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Long-term Monitoring of Aquatic Invertebrates in Christchurch's Waterways: Avon River Catchment 2009

EOS Ecology Report No. 06064-CCC02-02 | Oct 2009

AQUATIC RESEARCH CONSULTANTS

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REPORT

Prepared for
Christchurch City Council

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EXECUTIVE SUMMARY

The Christchurch City Council (CCC), in conjunction with Environment Canterbury (ECan) and the Avon-Heathcote Estuary Ihutai Trust, has instigated a long-term monitoring programme for aquatic invertebrates and habitat of the City's waterways. Invertebrates are useful animals to monitor as they are a good indication of stream health and respond to catchment land use changes. EOS Ecology was commissioned by the CCC to develop and undertake an aquatic invertebrate monitoring program that incorporated the Styx, Otukaikino, Avon, Heathcote, and Halswell catchments. It was requested by the CCC that each catchment was surveyed once every five years, with two catchments to be surveyed in the first year of the programme.

This report summarises the results of the second year of monitoring, where ten sites in the Avon River catchment were surveyed during March 2009. Sites along the mainstem rivers as well as tributary waterways were included in the monitoring programme. The sites surveyed had slow–moderate water velocity and a substrate that although coarse (gravel–pebble size) was partially embedded with fine particles and algae. The invertebrate community was moderately diverse, with a total of 40 different taxa identified from the study area and 11–23 taxa found on an individual site basis. The most diverse group were caddisflies with 14 taxa, and two-winged flies with nine taxa identified.

There was a clear difference in habitat attributes between tributary and mainstem sites, with the mainstem river having deeper water, greater channel width, faster water velocity, and coarser substrate. Despite these physical differences there was no discernable difference in the invertebrate community between the mainstem river and tributaries.

The aquatic invertebrate community was rated as being in 'poor' or 'fair' health by the MCI/QMCI biotic indices. Cleanwater taxa (made up of mayflies, stoneflies, and caddisflies) were limited to caddisflies, which were in low abundance (e.g., <10%) at all but three sites. Mayflies, which were once found throughout the Avon catchment, were not found at any of the sites during the current study. Today the aquatic fauna of the Avon River catchment is dominated by pollution-tolerant taxa that are common throughout New Zealand's urban waterways, and is symptomatic of the 'urban stream syndrome'. However, the diversity of caddisflies taxa (14 in total) and high abundance of these insects in at least a few sites (>40% at two sites) indicates that the catchment has not thoroughly succumbed to the inevitable impacts of urbanisation.

1 INTRODUCTION

In the Christchurch City Council's (CCC) Long-Term Council Community Plan (LTCCP; Christchurch City Council (2006)) Christchurch residents identified the retention and restoration of biodiversity and protection of the environment as key factors important to their wellbeing. The LTCCP states that the CCC will know it is succeeding in meeting these community desires when 'our lifestyles reflect our commitment to guardianship of the natural environment in and around Christchurch', when 'biodiversity is restored, protected and enhanced', and when 'we manage our city to minimise damage to the environment' (Christchurch City Council, 2006).

Inevitably urbanisation of a catchment is detrimental to biodiversity values and the general health of waterways. As a catchment is developed it becomes more impervious to stormwater run-off, causing lower but flashier flows (Suren & Elliott, 2004). Pollutants and fine sediment from road run-off accumulate in the river sediment and the addition of buildings, bridges, and culverts impede the dispersal of adult aquatic insects (Suren, 2000; Blakely *et al.*, 2006). These factors detrimentally affect the health of our waterways by making the river suitable for only a small subset of the aquatic invertebrates and fish usually found in our streams and rivers. With increasing residential development of the outlying areas of Christchurch City and infill housing occurring in the suburbs, much of the land surrounding our city's waterways has, or is, changing from rural to urban use. This change in land use impacts the health of the catchment's rivers.

Successful achievement of the community's desire for biodiversity and healthy ecosystems in the face of urban expansion and its negative impacts on waterways, first requires a better understanding of the current state of our waterways. In an attempt to achieve this the CCC, in conjunction with Environment Canterbury (ECan) and the Avon-Heathcote Estuary Ihutai Trust (Batcheler *et al.*, 2006) has decided to instigate a freshwater monitoring programme that will help to determine the existing state of our waterways and monitor any change in health over time.

EOS Ecology was commissioned by the CCC to develop and undertake a suitable freshwater invertebrate monitoring program for the City's main waterways. This incorporated the City's five main river catchments: the Styx, Otukaikino, Avon, Heathcote, and Halswell Rivers. The Styx and Otukaikino catchments were surveyed in March 2008 (McMurtrie & Greenwood, 2008), while for this current study the Avon catchment was surveyed in March 2009. The remaining two catchments will be sampled one per year over the next two years. This cycle of five yearly sampling will be repeated to allow for comparisons of temporal change within each catchment as well as between-catchment comparisons. Sampling all five river systems will provide data over a range of catchment land-use types including fully urbanised (Avon River catchment), urban–rural mixture (Heathcote River catchment), rural–urban mixture (Styx River catchment), and a predominantly rural catchment (Halswell and Otukaikino catchments).

1.1 Aim of this report

This report is designed to provide a summary of the results for this catchment. It is not designed to provide any detailed statistical comparison between sites within the same catchment or between other previously surveyed catchments. On the completion of the first round of sampling for each catchment an additional report will be produced that provides more detailed analysis of the data including catchment-wide comparisons.

1.2 Why is monitoring important?

Long-term monitoring of invertebrate communities will tell us how the health of the City's rivers change over time (e.g., is it getting better, worse, or remaining the same). In river systems with less catchment development, such as the predominantly rural Otukaikino and Styx catchments, the invertebrate community is made up of more 'cleanwater' taxa that are sensitve to habitat and water quality changes. Thus a small increase in the level of catchment development could effect a large change in the invertebrate community, with those more sensitive species declining in abundance. In comparison, we would expect those rivers that are already heavily urbanised (e.g., the Avon and Heathcote) to change less over time as their invertebrate fauna may already be limited to pollution-tolerant taxa. Results from the monitoring will also be important in designing restoration and remediation efforts to minimise the impact of urban development on our rivers. Refer to McMurtrie & Greenwood (2008) for further information on why invertebrates are important to monitor.

2 METHODS

The aim of the monitoring programme was to use the 'River Habitat and its Biota' section of Batcheler *et al*. (2006) as the basis for this monitoring programme. Batcheler *et al*. (2006) recommends sampling 'within the shallower, gravel bottom reaches of the Avon/Otakaro and Heathcote/Opawaho rivers', which are the two main rivers that drain into the Avon-Heathcote Estuary/Ihutai. However, this programme has been broadened to include the Styx, Otukaikino, and Halswell river systems, which are partly or fully within the confines of the Christchurch City boundary.

