Waitakere City Council
Te Taiao o Waitakere

PROJECT TWIN STREAMS WAITAKERE

Project Twin Streams
Catchment Monitoring

ECOLOGICAL MONITORING REPORT

Kingett Mitchell Ltd RESOURCE & ENVIRONMENTAL CONSULTANTS • Enviro Ventures Ltd • Diffuse Sources Ltd

Executive Summary

This report presents and summarises results of the aquatic ecology and habitat monitoring undertaken in summer 2005-2006 as part of the Project Twin Streams Pressure State Response (PSR) programme (contract EW03 424P).

The report details the following:

- Catchment characteristics, including predominant landuse and the percentage of impervious surface area.
- Instream habitat, including channel morphology, flow regime, inorganic and organic substrate composition, aquatic macrophyte cover, periphyton cover, channel shading, streambank characteristics and streambank modifications.
- Riparian vegetation, including understorey and canopy vegetation composition, density and structure.
- Macroinvertebrates (insects, snails etc.), including taxonomic richness, community composition and biological indices (MCI, SQMCI, EPT and %EPT).

Findings

Baseline ecological monitoring was undertaken at 19 sites in the Opanuku, Oratia, Waikumete and Swanson Stream systems during February 2006. Monitoring has shown the following key features relevant to the Twin Streams PSR programme:

- The Opanuku and Oratia catchments have a relatively low proportion of impervious surface areas (10% and 17% respectively). The Waikumete catchment has a greater proportion of impervious surface area (32%).
- Stream shading is lower in the lower catchments, which coincides with widening streams. Bank stability is variable throughout the Project Twin Streams.
- The Twin Stream sites have good quality riparian vegetation and canopy cover compared to other Auckland urban streams, which provides good bank stability, shade, detritus and woody debris inputs.
- Macrophytes and dense periphyton growths are uncommon within the Project Twin Streams catchments, possibly due to turbid water conditions and poor light penetration, solid bedrock streambeds in the lower catchments preventing the establishment of roots, and flash floods scouring macrophytes and periphyton from the streambed.
- The mean number of macroinvertebrate taxa recorded from each Project Twin Streams monitoring sites is higher than average for streams in the Auckland region.
- The mean number of taxa recorded per site was greater in 2005/06 than 2003/04 at Opanuku and Waikumete sites but lower at Oratia sites. Taxonomic richness was greatest at native bush reference sites and generally decreased with distance down the catchments through rural/peri-urban to urban/industrial landuses.
- Macroinvertebrate communities from the upper native bush and rural sites within the Opanuku, Oratia and Swanson catchments are diverse and contain a high number and proportion of sensitive EPT taxa (i.e., mayflies and caddisflies). In contrast, Potamopyrgus snails numerically dominate the upper Waikumete reference site community.
- Koura recorded from the upper Oratia (Potters Stream) and Swanson catchments was significant as koura are an iconic New Zealand species seldom found in urban streams due

to a lack of hiding places, poor water quality, and the severe flash-flooding nature of urban streams fed by city stormwater networks.

- Macroinvertebrate communities from the urban catchments have lower EPT diversity and abundance and a greater proportion of taxa typically associated with sluggish and degraded habitats (i.e., chironomids, snails, oligochaetes, amphipods).

Overall

Based on macroinvertebrate indices, there has been no overall improvement or decline in water quality or habitat within the Project Twin Streams catchment since 2003/04.

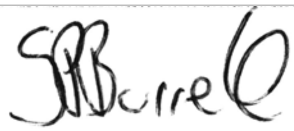
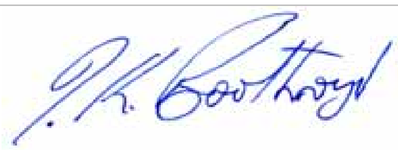
Table of Contents

List of Tables

List of Figures

Document Quality Assurance

This report has been prepared in accordance with Kingett Mitchell quality assurance procedures. All relevant quality control information in relation to biological and/or environmental data is identified within the document. The report has been reviewed and is approved for release as set out below.

	Name	**Signature**
Project Manager	**Ian Boothroyd**	
Project Reviewer	**Greg Burrell**	
Director approval for release	**Ian Boothroyd**	

1. Introduction

1.1 Background

Waitakere City Council (WCC) initiated the 'Project Twin Streams' as a programme of works designed to alleviate flooding, and improve water quality and the ecological health of the Oratia and Opanuku Streams, and the Waitemata Harbour. The project involves planning and controlling catchment development to reduce floods and control pollution, restoring native trees along stream banks, clearing stream channels and developing wetlands to reduce pressures and enhance environmental values. As part of Project Twin Streams, a 'Pressure, State and Response' (PSR) monitoring programme was designed and implemented (EVA 2003a).

The Project Twin Streams monitoring programme comprises:

- Pressure monitoring, including land use, potential sources of contamination, and treatment.
- Aquatic ecology and habitat quality assessment.
- Stream water quality monitoring.
- Stream sediment quality monitoring.
- Estuarine sediment quality monitoring.

The Project Twin Streams monitoring programme was initiated over the summer of 2003-2004, with 'aquatic ecology and habitat', 'sediment', 'water quality' and 'synthesis' reports presented. In 2005/06, the Swanson Stream catchment was added to the Project Twin Streams monitoring programme

1.2 Report Scope

The purpose of this report is to present and summarise the results of the Project Twin Streams 'aquatic ecology and habitat' monitoring undertaken in summer 2005-2006, and to compare results with those obtained previously in 2003/04. A summary of results from all of the Project Twin Streams monitoring reports will be presented in a synthesis report. The purpose of the synthesis report is to provide a measure of how the ecological state of waterways changes over time in response to changes in land use and WCC management practices.

