, these transects were situated several metres downstream or upstream of the fishing area. Samples were collected by disturbing the substrate in an approximate 0.3 x 0.5 m area immediately upstream of a conventional kicknet (420 micron mesh). Due to insufficient water velocity collection was facilitated at all sites by using a sweeping motion to create flow into the net. Macrophyte species and abundance was recorded from all invertebrate sampling sites, along with water and sediment depths.

All invertebrate samples were preserved in the field in 40% isopropyl alcohol, and taken to the laboratory for identification. The contents of each sample were passed through a series of nested sieves (minimum 500 µm mesh size). The contents of each sieve were placed in a Bogorov sorting tray (Winterbourn *et al.*, 2000) and all invertebrates counted and identified to the lowest practical level, using a binocular microscope and the keys of Chapman and Lewis (1976), Winterbourn (1973), Winterbourn *et al.* (2000), and Smith (2001). Sub-sampling was utilised for particularly large samples, but the unsorted fraction was scanned for taxa not already identified.

Invertebrate data from the current survey were summarised using various community and biotic indices; number of taxa, species diversity (Margalefs Index), and Urban Community Index (UCI) and Quantitative Urban Community Index (QUCI) scores. Parametric t-tests were then used to determine if there was any significant difference between sites with permanent water (Sites 1 and 3), and those with ephemeral flows (Sites 4 and 5).

The habitat-based UCI and QUCI are univariate indexes that combine tolerance values for invertebrates with either presence/absence (UCI) or abundance (QUCI) invertebrate data. They have been specifically developed for New Zealand urban streams, and are based on a multivariate analysis of 59 streams throughout the country (Suren *et al.*, 1998). The Macroinvertebrate Community Index (MCI) score (Stark, 1985) was not used in this study. This index was designed to determine the health of stony streams subject to organic enrichment (Stark, 1993), and was not relevant to the heavily silted substrates of Kaputone Stream.

It was not possible to statistically compare our invertebrate data to that of the earlier McMurtrie and McNickel (1996) survey. This earlier study involved collection of one kicknet sample at each site (with the exception of Site 3, where 10 replicate kicknet samples were collected). Invertebrates collected from most sites (Sites 1, 4, 5) were identified to a coarse taxonomic level only (often only to Order or Family), and were recorded as relative ranked abundance values (i.e. absent, rare, rare-common, common, common-abundant, abundant, abundant-dominant, dominant) instead of percentage abundance. Consequently, our data were converted to the coarser taxonomic groupings and ranked abundance values, to enable graphical comparisons with the earlier data.

Six sites along Kaputone Stream were electric-fished (Fig. 1), with Sites 2a and 2b having also been fished in 1998. A Kainga EFM 300 packset was used for electric-fishing, the conventional and appropriate fishing technique for small streams of this nature. A setting of 200 Volts was used, the minimum level required to achieve an effective electric field with a current of 300-400mA. The machine incorporates a timer, allowing the effective fishing time to be recorded. Electric fishing serves to briefly (approx. 3 seconds) render fish unconscious to facilitate their capture in nets for identification.

Conditions for fish capture using electric fishing were adequate, owing to the reasonable water conductivity and clarity, although thick weed and bottom silts may have increased fish escapement in some areas. A number of habitat parameters were recorded: available fish cover (% bed area), riparian vegetation (% of 12m riparian strip), substrate composition, and substrate silt thickness.

Permission to collect aquatic life (invertebrates and fish) for investigative research, by techniques outlined above is conferred to the senior author by the Ministry of Fisheries under section 97(1)(a) of the Fisheries Act and covered by Special Permit S2001/8. This permit also confers similar permissions to the senior author's associates that work on his behalf.

The New Zealand Freshwater Fish Database (NZFFDB) was accessed for information on fish fauna in the catchment. Geo-referencing in the field was achieved using a Garmin 12 Channel GPS receiver interfaced to TopoMap Pro (ver. 2.0) software.

3. Results

3.1 Character and vegetation of the upper Kaputone Stream upstream of Main North Road

At the time of the survey, and upstream of the Main North Road, only some reaches of Kaputone Stream contained surface water. At the upstream limit of the study area in Englefield Reserve, water was present, although some reaches were thickly ingrown with terrestrial vegetation (Figs. 2, 3). This wetted reach terminated at the downstream boundary of a small paddock (Fig. 4), approximately 80 m downstream of Englefield Road. Downstream of this point the bed was dewatered. A short distance (115m) further downstream, a reach of shallow ponded water was visible at Sefton Street (Fig. 5), but the stream bed was again dewatered 100m downstream of this

point. No surface water at all was present at 15 Lagan Street, 400 m further downstream, although the substrate was damp. All reaches with surface water had a barely perceptible flow, presumably due to groundwater exchange under the channel bed. Thus, occluded watered reaches were not stagnant.