Due to CCC budgetary limitations, it was not possible to sample all five catchments at one time, thus a yearly programme was developed to sample one catchment per year, with a five-year repeat cycle for each catchment. The catchments will be surveyed in the following order: Otukaikino, Styx, Avon, Heathcote, and Halswell. This report represents the second year of the monitoring programme, where the Avon catchment has been sampled, while last year the Otukaikino and Styx catchments were surveyed (McMurtrie & Greenwood, 2008).

2.1 Site selection

Ten sites were selected in the mainstem and key tributaries of the Avon River (sites 19-28 in Figure 1). Site numbering continues on from the previous year's monitoring of the Styx and Otukaikino catchment (McMurtrie & Greenwood, 2008), hence numbering of sites from 19-28. The monitoring programme required nine sites to be selected for monitoring, but Site 28 (Papanui Stream) was included as an additional site that was spatially separated from the other sites. This site may be dissimilar to the other sites due to the stream being so removed from the rest of the Avon catchment sites and having undergone some channel restoration in 2008.

Tributary as well as mainstem river sites were included, as the small size of tributaries makes them more susceptible to changes in environmental conditions, such as water quality or sediment inputs. One site was located in each of the four main headwater tributaries of the Avon River (e.g., Ilam Stream, Okeover Stream, Waimairi Stream, and Wairarapa Stream), five sites were located in the mainstem of the Avon River below the confluence of these four tributaries, and one additional site was located in the spatially separated Papauni Stream. Within these waterway types the sampling sites were located in areas of riffle habitat, or if this did not exist, in runs with coarse substrate. These types of habitats were chosen for

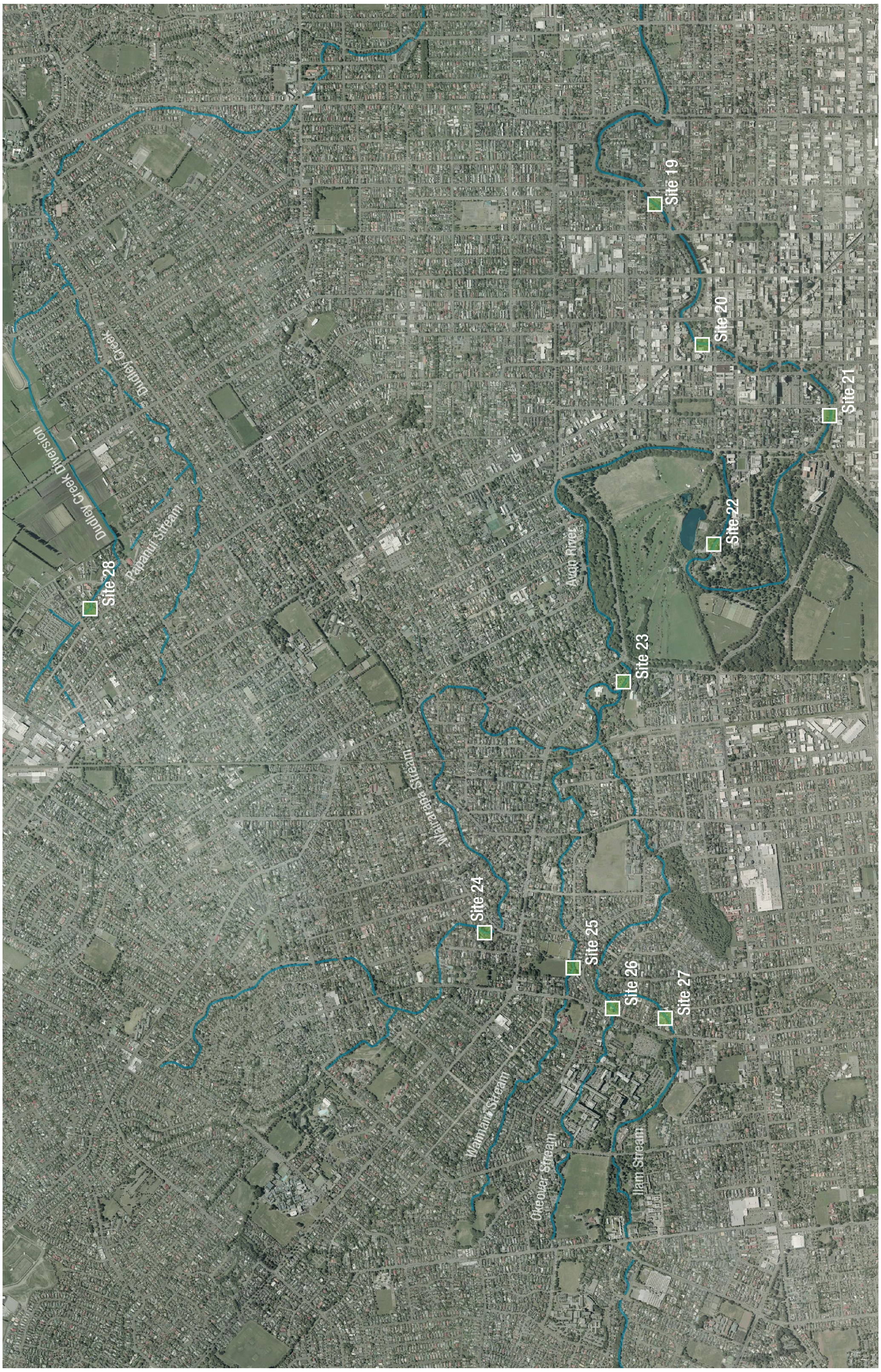


FIGURE 1 Location of the ten sites in the Avon River catchment surveyed from 19th to 26th March, 2009. Site photographs are provided in Appendix I.

monitoring to better enable between-site comparisons and because these areas typically support the most diverse invertebrate communities that are also the most sensitive to change. Sections of waterway that are deeply silted will support an invertebrate community already tolerant of particularly degraded conditions and as such they will be unlikely to respond to small changes in water and habitat quality.

Initial site location was derived using local knowledge and the CCC's Christchurch River Assessment Survey (CREAS) data, with final locations modified to suit the on-site conditions. final selection of sites was based primiarly on the areas of coarse substrate The most downstream site in each catchment represented the downstream extreme of wadeable water with suitable riffle habitat for sampling; 100 m below this point (e.g, downstream of Barbados Street) the river became too deep to wade, with silted substrates and extensive macrophyte beds.

2.2 Sampling

Following fine weather conditions, habitat and aquatic invertebrate communities were surveyed between the 19th and 26th March 2008. A detailed and quantitative to semi-quantitative methodology was developed to act as a suitable monitoring protocol that would enable a comparable repeat survey of habitat and invertebrate communities.