The report structure is similar to that of the 2003-2004 report and details the following:

- Section 2 (Sampling Sites) – describes the Project Twin Stream site details and locations.
- Section 3 (Methods) – outlines the sampling methods used during the 2005/06 ecological surveys.
- Section 4 (Catchment Characteristics) – presents the predominant landuses and percentage of impervious surface areas.
- Section 5 (Stream Habitat Characteristics) – description of instream habitat, channel morphology, flow regime, inorganic and organic substrate composition, periphyton cover, channel shading, streambank characteristics and streambank modifications recorded in 2005/06 and comparisons with 2003/04 data.
- Section 6 (Riparian Vegetation) – description of understorey and canopy vegetation composition.
- Section 7 (Macroinvertebrates) – assessment of macroinvertebrate communities including analysis of taxonomic richness, community composition and biological indices (MCI, QMCI, EPT and %EPT).
- Section 8 is a summary of report findings.

2. Sampling Sites

Project Twin Streams monitoring sites within the Opanuku Stream, Oratia Stream and Swanson Stream catchments were selected based on management frameworks including Stormwater Management Units (SMU)[1], landuse[2], response to activities[3], programme objectives, and practicalities of site access.

The aquatic ecology component of the Project Twin Streams monitoring programme was undertaken at 19 sites within the Opanuku, Oratia and Swanson catchments. Four sites are located within the Opanuku catchment (Sites A-D), including one site on Stoney Creek. Five sites are located within the Oratia catchment (Sites E-I) including an upper site on Potters Stream. Six sites were located within the Waikumete Stream sub-catchment (Sites J-O), which is within the wider Oratia Stream catchment. The Waikumete Stream sub-catchment includes Hibernia Stream and Whakarino Stream and enters the Oratia Stream between Railside Avenue and Serwayne Place. Four new sites (Sites P-S) within the Swanson Stream catchment (to the northwest) were surveyed for the first time during the 2005/06 monitoring period. Site descriptions and map locations are presented in Table 2.1 and Fig. 2.1.

[1] Stormwater Management Units (SMU): The SMU is the fundamental unit for the management of stormwater and has been a key unit for the assessment of pressures and state of the environment condition.

[2] Landuse: Landuse is a key factor driving water quality and ecological condition. In particular, the relative extent of diffuse and point-source inputs to waterways is derived from the type of landuse. The extent and magnitude of stormwater infrastructure and treatment is also driven by the intensity of landuse.

[3] Responses: A series of activities, which are in response to the pressures on the environment. We have anticipated some of these responses in the design of the Project Twin Streams programme but with no reference to any proposed sequence of response activity.

Table 2.1: Summary of location, landuse and general description of Project Twin Stream aquatic monitoring sites.

Catchment	Site	Stream	Access Point	Catchment	SMU	Land use	Purpose	Grid Reference
Opanuku	**A**	Stoney Creek	Sharp Track	Opanuku	16	Native bush	Headwaters reference site	503 762
	B	Opanuku Stream	Candia Road	Opanuku	16	Rural	Mixed rural	526 773
	C	Opanuku Stream	Border Road	Opanuku	15	Peri-urban	Land use change	543 777
	D	Opanuku Stream	Sel Peacocke Drive	Opanuku	15	Urban	Lower catchment cumulative effects	559 793
Oratia	**E**	Potters Stream	Bendall's Lane	Oratia	13	Native bush	Headwaters reference site	522 741
	F	Oratia Stream	West Coast Road	Oratia	13	Rural	Intensive peri-urban	537 746
	G	Oratia Stream	Parrs Cross Road	Oratia	13/10	Peri-urban	Land use change	552 762
	H	Oratia Stream	Aetna Place	Oratia	10	Industrial	Land use change (to urban)	556 769
	I	Oratia Stream	Alderman Drive	Oratia	10	Urban	Lower catchment cumulative effects	557 792
Waikumete	**J**	Hibernia Stream	Waerenga Place	Waikumete	12	Native bush	Bush living reference	576 728
	K	Hibernia Stream	Ceramco Park	Waikumete	12	Urban	Bush residential	576 743
	L	Whakarino Stream	Withers Reserve	Waikumete	12	Urban	Bush residential + WWOFs	570 741
	M	Waikumete Stream	Glendale Road	Waikumete	11	Urban	Residential + WWOFs	574 746
	N	Waikumete Stream	West Coast Road	Waikumete	11	Urban	Urban living	568 757
	O	Waikumete Stream	Benita Place	Waikumete	10	Industrial	Lower catchment cumulative effect	559 766
Swanson	**P**	Swanson Stream	Tram Valley Road	Swanson	17	Native bush	Headwaters reference site	495 792
	Q	Swanson Stream	Swanson Road	Swanson	17	Urban	Urban living	505 809
	R	Swanson Stream	Birdwood Road	Swanson	19	Urban	Urban living	525 811
	S	Swanson Stream	Woodside Road	Swanson	19	Urban	Urban living	542 817