The upstream reaches of Kaputone Stream possessed little variation in substrate composition, which was almost entirely composed of a variable layer of silt overlying a natural gravel base. Near the downstream margin of Englefield Park (Site 5), the silt layer was particularly thick (mean thickness 92cm), but it thinned to a depth of 13 cm further downstream at Site 4 (downstream of Sefton Street).

Despite the abundance of soft rooting substrate suitable for macrophytes, there appeared to be few, if any, aquatic macrophytes upstream of the Main North Road. Instead, what could be regarded as terrestrial vegetation choked the channel in many areas (Figs. 2, 3). This growth consisted of exotic grasses and terrestrial weeds such as Dock. Swards of willow weed (*Polygonum sp.*) probably *P. persicaria*, were observed at Lagan Street and in Englefield Reserve.

Mature shrubs and trees overhung the upper Kaputone Stream through public land, but riparian management varied where the stream flowed through residential areas. In most instances, however, the channel appeared to be well-shaded by vegetation, and the banks were consistently stable, with no slumping apparent.



Figure 2. Weed-choked channel at Englefield Park. Located just upstream of Site 5. Yellow lines indicate stream banks.



Figure 3. A sward of willow weed (*Polygonum persicaria*) at Englefield Reserve.



Figure 4. Looking downstream at the terminus of the watered section in a paddock on Englefield Road. The channel was dewatered beyond the fence line.



Figure 5. Site 4, downstream of 51 Sefton Street, was comprised of large puddles.

3.2 Character and vegetation of Kaputone Stream downstream of the Main North Road

Downstream of the Main North Road, in Shenley Reserve, the Kaputone Stream increased in width and depth. At the time of the survey, surface water was continuous from this point downstream, with thalweg water depths in the Reserve varying from 6 cm to 17 cm (mean of 11 cm). The mean wetted width was approximately 1.9 m,

although water flow was barely perceptible, due to the ingrowth of aquatic and vegetation into the channel.

Through Shenley Reserve, stream banks were vegetated with planted and overhanging *Carex*, and Flax, with water-emergent *Juncus* present in places. Aquatic macrophytes, especially curly pondweed (*Potamogeton crispus*), dominated the in-channel plant communities (Sites 3, 2a, 2b, 1, Figs. 6-9). *Azolla* (waterfern) and *Lemna* (duckweed) lined the stream margins and emergent plants. At the downstream boundary of Shenley Reserve, Kaputone Stream receives further spring water.

At the most downstream site (Site 1), the mean channel width was 3.7 m, with a mid-channel water depth of 35 cm (Fig. 9). The riparian margin at this site was dominated by grasses and short swards of water-emergent *Juncus* sp. Although the banks were grazed, they were not over-steepened, and appeared stable. Beds of *P. crispus*, dominated the aquatic macrophyte flora, with herbs (Monkey musk), and grasses (creeping bent) extending over the water surface from the bank margins.



Figure 6. Site 3, at Shenley Reserve near the footbridge. Yellow markers indicate the invertebrate survey section.



Figure 7. Site 2a, near the downstream margin of Shenley Reserve.



Figure 8. Site 2b, an atypical gravel habitat near the Main North Railway Line where upland bullies have been recorded in the past.



Figure 9. Site 1, the most downstream sampled site. Yellow markers indicate the fished section.

3.3 Invertebrate fauna

Nineteen invertebrate taxa were identified from the four sites along Kaputone Stream (Table 1). The most diverse invertebrate group was two-winged flies (Diptera; 7 taxa) followed by snails (Gastropoda; 3 taxa), crustaceans (2 taxa), and caddisflies (Trichoptera; 2 taxa). Other groups were represented by only one taxon.

Percentage abundance of two of the three most abundant taxa were also significantly different between ephemeral and non-ephemeral sites. More specifically, abundance of oligochaetes was seven times greater in ephemeral sites (Fig. 11a). In comparison, the native snail, *Potamopyrgus antipodarum*, was abundant where there was permanent water but absent from ephemeral sites altogether (Table 1, Fig. 11b). Ostracod percentage abundance was not significantly different between these two areas (Fig. 11c).