At each site three equally-spaced transects were placed across the stream at 10 m intervals (i.e., at 0, 10, and 20 m) and aspects of the instream habitat and aquatic invertebrate community quantified along them. Instream habitat variables were quantified at equidistant points across each of the three transects, with the first and last measurements across the transect at the water's edge. Habitat variables measured included substrate composition, presence and type of organic material, depths (water, macrophyte, and sediment), and water velocity (Figure 2). General bank attributes, including lower and upper bank height and angles, lower bank undercut, and lower bank vegetative overhang were measured for each bank at each transect. Bank material and stability were also assessed.

The riparian zone condition was assessed within a 5 m band along the 20 m site on either side of the bank. The cover of 15 different vegetation types were estimated on a ranking scale of present (< 10%), common (10–50%), and abundant (> 50%). The vegetation was assessed three dimensionally so included ground, shrub, and canopy cover levels.

FIGURE 2 Waiting for punters to pass by before setting up a sample transect at Site 20 in the Avon River (left) and measuring water velocity across a transect at Site 27 in Ilam Stream (right).

Aquatic benthic invertebrates were collected at each transect by disturbing the substrate across an approximate 1.5 m width and within a 0.3 m band immediately upstream of a conventional kicknet (ca. 500 µm mesh size). The full range of habitat types were surveyed across each transect, including mid-channel and margin areas, inorganic substrate (e.g., the streambed), and macrophytes (aquatic plants). Each invertebrate sample was kept in a separate container, preserved in 60% isopropyl alcohol, and taken to the laboratory for identification. The contents of each sample were passed through a series of nested sieves (2 mm, 1 mm, and 500 µm) and placed in a Bogorov sorting tray (Winterbourn *et al.*, 2006). All invertebrates were counted and identified to the lowest practical level using a binocular microscope and several identification keys. Sub-sampling was utilised for particularly large samples and the unsorted fraction scanned for taxa not already identified.

2.3 Data analysis

The data describing the substrate composition was simplified by creating a substrate index, such that:

Substrate index = [(0.7 x % boulders) + (0.6 x % large cobbles) + (0.5 x % small cobbles) + (0.4 x % pebbles) + (0.3 x % gravels) + (0.2 x % sand) + (0.1 x % silt) + (0.1 x % concrete/bedrock)] / 10

Where derived values for the substrate index range from 1 (i.e., a substrate of 100% silt) to 7 (i.e., a substrate of 100% boulder); the larger the index, the coarser the overall substrate. In general, coarser substrate (up to cobbles) represents better instream habitat than finer substrate. The same low coefficients for silt and concrete/bedrock reflect their uniform nature and lack of spatial heterogeneity, and in the case of silt, instability during high flow.

Invertebrate data were summarised by taxa richness, total abundance, abundance of common taxa, and Detrended Correspondence Analysis (DCA) axis scores. Biotic indices calculated were the number of Ephemeroptera-Plecoptera-Trichoptera taxa (EPT richness), % EPT, the Macroinvertebrate Community Index (MCI), Urban Community Index (UCI), and their quantitative equivalents (QMCI and QUCI, respectively). The paragraphs below provide clarification on some of these metrics.

Taxa richness is the number of different taxa identified in each sample. 'Taxa' is generally a term for taxonomic groups, and in this case refers to the lowest level of classification that was obtained during the study. Taxa richness can be used as an indication of stream health or habitat type, where sites with greater taxa richness are usually healthier and/or have a more diverse habitat.

DCA is an ordination of data that is often used to examine how communities composed of many different taxa differ between sites. It can graphically describe communities by representing each site as a point (an ordination score) on an x–y plot. The location of each point/site reflects its community composition, as well as its similarity to communities in other sites/points. Thus points situated close together indicate sites with similar invertebrate communities, whereas points with little similarity are situated further away. Habitat variables can also be associated with the different axes, indicating whether the invertebrate communities are responding to habitat differences.

EPT refers to three Orders of invertebrates that are generally regarded as 'cleanwater' taxa. These Orders are Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies); forming the acronym EPT. These taxa are relatively intolerant of organic enrichment or other pollutants and habitat degradation. The exception to the rule are hydroptilid caddisflies (e.g., Trichoptera: Hydroptilidae: *Oxyethira*, *Paroxyethira*), which are algal piercers and often found in high numbers in nutrient enriched waters and urban streams. EPT richness and % EPT scores can provide a good indication as to the health of a particular site. EPT taxa are generally diverse in non-impacted, non-urbanised stream systems, although there is a small set of EPT taxa that are also found in urbanised waterways (e.g., hydroptilid caddisflies and some leptocerid caddisflies such as *Triplectides* and *Hudsonema*).

The MCI/QMCI score can be used to determine the level of organic enrichment for stony-bottomed waterways in New Zealand (Stark, 1985). It calculates an overall score for each sample, which is based on pollution-tolerance values for each invertebrate taxon that range from 1 (very pollution tolerant) to 10 (pollution-sensitive). MCI is calculated using presence/absence data, whereas the QMCI score incorporates abundance data and so gives a more accurate result by differentiating rare taxa from abundant taxa. MCI scores < 80 and QMCI scores < 4 indicate poor stream conditions with probable severe organic pollution, whereas MCI scores > 120 and QMCI scores > 6 indicate excellent conditions and clean water (Boothroyd & Stark, 2000). MCI/QMCI indices are best suited to waterways with shallow depths (0.1–0.4 m), moderate velocities (0.2–1.2 m/s), and a coarse substrate (60–140 mm diameter (Stark, 1993); conditions which the sites surveyed in this study met.

The UCI/QUCI score can be used to determine the health of urban and peri-urban streams by combining tolerance values for invertebrates with presence/absence or abundance invertebrate data (Suren *et al.*, 1998). Negative scores are often indicative of invertebrate communities tolerant of poor conditions and silted habitats, whereas positive scores are indicative of communities found in healthier streams, usually with clean water and coarse substrate (Suren *et al.*, 1998). This biotic index is indicative of habitat relationships, and to some degree incorporates urban impacts.

3 RESULTS

3.1 Habitat

Not surprisingly, instream habitat varied greatly between the mainstem and tributary sites, with the mainstem river generally wider, deeper and faster flowing than the smaller tributary waterways (Figure 3). Mainstem sites were particularly wide (10–15 m wide) compared to tributary waterways (2–5 m wide), with channel width generally decreasing with distance upstream. Water depth in the Avon River ranged between 0.22–0.29 m compared to 0.10–0.19 m for tributary waterways. Velocity ranged from slow to moderate speeds, with mainstem velocities faster (0.46–0.63 m/s) compared to tributary sites (0.28–0.45 m/s). Substrate size was more variable between sites, but there remained a trend for a slightly larger substrate (average pebble size) in the mainstem sites compared to a smaller substrate (gravel–pebble sized) in the tributary waterways. The broad water velocity preferences of many of New Zealand's aquatic invertebrates (Jowett *et al.*, 1991) means that most of these sites contain habitat suitable for a wide range of aquatic invertebrates, including cleanwater EPT taxa.