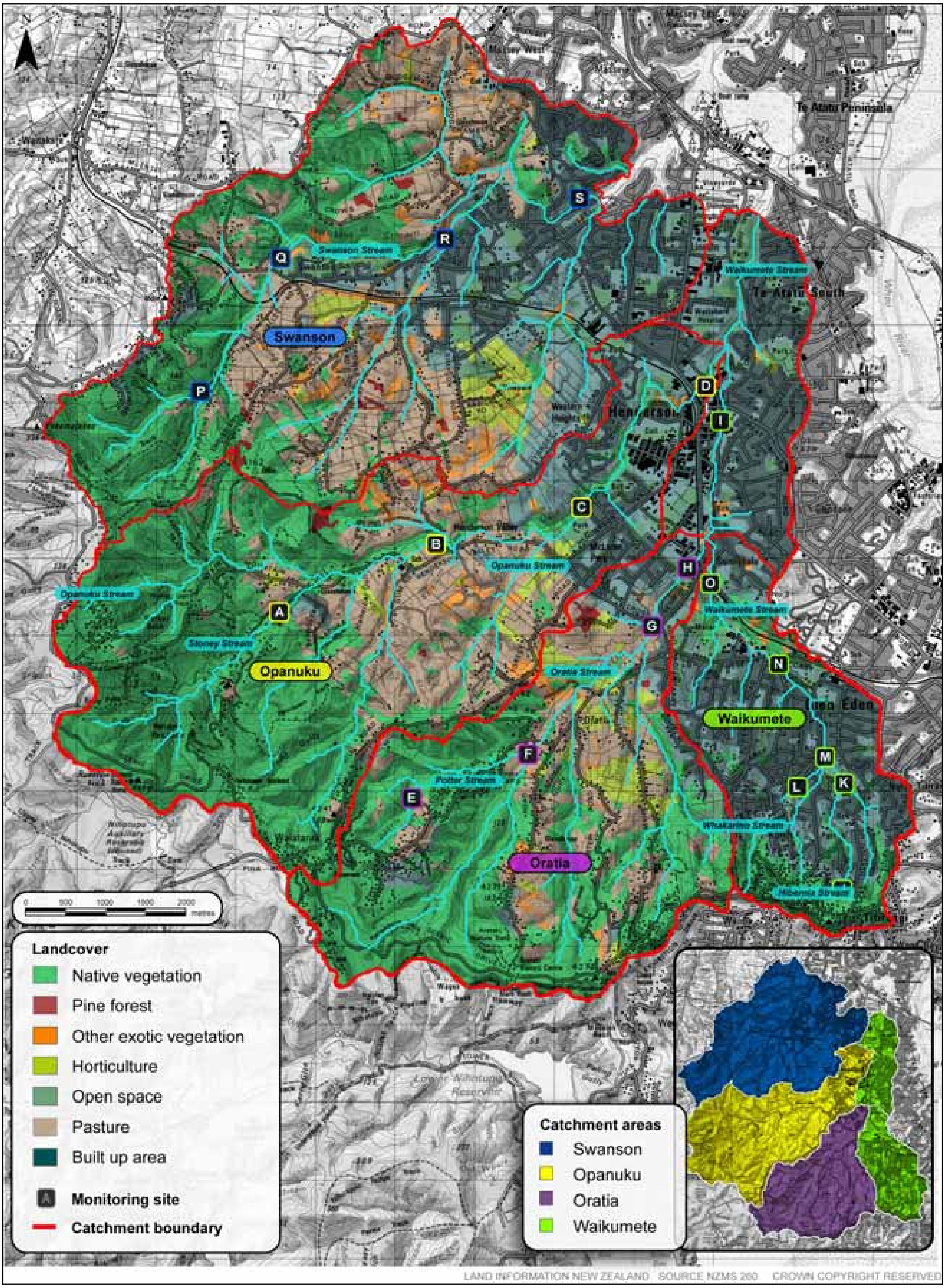


Fig. 2.1: Map showing Project Twin Streams monitoring sites.

3. Methods

3.1 Catchment Characteristics

The most obvious features of the land surface in an urban area are the impervious surfaces, such as roads, roofs, driveways and parking areas (Suren & Elliot 2004). In a typical urban catchment, impervious surfaces will cover around 40% of the land area (Suren & Elliot 2004). In general, as the impervious area within a catchment increases, the greater the impact on aquatic biota (Schueler 1994; Arnold & Gibbons 1996). Schueler et al. (1999) suggested that negative impacts of stormwater run-off for stream biota can occur with as little as 15% of the catchment in urban landuse (i.e., impervious surfaces).

Catchment characteristics presented in this report include the predominant landuse type and percentage of impervious surface area within each catchment. Landuse type and percentage surface areas were obtained from GIS based information. In addition, sites were categorised into Stormwater Management Units (SMU), which allows comparisons to be made between sites based on known pressure indicators[4] resulting from urbanisation.

3.2 Instream Habitat

The channel and habitat condition is an important determinant of the ecology and instream values associated with aquatic habitats. Habitat assessments were carried out within standardised reaches (typically 30-100 m) at identified sites using an ARC Habitat Assessment method (ARC 2002). This included a combination of qualitative and visual assessments of key habitat features including:

- Channel width and depth (m).
- Flow regime (percent run, riffle and pool).
- Inorganic substrate composition (%).
- Organic substrate composition (%) (woody debris, periphyton, tree roots, macrophytes).
- Channel shading (%).
- Streambank characteristics (form, erosion, slope).
- Streambank modification.

3.3 Riparian Vegetation

Riparian vegetation is important to stream ecosystems and can substantially affect water velocities, physical instream habitat, nutrient dynamics, water clarity and quantity and ultimately the abundance and diversity of aquatic life (Reeves et al. 2004). Semi-quantitative estimates of understorey and canopy riparian vegetation composition, density, and structure were assessed using standard field methods adopted by ARC. Riparian vegetation surveys were undertaken along standardised stream reaches (typically 30-100 m) at 0-5 m and 5-20 m intervals away from the stream channel. The methods used assess the integrity and extent of riparian vegetation without the need for extensive botanical surveys.

3.4 Macroinvertebrates

Macroinvertebrates include the diverse assemblage of organisms that live on the surface, under, or within the substrates of streams and include insect larvae (e.g., mayflies, stoneflies, caddisflies, beetles), aquatic oligochaetes (worms), molluscs (e.g., snails) and crustaceans (e.g., shrimps and crayfish).