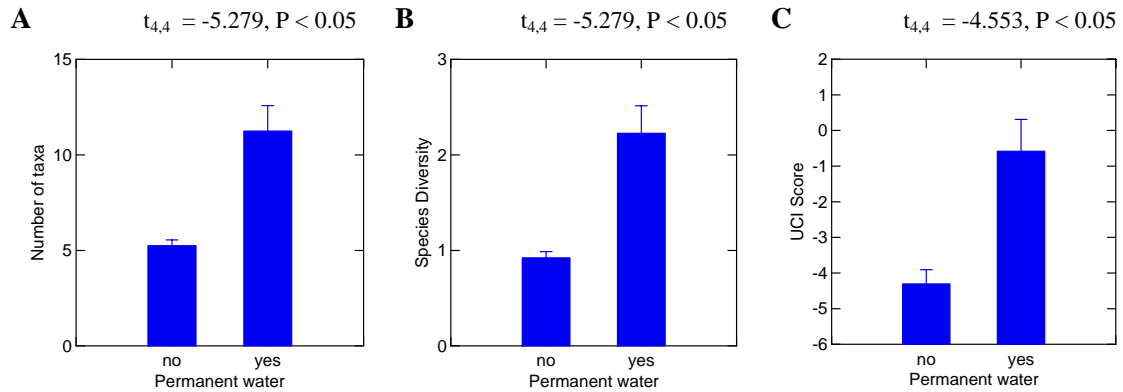


Figure 10. Difference in A) number of taxa, B) species diversity (Margalefs Index), and C) UCI scores (+/- SE) between potentially ephemeral (sites 1, 3) and non-ephemeral areas (sites 4, 5). Parametric t-test results are indicated.

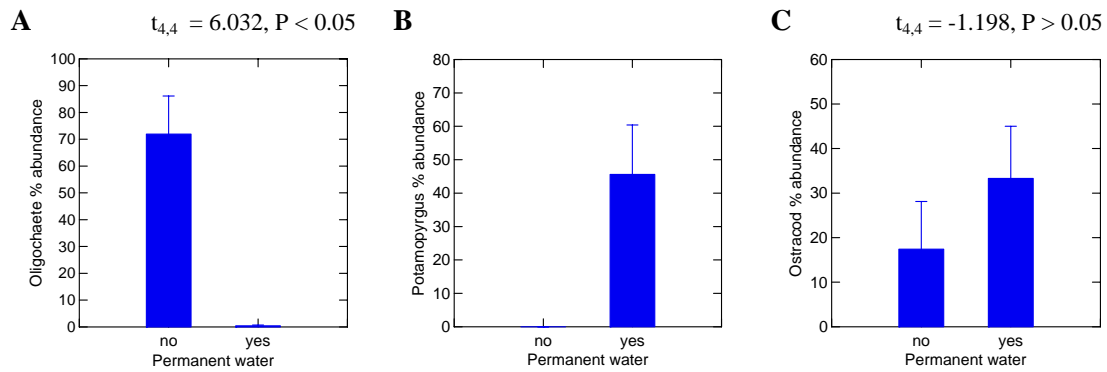


Figure 11. Differences in percentage abundance (+/- SE) of the three most overall abundant taxa between potentially ephemeral (sites 1, 3) and non-ephemeral areas (sites 4, 5). A) oligochaetes, B) the snail *P. antipodarum*, and C) ostracods. Parametric t-test results are indicated.

3.3.2 Temporal trends

It was difficult to compare data collected during 1996 with our current data due to differences in sample size and taxonomic detail. However, by graphically comparing ranked abundance data between the two dates, some general changes in broad invertebrate community structure were evident. There appeared to be an increase in the abundance of oligochaetes (worms) and crustaceans in those sites now potentially affected by increasing periods of dewatering (Fig. 12), and a decrease in snails,

bivalves, and fly larvae abundance. Community structure in those sites where water is still permanent (i.e. downstream of the Main North Road), showed a decrease in oligochaete abundance, and the disappearance of waterbugs (e.g. waterboatmen, backswimmers) in 2004, but with an increase in crustaceans, and the appearance of purse caddisflies and hydra.