3.2 Invertebrates

3.2.1 Overview

A total of 40 invertebrate taxa were recorded from the Avon catchment. The most diverse groups were the caddisflies (Trichoptera) with 14 taxa, followed by two-winged flies (Diptera: 9 taxa), molluscs (Mollusca: 5 taxa), and crustaceans (Crustacea: 5 taxa). Groups represented by one taxon included worms (Nematoda, Nemertea, Oligochaeta, Platyhelminthes), springtails (Hexapoda: Collembola), hydra (Cnidaria: Hydrozoa: Hydridae), and mites (Arachnida: Acari).

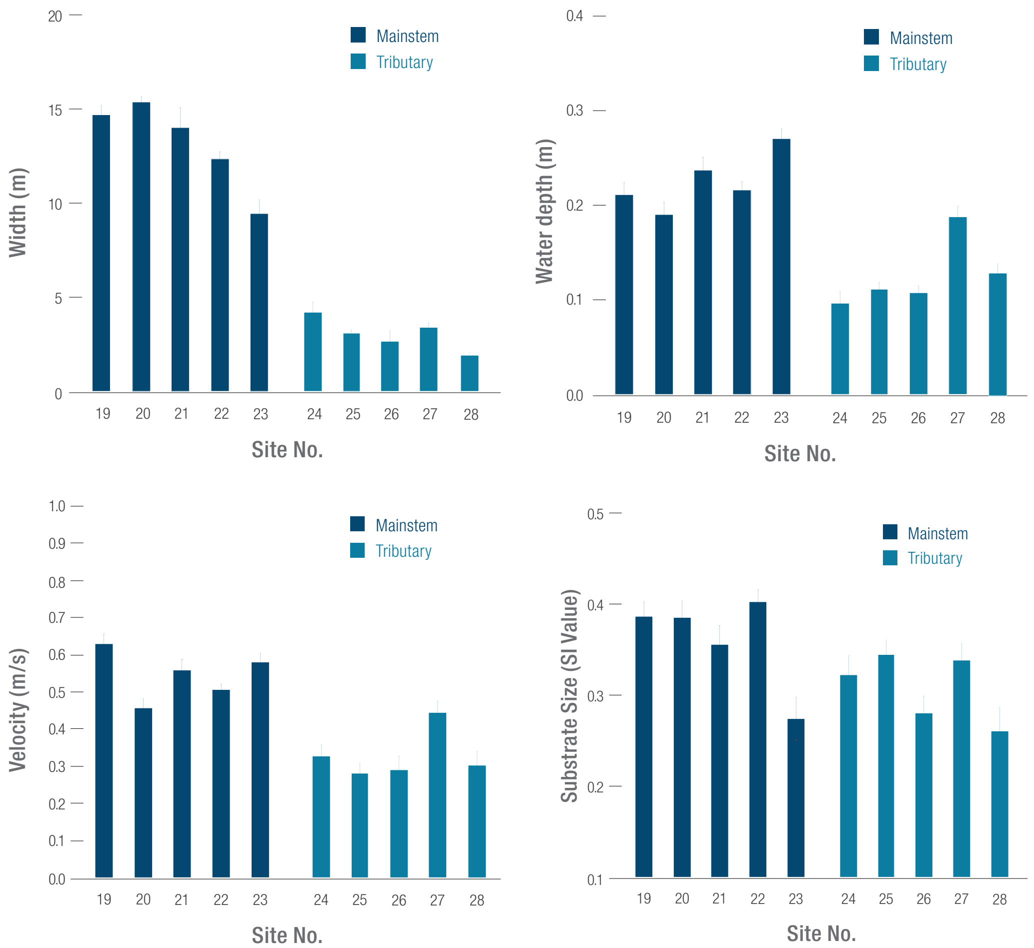


FIGURE 3 Average (+/- SE) aquatic habitat conditions at ten sites in the Avon catchment sampled between 19th and 26th March 2009. Site 19 is the most downstream site. For site locations refer to Figure 1.

On average, the community was dominated by the amphipod *Paracalliope fluviatilis* (28.8% ± 21.7%) and the freshwater snail *Potamopyrgus antipodarum* (22.1% ± 17.9%, Figure 4). Other relatively abundant taxa included microcrustacean ostracods (9.7% ± 16.4%), oligochaete worms (9% ± 12%), the caddisfly *Pycnocentrodes* (8.8% ± 14.4%), and the introduced snail *Physa* (6% ± 4.5%; Figure 4). The most widespread (e.g., found in over 95% of samples) were pollution-tolerant taxa such as oligochaete worms, microcrustacean ostracods (both found in all 30 samples), the snail *P. antipodarum*, orthoclad midges (Orthocladiinae), and empidid flies (Empididae) (found in 29 of 30 samples, Figure 4). There were three rare taxa that occurred in only 1–2 samples each; microcrustacean copepods, and the caddisflies *Oeconesis* and *Triplectides cephalotes*.

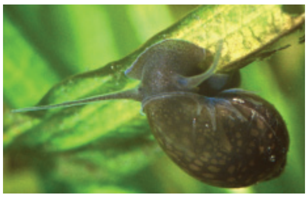
The cleanwater EPT group was represented by caddisflies (order Trichoptera), with both the mayfly (Ephemeroptera) and stonefly (Plecoptera) orders absent. Caddisflies accounted for only 13.5% of total invertebrate abundance, but had a good diversity with 14 different taxa recorded. Of these 14 taxa, only two had an overall abundance greater than 1%: *Pycnocentrodes* (8.8% ± 14.4%) and *Hudsonema amabile* (2.7%% ± 3.4%): with their abundance varying considerably per site. While *Pycnocentrodes* may have been the most abundant caddisfly, it was not the most widespread, being found in 57% of samples (17 of 30 samples). *H. amabile* was the most widespread caddisfly, being found in 27 of the 30 samples (90% of samples). The more pollution-tolerant hydroptillid caddisfly *Oxyethira albiceps* was also moderately widespread, being found in 67% of samples (20 of 30 samples).

Pollution-tolerant taxa

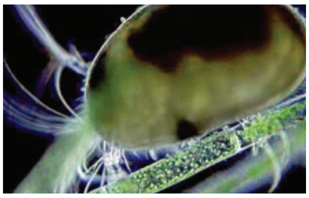
Paracalliope fluviatilis (29%)

Oligochaete worm (9%, widespread)

Potamopyrgus antipodarum (22%, widespread)

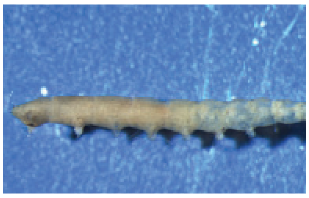


Physa (6%)



Ostracod (10%, widespread)

Orthoclad midge (widespread)



Empidid fly (widespread)

Cleanwater (EPT) taxa

Pycnocentrodes (9%)

FIGURE 4 Photographs of the most abundant (% indicated) and widespread (found in at least 29 of the 30 samples) aquatic invertebrates in the Avon catchment. Unless indicated, photos are by EOS Ecology.