[4] Pressure indicators: Percentage of SMU in impervious surface; volume of wastewater overflows/km^2; annual vehicle count; number of stormwater outlets of 375 mm i.d/km^2; percentage area of SMU with stormwater treatment; percentage continuous riparian vegetation and percentage riparian vegetation >10m.

Because stream macroinvertebrates are such a diverse group and are influenced by aquatic habitat and water quality, they are widely used for monitoring and evaluating water quality and more broadly 'stream health' in New Zealand and overseas (Winterbourn 2004). Standardised macroinvertebrate sampling protocols exist and are being adopted by many agencies, thus enabling consistent data collection with quality control procedures and the ready comparison of data. The following macroinvertebrate sampling methodologies were used in Project Twin Streams monitoring:

- A single sample was collected along a standard 50-100 m reach at each site using either Protocol C1 for soft-bottomed streams or C2 for hard-bottomed streams (Stark et al 2001). Both sampling protocols allow for comparison between sites, between years, and with other urban streams in New Zealand.
- Macroinvertebrate identification was undertaken to at least the MCI level as determined in Stark et al. (2001).
- Macroinvertebrate enumeration and identification was by way of a 200 fixed count and scan for rare taxa method (Protocols P2 and QC2, Stark et al. 2001) (see Appendix 1 for details).

A benefit of using macroinvertebrates is that they can be indicators of 'stream health' through the interpretation of biological indices based on macroinvertebrate community data.

Taxonomic Richness – A measure of the number of macroinvertebrate taxa present at each site. In general, the greater the number of taxa will typically indicate a higher quality aquatic environment.

Ephemeroptera, Plecoptera and Trichoptera index (EPT) – The EPT index is based on a combined total count of the number of sensitive mayfly, stonefly and caddisfly[5] taxa present at each site (Lenat 1988). EPT values are generally sensitive to changes in water and habitat quality and give a good indication of 'stream health'. High EPT scores suggest high water and/or habitat quality, whilst low scores typically indicate low water and/or habitat quality. EPT abundance is often expressed as a percentage of the whole community and is referred to as the %EPT.

Macroinvertebrate Community Index (MCI) – The MCI provides an assessment of water quality and habitat conditions within a stream using benthic macroinvertebrates (Stark 1985). The MCI is based on scores between 1 and 10 assigned to each taxon reflecting their sensitivity to water and habitat quality change (e.g., 1 being tolerant and 10 being sensitive). The MCI is a presence/absence based index calculated using the formula below and used to describe 'stream health' using the guidelines presented in Table 3.1:

$$MCI = \sum_{i=1} 20 \times \frac{a_i}{N}$$

Where: a_i = the sum of individual taxon scores in a sample.
N = number of taxa.
20 is a scaling factor.

Quantitative Macroinvertebrate Community Index (QMCI) – The QMCI index is similar to the MCI in that it is based on the relative sensitivity of different taxa in a sample to changes in water quality but uses abundance data in its calculation (Stark 1993). The QMCI is particularly sensitive to changes in the relative abundance of individual taxa within a community and interpreted using the guidelines presented in Table 3.1.

[5] The caddisfly *Oxyethira* was removed during calculation of EPT scores due to its tolerance to organic enrichment.

The QMCI is calculated using the following formula:

$$QMCI = \sum_{i=1}^{i=S} \frac{(n_i \times a_i)}{N}$$

Where: S = the total number of taxa in the sample.
n_i = the number of individuals in the i-th scoring taxon.
a_i = the score of the i-th taxa.
N = the total number of individuals collected in the sample.

Table 3.1: Estimates of water and habitat quality in streams using MCI and QMCI indices (from Boothroyd and Stark 2000).

Quality	Description	MCI	QMCI
Excellent	Clean Water	> 120	> 6
Good	Doubtful quality or possible mild pollution	100 - 120	5 – 6
Fair	Probable moderate pollution	80 – 100	4 – 5
Poor	Probable severe pollution	< 80	< 4

4. Catchment Landuse

4.1 Opanuku Catchment

The upper Opanuku catchment is situated in the Waitakere Ranges and is characterised by low intensity land uses, open spaces, foothills topography and rural living. The upstream Opanuku Sites A and B are in SMU16, which has good ecological condition with natural or low modification (EVA 2003b). Site A has a total catchment area of 365 ha, and the predominant land cover is native forest (Table 4.1). Only 7 ha or 2% of the surface area of the Site A catchment is impervious. The cumulative catchment size at Site B is 1,675 ha. The predominant landuse in the Site B catchment is pasture, with 67 ha (4%) being impervious surfaces. The lower Opanuku Sites C and D are in SMU 15, which is subject to moderate-high urban pressures (i.e., imperviousness, EVA 2003b). The downstream peri-urban Site C has a cumulative catchment size area of 2,182 ha with 118 ha (5%) being impervious. The lowermost urban Site D has a cumulative catchment area of 2,556 ha with 256 ha (10%) in impervious area. In comparison with the other urban streams, the Opanuku catchment has a relatively low proportion of impervious surface areas.

4.2 Oratia Catchment

The upper Oratia catchment drains the foothills of the Waitakere Ranges and is characterised by open spaces and rural living as the predominant landuse. The upper catchment has a low percentage of impervious surface area. Sites E and F are in SMU13 and have cumulative catchment areas of 72 ha and 440 ha respectively. Impervious surface areas represent 3% of both catchments. The lower Oratia catchment is much larger than the upper catchment and drains a predominantly urban environment. Sites G, H and I are in SMU10, which has a moderate degree of catchment imperviousness (EVA 2003b). There is a significant increase in cumulative impervious surface area between Sites H (91 ha or 5%) and Site I (493 ha or 17%). The Oratia catchment is a large catchment with a relatively low percentage of urban land use and impervious surface areas.