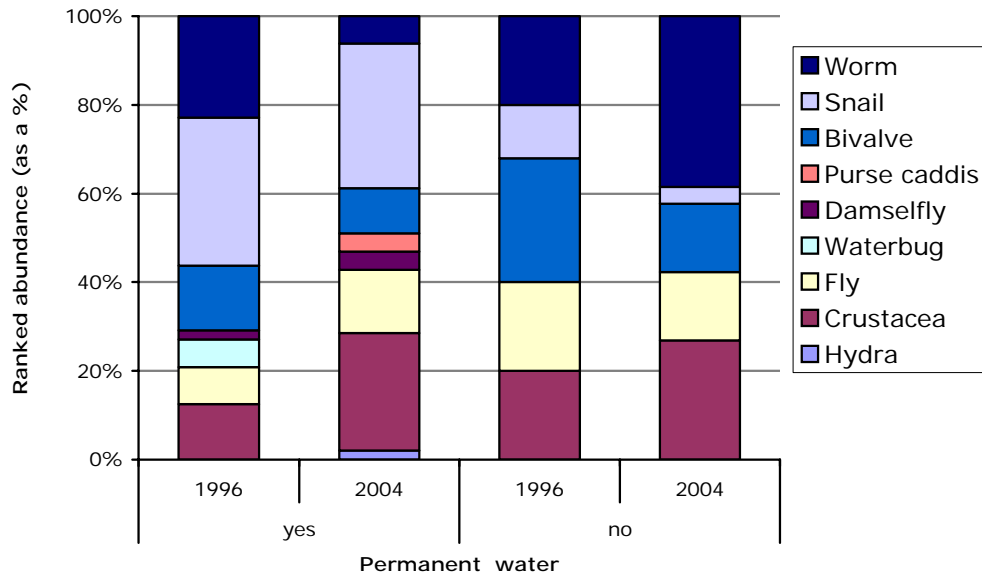


Figure 12. Ranked abundance (expressed as an overall percentage) of invertebrate groups (e.g. Order or Class) found in four sites surveyed during 1996 and 2004, that have been classified as potentially ephemeral and non-ephemeral (i.e. permanent water) areas.

3.4 Fish fauna

3.4.1 Catch and longitudinal variation in fish density

Only one fish species (Fig. 13) was recorded in the upper Kaputone Stream, the shortfin eel (*Anguilla australis*). This fish was caught in low to moderate abundance (Table 2), with eel density increasing with distance downstream (Fig. 14).



Figure 13. Shortfin eels were the only identified species from the upper Kaputone Stream in April 2004.

Table 2. Freshwater fish catch (shortfin eels) from the upper reaches of Kaputone Stream, April 2004, sorted by downstream distance from Englefield Park. Catch per unit effort (CPUE) is expressed as the catch per unit fishing time, and also the catch per unit fished area.

Site No.	No. shortfin eels	Fishing time (min.)	Fished area (m ²)	CPUE (fish/min)	CPUE (fish/100m ²)
5	1	9	26.9	0.1	3.7
4	1	3	8.5	0.3	11.8
3	1	3	11.2	0.3	8.9
2a	2	8	23.8	0.3	8.4
2b	2*	3	5.0	0.7	40
1	14	11	37.1	1.3	37.8

* = Juvenile eels (ca. 120 mm) in length.

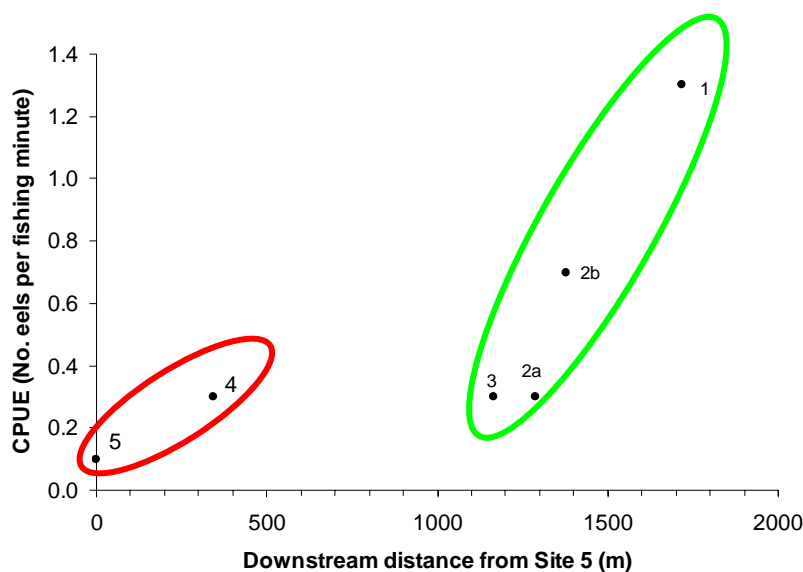


Figure 14. The positive relationship between increasing downstream distance and CPUE for shortfin eels in the upper reaches of Kaputone Stream. Numbers refer to Site numbers in the text. Red ring = habitats upstream of the Main North Road, Green ring = habitats downstream of the Main North Road.