3.2.2 Biotic indices

The DCA indicated there was little difference in the invertebrate communities from the mainstem river or tributary waterway sites, with the exception of the Papanui Stream site (Site 28; Figure 5). This site was distinctly separated from the remaining sites and was characterised by pollution-tollerant microcrustacean ostracods, midges, and worms. The remaining nine sites were more closely associated with amphipods and snails (Figure 5). Sites with high Axis 2 scores, such as Site 19, 22 (Avon River) and 26 (Okeover Stream) were characterised by higher numbers of caddisflies (*Pycnocentrodes*, *Hudsonema*, and *Hydrobiosis* species). No habitat variables (water depth, velocity, substrate size, and sediment depth) were significantly correlated with the DCA axes.

The health of each site appeared independent of waterway type, with both a mainstem (Site 22 in the Botanic Gardens) and tributary waterway (Site 26 at Okeover Stream) ranking best equal overall (Table 1). Similarly, a mainstem site (Site 20 in Victoria Park) and a tributary waterway (Site 28 at Papanui Stream) ranked the worst overall (Table 1). The abundance of EPT taxa were similar between the two waterway types, with 10–11 different taxa identified in the mainstem and tributary sites respectively (Table 2). Four caddisfly taxa were unique to the mainstem river; the free-living predatory caddisfly *Hydrobiosis umbripennis*, the cased caddisflies *Triplectides cephalotes* and *Oecetis*, and the hydroptilid micro-caddisfly *Paroxyethira*. Three caddisfly taxa were unique to the tributary waterways; the free-living caddis *Polyplectropus*, and the cased caddisflies *Pycnocentria* and *Triplectides obsoletus*.

Okeover Stream (Site 26) ranked the highest for both the MCI and QMCI scores but were still only rated in "fair" condition for these indices (Table 1, Figure 6). In fact, four mainstem sites (Site 19, 20, 22, 23) and two tributary sites (Wairarapa Stream at Site 24 and Okeover Stream at Site 26) were categorised as being in "fair" condition based on either the MCI or QMCI scores, while the remaining four sites were ranked as being in "poor" condition. Okeover Stream (Site 26) did not support the greatest abundance of cleanwater EPT taxa, but did support the highest diversity, with eight caddisfly taxa recognised (Figure 7).

The Avon River in the Botanic Gardens (Site 22) supported the greatest abundance of cleanwater EPT taxa, with an average of 42% abundance (Table 1, Figure 6). This was closely followed by Site 19 (Avon River at Kimore Street) with 41% abundance. The only other site to support more than 10% EPT taxa was Site 26 (Okeover Stream) with 18% abundance. The QUCI score also rated Site 22 as the highest quality site,

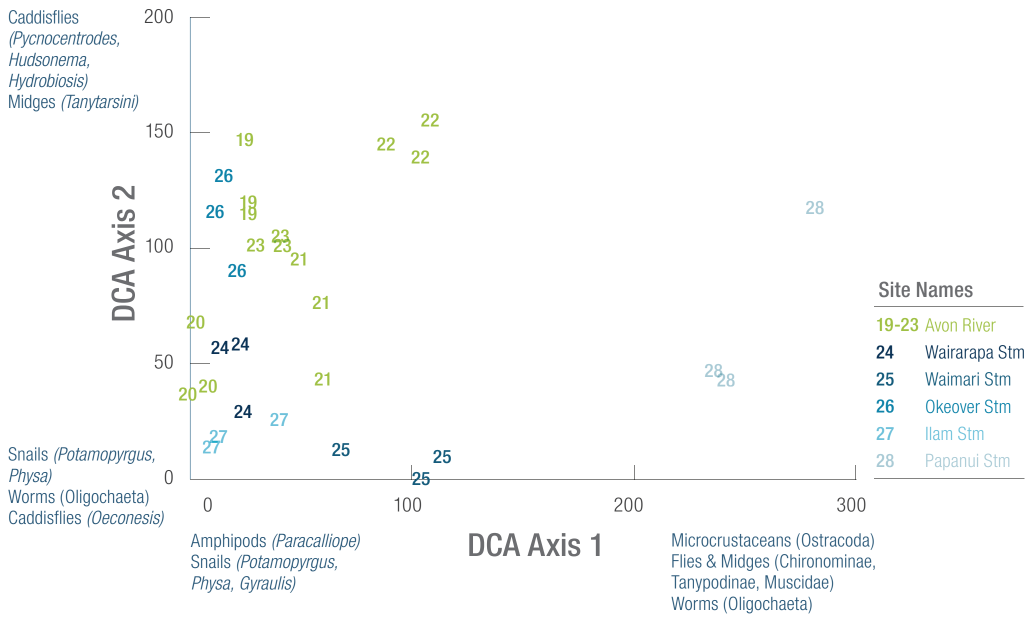
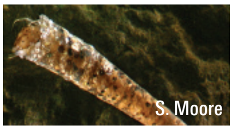
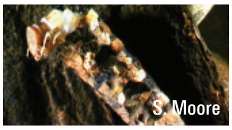


FIGURE 5 Detrended Correspondence Analysis (DCA) at the ten sites surveyed in the Avon catchments between the 19th and 26th March 2009. Invertebrate taxa correlated with the axes are shown; no habitat variables were significantly associated with either axis. For site locations see Figure 1.

TABLE 1 An overall site ranking (1 (best)–10 (worst)) of each of the ten sites surveyed in the Avon catchment; with site rank based on the summation of ranks for each biotic index. The possible final ranking score is from 7 (ranking 1 on all variables) to 70 (ranking 10 on all variables). The sites have also been divided into comparative groupings (best, medium, and worst) according to their final score.