Table 4.1: The cumulative area, predominant landuse and cumulative percent impervious area for the 15 Twin Stream sites.

Stream	Site	SMU	Predominant landuse	Total area (ha)	Impervious area (cumulative) (ha)	Impervious area (cumulative) (%)
Opanuku	A	16	native bush	365	7	2
	B	16	rural	1,675	67	4
	C	15	peri-urban	2,182	118	5
	D	15	urban	2,556	256	10
Oratia	E	13	native bush	72	2	3
	F	13	rural	440	13	3
	G	13/10	peri-urban	1,629	72	4
	H	10	industrial	1,681	91	5
	I	10	urban	2,850	493	17
Waikumete	J	12	native bush	14	2	13
	K	12	urban	96	26	27
	L	12	urban	86	23	27
	M	11	urban	392	106	27
	N	11	urban	543	163	30
	O	10	industrial	888	285	32
Swanson	P	17	native bush	322	12	4
	Q	17	urban	695	26	4
	R	19	urban	928	56	6
	S	19	urban	2,282	299	13

4.3 Waikumete Catchment

The Waikumete sub-catchment lies within the Oratia catchment and is therefore relatively small in comparison with the other Project Twin Streams catchments. The upper Waikumete catchment (including the Hibernia Stream and Whakarino Stream) is in SMU12 and drains relatively small bush/residential catchments ranging in size between 41-96 ha. The upper Waikumete catchment, although draining native bush, has a relatively high proportion of impervious surface areas (between 13-27%). The downstream urban Sites M and N are in SMU11 and Site O in SMU10 (EVA 2003a). The lower Waikumete catchment has a high proportion of roading and residential/industrial areas resulting in a large area of impervious surfaces (between 27-32%).

4.4 Swanson Catchment

The upper Swanson Stream catchment drains the foothills of the Waitakere Ranges and is situated in native bush. The upper Site P has a total catchment area of 322 ha, only 4% (12 ha) of which is in impervious built up areas. A similar proportion of the catchment above Site P is in pasture (4%). The catchment above site Q also has a high proportion of native bush (69% or 480 ha) but a greater proportion of land used in pasture (26%). Both sites P and Q are in SMU 17. Site O has a similar proportion of its catchment in impervious areas similar to Site P (4% or 26 ha). The urban sites R and S have progressively less catchment area in native bush (63% and 38% respectively) but still have relatively low proportions of impervious built up areas (6% and 13% respectively), and both are in SMU 19.

4.5 Summary

The upper reaches of all the Project Twin Streams waterways originate in the foothills of the Waitakere Ranges and drain relatively unmodified native bush and pasture landuses. The percentage of impervious surface areas within the upper Opanuku, Oratia and Swanson catchments is low (between 2-5%). In contrast, the upper Waikumete sub-catchment has a higher proportion of impervious area (13%). The lower Project Twin Streams catchments drain low-lying developed urban and industrial areas with cumulative catchment areas ranging in size from 285 ha (Waikumete sub-catchment) to 2,850 ha (Oratia). The lower Opanuku, Oratia and Swanson catchments have relatively low percentages of their total catchments in impervious surface areas (between 10-17%) compared with the Waikumete sub-catchment (32%), which has a high proportion of roading, residential and industrial land use.

5. Instream Habitat Characteristics

5.1 General

Stream channel characteristics recorded at each site in 2005/06 and 2003/04 are presented in Table 5.1. Photographs of selected sites are provided in Figs. 5.1, 5.4, 5.5 and 5.6. The relative proportion of the flow regime (i.e., pools, runs, riffles and chutes) types recorded at sites in 2005/06 is presented in Fig. 5.2. The inorganic sediment and organic substrate composition recorded at sites in 2005/06 is presented in Fig. 5.3.

Table 5.1: Stream channel characteristics recorded at the Project Twin Streams sites.

Stream	Landuse	Site	Mean width (m)	Mean depth (m)	Channel shade (%)	Bank stability L (%)	Bank stability R (%)
Opanuku	Native bush	A	3.8 (3.9)[1]	0.20 (0.28)	85 (65)	81 (82)	85 (91)
	Rural	B	6.4 (6.0)	0.55 (0.65)	60 (40)	69 (70)	86 (70)
	Peri-urban	C	3.2 (2.8)	0.26 (0.39)	10 (25)	66 (46)	85 (46)
	Urban	D	8.0 (8.1)	2.57 (0.50)	20 (15)	95 (73)	100 (100)
Oratia	Native bush	E	2.1 (1.7)	0.21 (0.22)	100 (90)	78 (82)	76 (82)
	Rural	F	3.1 (2.3)	0.38 (0.56)	70 (70)	71 (55)	86 (91)
	Peri-urban	G	3.3 (2.8)	0.38 (0.82)	60 (60)	44 (64)	67 (100)
	Industrial	H	3.0 (3.0)	0.51 (0.65)	10 (60)	63 (46)	75 (82)
	Urban	I	4.1 (4.0)	0.39 (0.57)	20 (40)	87 (64)	88 (73)
Waikumete	Native bush	J	0.8 (0.7)	0.18 (0.13)	100 (95)	58 (46)	59 (36)
	Urban	K	2.1 (2.2)	0.37 (0.31)	90 (95)	62 (64)	62 (82)
	Urban	L	1.5 (1.3)	0.09 (0.19)	50 (40)	91 (73)	91 (82)
	Urban	M	1.9 (2.1)	0.21 (0.33)	30 (10)	77 (100)	78 (100)
	Urban	N	4.7 (2.3)	0.47 (0.38)	90 (60)	91 (100)	92 (100)
	Industrial	O	2.3 (2.5)	0.54 (0.69)	90 (70)	66 (100)	63 (82)
Swanson[2]	Native bush	P	3.1	0.42	90	92	83
	Urban	Q	3.9	1.26	80	91	91
	Urban	R	3.6	0.61	80	48	60
	Urban	S	3.0	0.30	50	93	78

Notes: [1] The 2003/04 mean is presented in brackets.
[2] Swanson catchment first surveyed in 2005/06.