Aside from distance downstream, there was no clear relationship between eel population density and recorded habitat variables (e.g. available fish cover, silt thickness). The lengths of measured eels ranged from approximately 120 mm (Site 2b) to 521 mm (Site 1), with a mean length of 307mm (n=21). There was no apparent relationship between eel length and downstream distance.

3.4.2 Temporal variation

During the 1990 fisheries survey (Eldon and Taylor, 1990), upland bullies and shortfin eels were recorded from just upstream of Blakes Road (approx. 390m below our most downstream site). In 1997, the senior author electric-fished in Shenley Reserve at the same locations as in this survey (Sites 2a and 2b). Both upland bullies

and shortfin eels were recorded (NIWA data), with upland bullies being particularly common amongst the riprap downstream of the Main North Railway Bridge (Site 2b). This species was absent from these locations during this survey (Table 2).

4. Discussion

4.1 Temporal changes in hydrograph and flow regime

The hydraulic character of Kaputone Stream appears to have changed, particularly in the upper reaches above Main North Road, since the last ecological surveys conducted during 1996 and 1998. Analysis of CCC flow status data (from the Main North Road site) indicated that, for probably a number of reasons, periods of dewatering have increased in recent years (Taylor, 2002, Nikora, 2004).

A local resident commented on increasing periods of dewatering upstream of Main North Road, and of more acute storm flows, yet lower base flows (pers. comm. landowner at 15 Lagan Street). This change in storm hydrograph is typical of catchments undergoing urbanisation where greater storm peak flows and shorter lag times are observed (Suren, 2000).

Immediately downstream of the Main North Road, flow augmentation from a number of springs currently preserves continuous surface flow for the remaining downstream length of Kaputone Stream. However, based on our experience, mean water levels in the reach adjacent to Shenley Reserve appear to be generally lower than in the past.

4.2 Distribution of aquatic vegetation in the upper Kaputone Stream

There is a marked dichotomy within the longitudinal distribution of vegetation in Kaputone Stream. Upstream of the Main North Road, well-rooted aquatic vegetation is virtually absent, whereas downstream of the Main North Road, aquatic macrophyte growth is profuse and dominated by *Potamogeton crispus* (curly pondweed). *P. crispus* will not survive desiccation for any length of time (McMurtrie pers. obs.) thus its upstream limit in this catchment, despite suitable rooting substrate, is probably limited to the permanent aquatic habitat downstream of the Main North Road. Some free-floating *Azolla* (native waterfern) and *Lemna* (duckweed) is still present in some locations upstream of the Main North Road, as these plants recover and recolonise quickly after dewatering.

4.3 Temporal changes in vegetation in the upper Kaputone Stream

Upstream of the Main North Road, in-channel vegetation changes seems to have occurred, which probably reflects the change in flow regime there (Figs. 15-16). In 1996, there was little vegetation, either aquatic or terrestrial, in the stream channel, but various terrestrial plants (e.g. dock, willow weed, grasses) are now prolific in reaches which frequently dewater. This trend is probably indicative of increasing periods of dewatering, as some of plants are known to be intolerant of protracted inundation.

Figures 15-16. Pictorial comparison of sites along the Kaputone Stream visited during January 1996 and April 2004.

Date photos taken	
January 1996	April 2004
	
<p>Figure 15a. 15 Lagan Street (looking downstream). Water surface covered by free-floating macrophytes (<i>Azolla</i>, <i>Lemna</i>).</p>	<p>Figure 15b. 15 Lagan Street, looking downstream, at a sward of <i>Polygonum persicaria</i> (willow weed) growing in the channel.</p>
	
<p>Figure 16a. 51 Sefton Street (looking downstream, in property)</p>	<p>Figure 16b. 51 Sefton Street (looking downstream from road)</p>

Another change has occurred over the last year, in the reach adjacent to the Englefield Reserve. Tree canopy cover over the Kaputone Stream has been removed (Fig. 17). Light levels into this previously heavily-shaded reach are now higher, and this may facilitate the growth of adventive grasses in the channel when the reach dewateres (Figs. 2, 4).