Catchment	Site	Biotic Indices							Sum	Final Rank	Grouping
		TAXA	EPT	% EPT	MCI	QMCI	UCI	QUCI			
Okeover Stm	26	3=	1=	3	1	1	4	4	17	1	best
Avon River	22	1	3	1	3	6	3	1	18	2	best
Avon River	21	2	1=	7	7	8	1	3	29	3	medium
Avon River	23	6=	4	8	4	2	2	10	36	4=	medium
Waimari Stm	25	3=	5	5	2	9	6	6	36	4=	medium
Avon River	19	9	8=	2	8	3	5	2	37	5	medium
Wairarapa Stm	24	5	6=	6	6	5	10	7	45	6=	medium
Ilam Stm	27	6=	6=	9	5	7	7	5	45	6=	medium
Avon River	20	8	8=	10	10	4	9	8	57	9	worst
Papanui Stm	28	10	10	4	9	10	8	9	60	10	worst

TABLE 2 The presence of EPT taxa in the mainstem river and tributary waterways of the Avon catchment, as indicated by an ∆. The MCI values indicate the tolerance of the taxa to organic pollution (10 = highly pollution sensitive, 1 = pollution tolerant; (Stark, 1985). A stream with good water quality has a more pollution sensitive taxa, i.e., those with high MCI scores. MCI values are from Boothroyd & Stark (2000).

EPT taxa (caddisflies only)		MCI Value	Mainstem	Tributaries
Hudsonema amabile		6		∆
Hydrobiosis sp.		5	∆	∆
Hydrobiosis parumbripennis		5	∆	∆
Hydrobiosis umbripennis		5	∆	
Oecetis		6	∆	
Oeconesus		9	∆	∆
Oxyethira		2	∆	∆
Paroxyethira		2	∆	
Polyplectropus		8		∆
Psilochorema		8	∆	∆
Pycnocentria		7		∆
Pycnocentrodes		5	∆	∆
Triplectides cephalotes		5	∆	
Triplectides obsoletus		5		∆
Total EPT taxa			11	10

Unless indicated photos are © Shelley McMurtrie

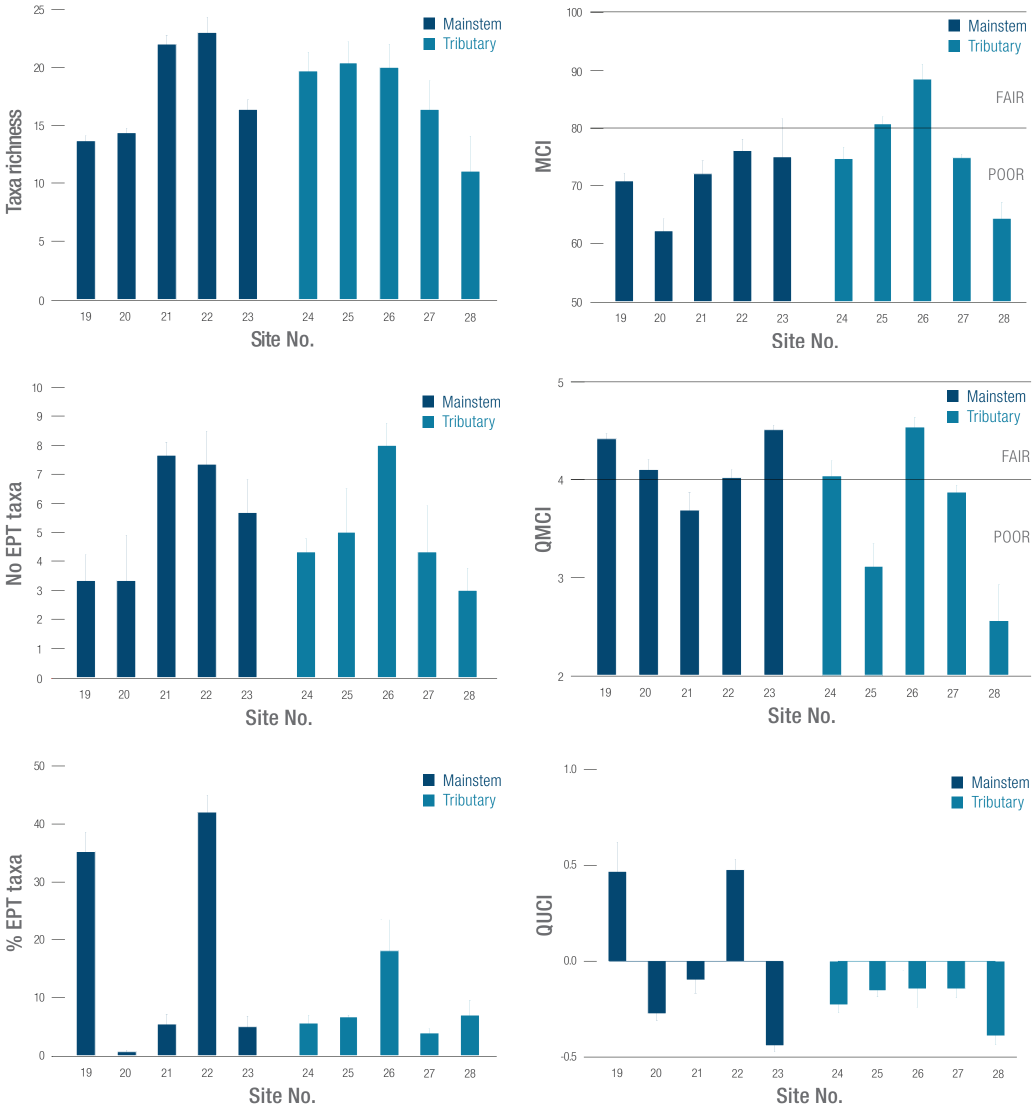


FIGURE 6 Average (+/- SE) biotic indices of invertebrate community health at the ten sites surveyed within the Avon catchment between the 19th and 26th March 2009. Site 19 is the most downstream site in the Avon River mainstem. The dotted lines on the QMCI and MCI graphs indicate the probable level of organic pollution (Stark, 1985; Stark, 1998). Good conditions (possible mild organic pollution) are indicated by MCI and QMCI values between 100-120 and 5-6, respectively. Poor conditions (probable severe organic pollution) are indicated less than 80 for the MCI and less than 4 for the QMCI.

closely followed by Site 19 (Avon River at Kilmore Street), while all other sites had negative values for this index. Taxa richness was highest at Site 22 on the Avon River (23 taxa), which was more than double that of the most depauperate site (Avon River Site 23, 11 taxa). However, this site ranked the lowest of those sites in the “fair” condition rating based on the QMCI score (and was thus ranked sixth overall for this score).

Those sites regarded as the worst were the Avon River in Victoria Square (Site 20) and the tributary Papanui Stream (Site 28, Table 1). These two sites supported the lowest number of taxa, including EPT taxa, and had the lowest MCI scores (Figure 6). Site 20 also had the lowest abundance of EPT taxa, with only 0.6% abundance. Site 28 at Papanui Stream rated the lowest for the the QMCI score, while UCI and QUCI scores were particularly low at both sites, rating eight or ninth out of the ten sites (Table 1).