5.2 Opanuku Catchment

Stoney Creek (Site A)

The reference Site A (Stoney Creek) stream channel has a mean width of 3.8 m, mean depth of 0.2 m, good stream shade (85%) and high streambank stability with undercuts (Fig. 5.1 and Table 5.1).

The hydrological characteristics within Stoney Creek are diverse with chutes (45%), pools (27%), riffles (18%) and run (9%) habitat providing good instream habitat (Fig. 5.2). The streambed substrate is predominantly bedrock (44%) and boulder (36%), with algae (40%), detritus (15%) and woody debris (13%) the predominant organic substrates recorded (Figs. 5.3 and 5.4). Stoney Creek channel

characteristics in 2005/06 were typical of a relatively unmodified Waitakere Ranges stream and were similar to those recorded in 2003/04.

Site A (native bush)

Site B (rural)

Site C (peri-urban)

Site D (urban)

Fig. 5.1: Habitat conditions at sites in the Opanuku catchment, February, 2006.

Opanuku Stream (Sites B to D)

The Opanuku Stream channel changes from a relatively natural meandering channel with run (73%), riffle, (9%) and pool (18%) sequences at the rural Site B (and to a lesser extent the peri-urban Site C) to a wide (8 m) and deep (2.57 m) channel dominated by sluggish pools (100%) at the urban Site D. The streambanks at Site C were more stable in 2005/06 than in 2003/04, possibly due to greater streambank vegetation cover and streambank protection (i.e., rock rip-rap). The greater channel depth recorded at Site D in 2005/06 (2.57 m) compared with 2003/04 (0.5 m) may reflect differences in sampling methodology used where actual measurements as opposed to estimates were made in 2005/06. The streambed substrate recorded at Sites B and C were diverse with a range of particle sizes recorded (predominantly coarse sized particles). In contrast, the substrate at the lowermost Site D was predominantly sand (60%) and bedrock (40%). There was an increase in the proportion of sand recorded at sites with distance down the catchment. Detritus and woody debris was the most abundant organic substrate recorded at sites, but was generally in lower proportions in 2005/06 than recorded in 2003/04. A high proportion of bryophytes growing on large boulders was recorded at Site C (31%).

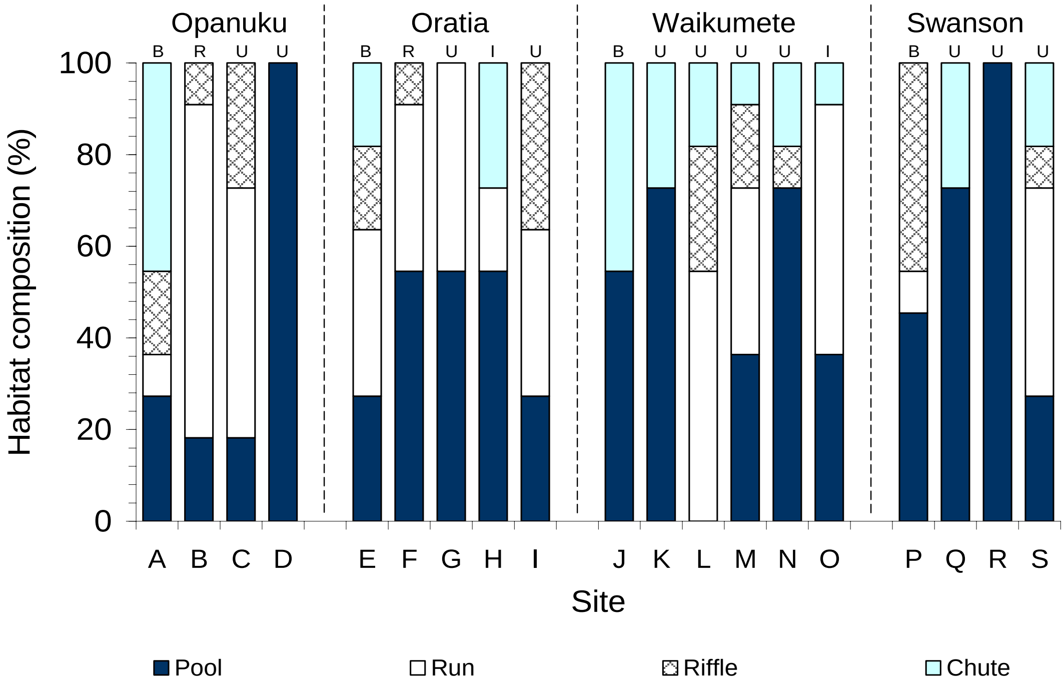


Fig. 5.2: **The relative proportion of flow regime types (%) recorded at Project Twin Streams monitoring sites in 2005/06 (B = native bush; R = rural; I = industrial; U = urban and peri-urban).**