Some of the in-channel terrestrial weeds are known to be frost-sensitive, for example willow weed (K. McCombs, CCC, pers. comm.), and many are annuals, so they will die off during the winter months. However, the intensive intrusion of terrestrial vegetation may reduce groundwater flow and exchange along the channel through plant evapotranspiration losses in the summer months, exacerbating lower baseflows. Secondly, the detrital load caused by the plants, and their ability to trap sediment could accelerate the channel filling with sediment, especially in Englefield Reserve where recent bank disturbance has taken place, and flushing flows are rare.

Figures 17 and 18. Removal of tree cover from Englefield Reserve.

Date photos taken

11 February 2003



Figure 17a. Kaputone Stream at Englefield Reserve looking downstream.

14 May 2004



Figure 17b. The same reach of Kaputone Stream at Englefield Reserve looking downstream, after a rain event.

4.4 Invertebrate fauna

4.4.1 Longitudinal distribution

The invertebrate community within the surveyed reach of Kaputone Stream is typical of an urbanised waterway of compromised health, being limited to those species tolerant of, or indifferent to, habitat degradation or modification. Species composition and negative UCI scores reflect the prevalent habitat conditions; namely an often heavily silted streambed and little perceptible water velocity. In particular, the dominance of oligochaetes at both sites upstream of the Main North Road attests to aquatic habitats in particularly poor health. The invertebrate community from sites downstream of the Main North Road were in comparatively better health, as evidenced by the doubling of taxa, species diversity, and higher UCI scores.

The marked reduction in the number of taxa, significant loss of species diversity and drop in UCI scores at sites upstream of the Main North Road demonstrates how dewatering detrimentally impacts aquatic invertebrate communities.

The invertebrate community inhabiting these drier reaches were limited to those species especially tolerant of ephemeral habitats. For example, many Diptera (fly) larvae have short life cycles with an aquatic stage lasting only a few weeks, enabling them to take advantage of short, isolated periods of inundation. The microcrustaceans, like ostracods, survive in ephemeral habitats because their eggs are particularly resistant to desiccation and can survive long periods of drought, while cyclopoid copepods can survive (and are often quite abundant) in thin films of moisture adhering to small plants and mosses (Chapman and Lewis 1976). The taxonomic grouping of all worms as Oligochaetes means the proportion of truly aquatic to terrestrial species is unknown, but provided the substrate remains damp, even those regarded as aquatic species are tolerant of surface water loss in area with silty substrates.

Those invertebrate species requiring permanent aquatic habitats, such as hydra, caddisfly larvae, damselfly larvae, and native snails, were only found at sites downstream of the Main North Road. The absence of the native snail, *P. antipodarum*, from the upper reaches is probably the most significant indication of long periods of dewatering in this area, as this ubiquitous and cosmopolitan snail is found almost anywhere in Christchurch where there is permanent water.

4.4.2 Temporal trends in invertebrate distribution

Since the last invertebrate survey in 1996 (see McMurtrie and McNickel 1996), the invertebrate community upstream of the Main North Road appears to be increasingly dominated by those species tolerant or indifferent to increasing periods of dewatering. In the uppermost reaches, a significant trend is the decline in snails since 1996; an invertebrate group generally intolerant of protracted periods of dewatering. The increasing abundance of oligochaetes and microcrustaceans, which appear to be as comfortable in damp habitats as in fully aquatic habitats, is further testament to increasing periods of dewatering in this reach.

Downstream of the Main North Road, the invertebrate community appeared to be much the same as that recorded in 1996, with the doubling in the abundance of microcrustacea likely to be more related to the high abundance of macrophytes and slow water velocity in this reach at the time of the survey. The lack of waterbugs from the 2004 survey is most likely to be an artefact of sampling rather than a loss of species; because waterbugs are fast-moving slow-water specialists, it is often difficult to capture them in kicknet samples. Similarly, the absence of hydra in the 1996 samples is likely due to their rarity in this system, making it more difficult to pick up in samples.

4.5 Fish

4.5.1 Longitudinal distribution

The fish fauna in the upper Kaputone Stream is now limited to one species, shortfin eel, the most ubiquitous fish in the Styx River (Eldon and Taylor, 1990), and one of the most widespread species in New Zealand (McDowall, 1990).