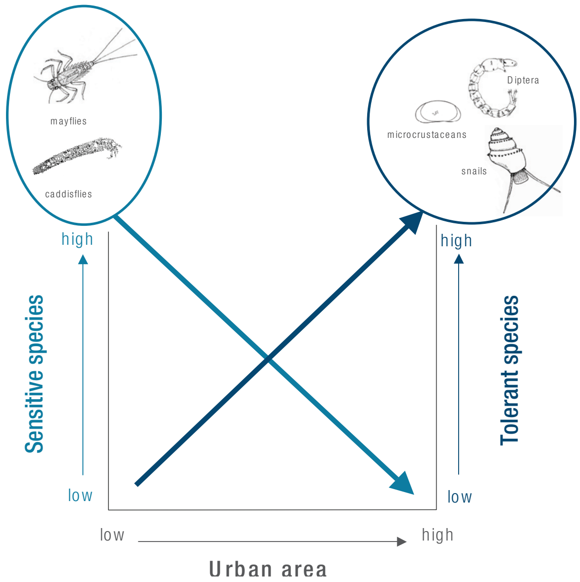


FIGURE 7 The Urban Stream Syndrome describes the decline in cleanwater EPT taxa (mayflies, stoneflies, and caddisflies) and increase in pollution-tolerant taxa (flies, snails, and worms) with an increase in urban area and catchment imperviousness.

4 DISCUSSION

Overall health as categorised by the MCI and QMCI score indicated that all sites in the Avon catchment were either in 'poor' or 'fair' condition. This is in constrast to the rural Otukaikino catchment, where sites were mostly rated as being in 'fair' or 'good' condition (McMurtrie & Greenwood, 2008). The dominant invertebrate community of the Avon catchment was typical of that usually found in urban rivers of moderate degradation (Suren, 2000). Crustaceans (amphipods, ostracods), snails, chironomids, and worms are all reasonably indifferent to poor habitat and water quality and are less affected by habitat fragmentation caused by loss of riparian zones, waterway piping, or culverting. This pattern of low invertebrate community health in urban waterways is the same the world over and is referred to as the 'urban stream syndrome' (Walsh et al., 2005, Figure 7). This syndrome describes the gradual decline in cleanwater taxa, which are typically intolerant of habitat degradation and poor water quality, and a subsequent increase in more pollution tolerant taxa such as snails (*P. antipodarum*, *Physa*), chironomids, worms, and some micro-crustaceans (ostracods). The urban stream syndrome is brought about by a combination of factors that pervade an urban catchment, including increased catchment imperviousness, altered hydrologic regimes (lower but flashier flow regimes), increased water-borne contaminants from stormwater inputs (e.g., heavy metals and polycyclic aromatic hydrocarbons), and a significant input of fine sediment during the initial catchment development phase (Paul & Meyer, 2001). The stream systems also become more fragmented due to buildings, bridges, and culverts, which interrupt the dispersal of winged adult aquatic insects (Blakely *et al.*, 2006).

Cleanwater taxa in the Avon catchment were limited to caddisfly taxa, with mayflies and stoneflies absent. Mayflies were once abundant in the Avon River; the earliest invertebrate surveys in the Avon catchment were undertaken in the 1978–79 summer by Dr. J. Robb of the Christchurch Drainage Board (Christchurch Drainage Board, 1980), who recorded two mayfly species (*Deleatidium*, *Coloburiscus*) at nine sites in the Avon River and six sites in its tributary system (Figure 8). A repeat survey in 1989 (Robb, 1992) indicated their distribution had diminished to three sites in the Avon River mainstem and one site in the tributaries. Both our current survey and one undertaken in the Avon River mainstem in 2003 (McMurtrie & Taylor, 2003) showed that they have since disappeared from the Avon catchment. While mayflies remain in the less urbanised streams to the north (e.g., the Styx and Otukaikino catchments), the urbanised nature of central Christchurch seems to have been the demise of the mayfly fauna for the Avon catchment.

The most likely factor responsible for loss of mayflies in the Avon River is continued stormwater contamination of water and sediments, and habitat fragmentation. Unpublished work by NIWA and EOS Ecology has shown the algal films growing on the surfaces of stones accumulate heavy metals and polycyclic

FIGURE 8 The mayflies *Coloburiscus* and *Deleatidium* were once found in the Avon catchment in the 1980's and 1990's but have since disappeared.

aromatic hydrocarbons (PAHs), and when grazing mayflies (such as *Deleatidium*) feed on this contaminated algal layer their survival is greatly reduced. The loss of a filter-feeding mayfly like *Coloburiscus* may be more due to loss of suitable habitat. These mayflies require highly oxygenated water and are typically found in fast-flowing riffle areas with a coarse, clean substrate. There are few fast flowing riffle sections in the Avon catchment today, and in these areas the coarse substrate has become more silted and covered with filamentous algae (Figure 9).

Caddisflies are generally more tolerant of some habitat degradation than mayflies, and it appears that the Avon catchment is at least still suitable for some of these taxa. The abundance of caddisflies is still greatly diminished in comparison to the less urbanised river systems to the north (e.g., the Styx and Otukaikino catchments). Yet the presence of 14 caddisfly taxa in the Avon catchment is in good stead with the rural Styx and Otukaikino catchments that support 18–20 taxa (respectively), and indicates that the Avon catchment is not yet fully degraded. Twelve of the 14 recorded caddisfly taxa are either predators or generalist grazers that consume both algae and decaying detrital matter (leaves and twigs). It is therefore possible that these caddisflies are not exposed to the same contaminated food sources as grazing mayflies, and consequently can tolerate the contaminant levels in the river. In addition, their habitat preferences appear to be less specific than mayflies, and they are known to tolerate some siltation of the coarse gravels.

Despite habitat conditions being so different between tributary and mainstem river sites, community composition was not related to waterway type (e.g., headwater or mainstem river). In fact, both a mainstem and tributary waterway site ranked as the best and worst sites. The best sites in the Avon catchment was the small headwater Okeover Stream (Site 26) and the Avon River in the Hagley Park Botanic Gardens (Site 22) (Figure 10). Both sites supported a reasonable abundance of caddisfly taxa (42% at Site 22 and 18% at Site 26), although this abundance of EPT taxa was still lower than most sites surveyed in the rural Otukaikino catchment (see McMurtrie & Greenwood, 2008). The comparatively high abundance of caddisfly taxa at Site 22 is most likely related to its location within Hagley Park. Through this area there is an unbroken riparian zone, little channel fragmentation due to the lack of road culverts, and limited night lighting. Night lighting from street lights and houses is known to confuse adult aerial insects such as mayflies and caddisflies at night. Thus instead of flying upstream to oviposit (lay their eggs) they are drawn away from the stream by the lights, thereby reducing the number of eggs laid in the stream.