5.3 Oratia Catchment

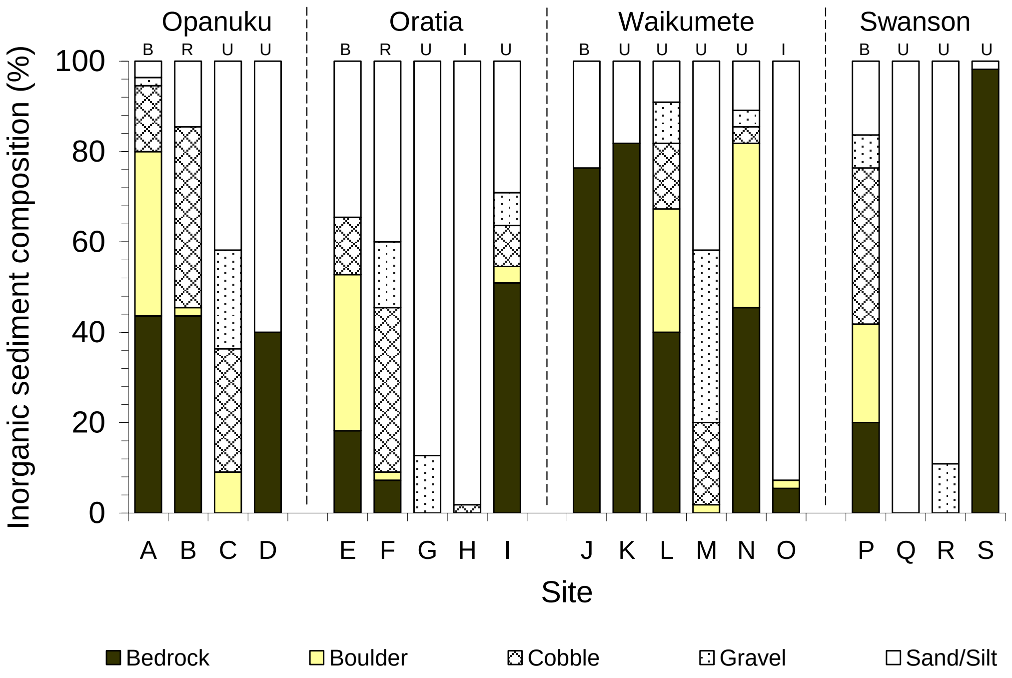
Potters Stream (Site E)

The uppermost Oratia reference Site E (Potters Stream) drains a predominantly unmodified native bush catchment. The stream is incised within a relatively narrow (2.1 m wide) and shallow (0.21 m deep) channel with stable undercut streambanks (Fig. 5.4). Hydrological conditions within Potters Stream are diverse, with natural pool (27%), run (36%) and riffle (18%) sequences with chutes (18%) providing good aquatic habitat for invertebrates and fish. Potters Stream has a diverse inorganic sediment and organic substrate composition, which reflects high instream habitat quality within this stream. Site E (along with Site F) had the greatest proportion of algal growth recorded of the Oratia sites (13%). Habitat conditions within Potters Stream had not changed since 2003/04.

Oratia Stream (Sites F to I)

Oratia Stream is incised and confined within a channel with high streambanks. The confined nature of the Oratia channel can result in high flows during flood events, which has a scouring effect on the streambed and streambanks. Streambank stability was poor at Sites G and H (as low as 44%). Streambank stability at Site G has deteriorated since 2003/04. Poor streambank stability at Sites G and H corresponds with a predominantly fine sand/silt streambed substrate more prone to accelerated erosion. The Oratia Stream is relatively deep throughout (ranging between 0.38-0.51 m deep), which is reflected in the predominance of run and pool habitats. Debris dams as opposed to natural channel morphology created the chute habitats recorded at Site H. Channel shade decreases with distance down the catchment from 70% at Site F to 10% at Site H. Site H has little channel shading due to highly modified riparian vegetation and has worsened since 2003/04 (from 60% to 10%). The Oratia Stream sites have a high proportion of accumulated organic matter in the form of detritus and woody debris. Bryophytes, algae and tree roots are also recorded at all sites. Algal growth was greatest at Site E and Site F (20%) but covered a smaller proportion of stable substrates at the downstream urban sites. Algal growth was significantly less abundant at Site I in 2005/06 (2%) than in 2003/04 (64%).

a)



b)