Eel density was demonstrated to increase in a downstream direction, and this is considered to reflect the greater degree of aquatic habitat permanence (as indicated by the presence of aquatic vegetation) in the downstream reaches of the study area. Habitats which dewater regularly are still compromised even when the water returns. Eels have a capacity to migrate during dewatering, but the aquatic invertebrate fauna – the only food source for fish - is severely affected (section 4.4.1). Therefore a habitat's ability to maintain an eel population could be limited by a depleted food supply caused by long periods of dewatering.

As with some aquatic invertebrates (section 4.4.1), eels are able to survive variable periods of drought, given a favourable substrate which retains some moisture. However, they are not strongly adapted to survive long-term dewatering. They are

capable of retaining mobility in adverse conditions, and may therefore escape by moving downstream to residual water.

Most other fish species lack these physiological and behavioural adaptations for survival in temporary aquatic habitats, therefore their absence in the upper Kaputone Stream is of no surprise. Even if there was permanent water, the low hydraulic variation in the channel (i.e. variation in width and depth), could limit fish species diversity.

Unfortunately, even if more permanent aquatic habitat was available upstream of the Main North Road, its ecological potential would still be compromised by a small weir at the downstream end of Blakes Road (Fig. 18). Historically, this weir was used for the impoundment of water for fire-fighting. The centre section of the weir incorporates a sluice-gate which can be lifted to varying heights. However, with the sluice-gate closed, the weir was demonstrated to restrict some migratory fish (i.e. inanga, common bully) access to reaches upstream of Blakes Road (Sykes *et al.*, 1998). Eels, though, could evidently negotiate this weir. The operation of the centre sluice-gate and the weir's hydraulics are currently unknown, but it may be possible to improve the management of the weir to allow better fish access into the upper Kaputone Stream.

The culvert under the Main North Road (Fig. 19) was also briefly examined to evaluate whether its orientation or hydraulics could potentially impede fish passage to the upper Kaputone Stream. It was considered that this conduit did not impede fish passage, because the culvert's invert is under the bed of the stream at both ends, and water velocities through the culvert are not likely to be excessive.



Figure 18. Looking downstream at the old weir at the end of Blakes Road. The centre sluice-gate is open (arrowed).



Figure 19. The upstream end of the Kaputone Stream culvert under the Main North Road on 16 May.

4.5.2 Temporal changes

Since 1997, the population of non-migratory upland bully in the Kaputone Stream along Shenley Reserve has been lost. This may be due in part to changes in the substrate. Most of the coarse substrate near the Main North Railway Line, where upland bullies were previously abundant (Site 2b), has been buried under silt. Silt is detrimental for nearly all species, and experimental substrate manipulation has

demonstrated the negative effects for upland bully abundance when the substrate is silted (Jowett and Boustead, 2001).

Other factors may also be responsible for the decline in upland bullies. While we lack data on base flows in the Kaputone Stream, our impression was that water depth has declined along the reach bordering Shenley Reserve. Shallower depths and the ingrowth of vegetation into the channel may be detrimental to upland bullies, by restricting open-water feeding areas for juvenile bullies, and a general loss of wetted habitat area.

Because of a lack of data on fish distribution upstream of Main North Road, it is not possible to determine exactly how the shortfin eel distribution has changed since 1997. There is clear evidence that periods of dewatering have increased, however, and this is clearly detrimental for any fish species. The strong longitudinal pattern in eel density as a function of distance downstream indicates dewatering may be a strong determining factor on eel abundance.

Dewatering may act directly on the eel community as a continuous disruption of habitat, and/or a negative impact on the invertebrate food source. Upstream of the Main North Road, the absence of the snail *P. antipodarum* from the recent invertebrate samples is ecologically significant because this snail often reaches high densities, and is a major component of the shortfin eel diet (Ryan, 1984).

5. Recommendations

We recommend the following:

- Efforts continue to investigate mechanisms to restore baseflow to the upper Kaputone Stream.
- We endorse the recommendation by Nikora 2004, for the use of properly-designed soakage or stormwater retention basins (CCC 2003) in the upper Kaputone catchment, which will serve to moderate storm hydrographs.
- That the weir at Blakes Road be managed to consider fish migration requirements
- Adventive terrestrial weeds in the dewatered Kaputone Stream channel be monitored and controlled.

6. Acknowledgements

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