Okoever Stream (Site 26) is located in the upper Avon catchment within the University of Canterbury grounds (Figure 10). While it had the lowest average water depth and velocity, and one of the finer substrates (predominately gravel) of the ten surveyed sites, it ranked second-best overall in terms of the

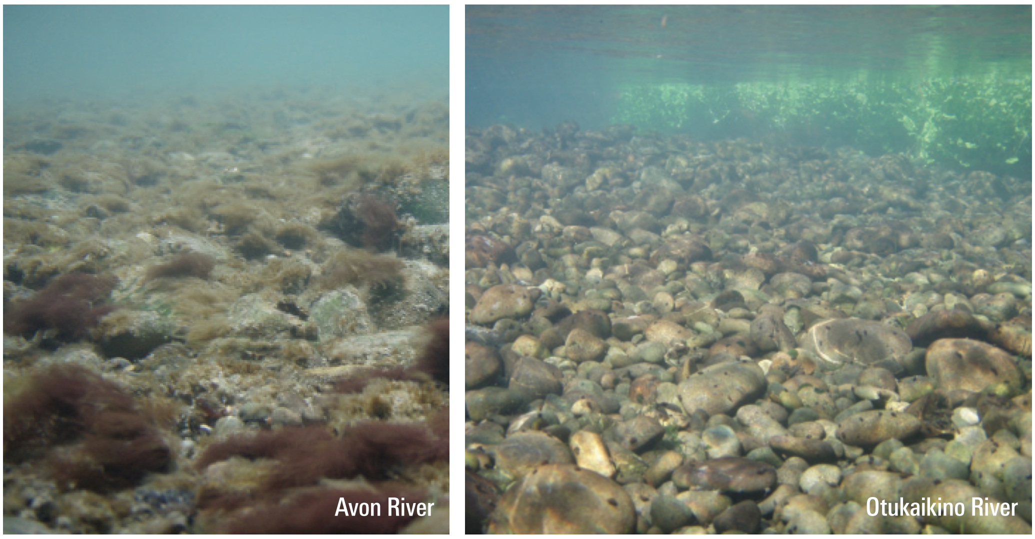


FIGURE 9 There are still areas of coarse substrate in the Avon catchment but this substrate is much more embedded (e.g., the gaps between the stones are filled with fine particles) and covered in algae than in less urbanised systems such as the Otukaikino River.

SITE 26 : Ranked 1st, Okeover Stream (looking upstream).

SITE 22: Ranked 2nd, Avon River in the Botanic Gardens (looking upstream).

FIGURE 10 Two sites, one mainstem and one tributary, in the Avon catchment that supported the best invertebrate communities.

invertebrate community. The small stream is heavily shaded with canopy cover and much of the flow is sourced from groundwater pumped from beneath the university buildings. It is probable that these factors have contributed to the life supporting capacity of the stream. In particular the heavy canopy cover and wide riparian zone may also be a useful refuge for adult caddisflies, and may help explain the high diversity of caddisfly taxa (ten) at this site. While the diversity of caddisflies was high, at 18% the overall abundance was low in comparison to Site 22. The lower abundance of caddisflies in Okeover Stream may be related to the many culverts downstream reducing the number of caddisflies able to access the Okoever Stream through the university grounds. A local study on the stream by Blakely *et al.*, (2006) found that culverts represented a significant barrier to the upstream flight of adult caddisflies (Figure 11). As adult caddisflies typically fly upstream to lay their eggs there would be a high level of attrition for adults flying upstream from the Avon River mainstem into Okoever Stream, due to the numerous culverts in their flight path.

The influence of barriers to the upstream movement of adult insects is probably most obvious at Papanui Stream in Grants Road Reserve (Site 28, Figure 12). This site was rated the worst site overall, and although caddisfly abundance (7%) was ranked fourth overall it was made up only three taxa. The survey section in Papanui Stream is located many kilometres across the city from the other study sites in the Avon catchment, which may be too difficult for the adult phase of aquatic insects to traverse compared to rural or unmodified catchments. For example, (Smith & Collier, 2001) found that the Auckland urban environment was too large a barrier for the North Island caddisfly *Orthopsyche* to traverse, with distinct populations found above and below the Auckland isthmus. Other surveys in streams in the vicinity of Papanui Stream (McMurtrie *et al.*, 2005) also indicate a low diversity and abundance of EPT taxa, meaning that the only possible source of caddisfly taxa would be limited to Papanui Stream itself. The 300 m upper reach was restored in 2002 and is known to support six caddisfly taxa. However, as the surveyed section of

FIGURE 11 Culverts are now known to be a significant barrier to the upstream flight of adult insects. This may be in part due to the large number of spiderwebs in culverts that would catch the adult insects, but may also be due to related factors such as lack of bank vegetation and dim light within culverts discouraging adult insects flying into culverts while bright street lights attract them away from the stream.

SITE 20: Ranked 9th, Avon River at Victoria Square (looking upstream).

SITE 28: Ranked 10th, Papanui Sream (looking upstream).

FIGURE 12 Two waterways sites, one mainstem and one tributary, in the Avon catchment that supported the poorest invertebrate communities.

the stream was restored as recently as 2008 it is possible that all of these taxa have not yet had time to colonise this new section of channel.

The Avon River through Victoria Square (Site 20) also rated poorly, being ranked ninth of the ten surveyed waterways (Figure 12). This site supported the lowest abundance (0.6%) and low diversity (four) of caddisfly taxa, and ranked similarly poorly for the MCI, UCI and QUCI indices. The reasons for a poor invertebrate community may in part be related to an unusual disturbance regime. Punting on the river is a popular attraction along the Avon River through the central city area, and the shallow water (the shallowest of the mainstem sites) through this part of Victoria Square causes the punts to scrape along the streambed. This continual abrasion may potentially reduce the diversity of fauna that would typically inhabitat this section. It is interesting to note that this site had the coarsest substrate of all the sampled sites, which may also be related to the scraping of the punts disturbing the substrate and keeping it free of fines. The mainstem channel was the widest at this point, and due to the subsequent shallow water it would be advisable to undertake some channel modification work to reduce the channel width. This would be a simple way of increasing the water depth and so reducing the likelihood of elevated water temperatures and of punts scraping on the streambed.

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7 APPENDICES

7.1 Appendix I: Site photographs

SITE 19 Avon River near Kilmore Street (looking downstream from top of site)

SITE 20 Avon River at Victoria Square (looking downstream from top of site)

SITE 21 Avon River near Durham Street (looking downstream from top of site)

SITE 22 Avon River in Hagley Park (looking downstream from top of site)

SITE 23 Avon River at Mona Vale (looking downstream from top of site)

SITE 24 Wairarapa Stream (looking downstream from top of site)

SITE 25 Waimairi Stream (looking downstream from top of site)

SITE 26 Okeover Stream (looking upstream from bottom of site)

SITE 27 Ilam Stream (looking upstream from bottom of site)

SITE 28 Papanui Stream (looking upstream from bottom of site)

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