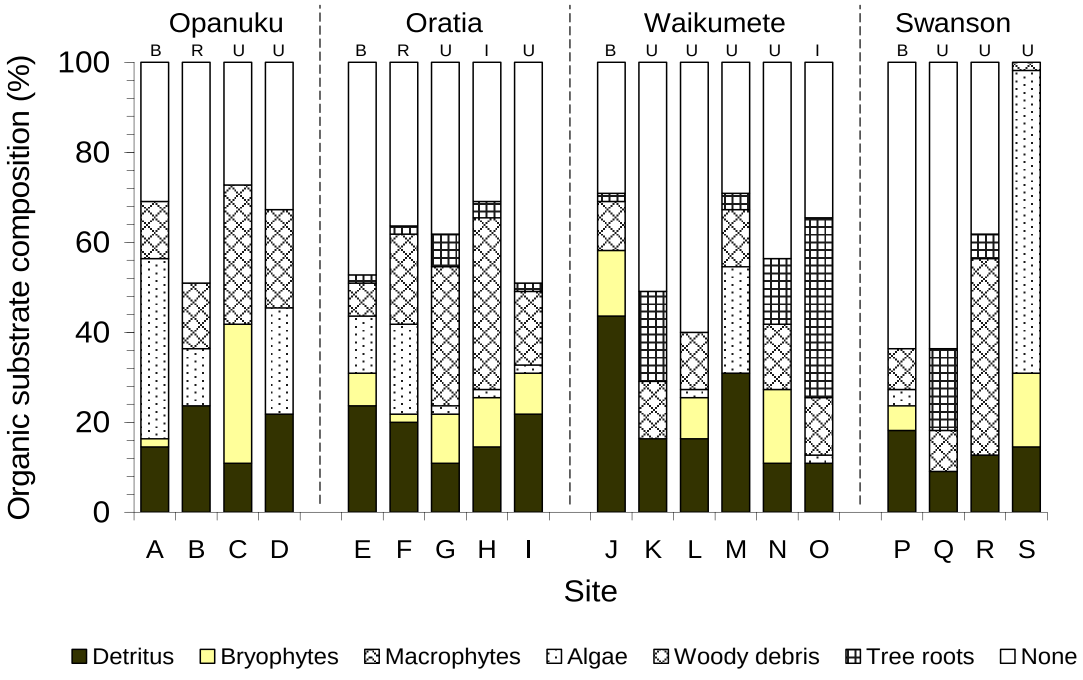


Fig. 5.3: The relative a) inorganic sediment and b) organic substrate composition recorded at Project Twin Streams monitoring sites (B = native bush; R = rural; I = industrial; U = urban and peri-urban).

Site E (native bush)

Site F (rural)

Site G (peri-urban)

Site H (industrial)

Site I (urban)

Fig. 5.4: Habitat conditions at sites in the Oratia catchment, February 2006.

5.4 Waikumete Catchment

Hibernia Stream (Sites J and K)

The upper Hibernia Stream reference Site J has a narrow (0.8 m wide) and shallow (0.18 m deep) channel draining through native bush and steep weathered geology (Fig. 5.5). The stream channel is characterised by large natural vertical drops in channel height (some >1 m). Instream habitat consists of narrow chutes (45%) and pools (55%) that form at the base of vertical drops. There is limited flow during baseflow conditions. However, based on the heavily eroding, undercut and slumped streambanks (58% stable), the upper reach of the Hibernia Stream conveys significant quantities of water during floods. Organic matter at Site J is abundant and in the form of detritus (44%), bryophytes (15%), woody debris (11%) and tree roots (2%). The downstream Hibernia Stream Site K channel is wider (2.1 m), deeper (0.37 m), and drains less steep topography than that at Site J. The channel has a predominantly bedrock (82%) and fine sand/silt (18%) streambed. The channel is well shaded (90%) and characterised by a deep pool (73%) and chute (27%) channel pattern. The streambanks at Site K lacked vegetative cover and were of moderate-poor stability (62% stable). There were significantly less algal growths recorded at Site K in 2005/06 than in 2003/04.

Whakarino Stream (Site L)

The Whakarino Stream at Site L drains through predominantly urban landuse and is a narrow (1.5 m) and shallow (0.09 m) waterway that emerges from an upstream piped section. The stream has low baseflow, which is reflected in the high proportion of shallow riffle (27%) and chute (18%) habitats. The streambanks are stable and shade is approximately 50%. The streambed substrate is diverse with bedrock (40%), boulder (27%), cobble (15%), gravel (9%) and sand (9%). There was significantly less algal growth recorded at Site L in 2005/06 than in 2003/04 .

Waikumete Stream (Sites M to O)

Waikumete Stream at Sites M, N and O drains through predominantly urban and industrial landuses. Channel widths range between 1.9-4.7 m and depths vary between 0.21-0.54 m. Channel depth generally increases with distance down the catchment. The stream at Site M meanders naturally through an open area but has a deeply incised and confined U-shaped channel at Site O. The streambed substrate recorded at Sites M-O ranges from a high proportion of bedrock at Site N to sand/silt at Site O. Bank stability at Waikumete sites was poorer in 2005/06 than in 2003/04. The Waikumete Stream has a high proportion of sluggish water held in pools (between 36-73%) and runs (between 0-55%). Chutes form over natural bedrock outcrops at Site N and debris dams at Site O. Channel shading was generally high at Waikumete Stream sites in 2005/06 compared with 2003/04, however low shading at Site M corresponded with a high proportion of algal growth. Site O had a high proportion of tree roots (40%) in the form of fibrous mats and large woody tree roots.

5.5 Swanson Catchment

The upper reference Site P in the Swanson Stream catchment has a relatively unmodified channel with a width of 3.1 m, depth of 0.42 m, and a natural run (9%), riffle (45%) and pool (45%) pattern (Fig. 5.6). The surrounding native bush provides approximately 90% channel shade and a high degree of streambank stability (83-92%). Streambanks are undercut, which provides good native fish habitat. The streambed substrate is diverse with bedrock (20%), boulder (22%), cobble (35%), gravel (7%) and sand/silt (16%). The mean channel widths at the urban Sites Q, R and S range between 3.0-3.9 m, which is similar to the width recorded at the upstream Site P (3.1 m wide). The greatest mean depth was recorded at Site Q (1.26 m) due to the many large pools at this site. The urban stream sites generally had less diverse hydrological conditions and contained a higher proportion of sluggish runs and pools. Streambank stability was generally good at Swanson Stream sites due to good vegetation cover. An exception was Site R where streambank stability was relatively poor (48-60% stability), although canopy cover was good.

Site J (native bush)

Site K (urban)

Site L (urban)

Site M (urban)

Site N (urban)

Site O (industrial)

Fig. 5.5: Habitat conditions at sites in the Waikumete catchment, February, 2006.

The streambed substrate recorded at Swanson Stream sites was relatively homogeneous and comprised of either bedrock (Site S) or sand/silt (Sites Q and R). There was abundant woody debris at Site R (44%) and high algal growth at Site S (67%). Between 9-13% detritus was recorded at Swanson Stream sites. It is worth noting that stream infilling works (of a large pool) are planned at a location downstream of Site S.

Site P (native bush)

Site Q (urban)

Site R (urban)

Site S (urban)

Fig. 5.6: Habitat conditions at sites in the Swanson catchment, February, 2006.

5.6 Summary

The upper reaches of the Project Twin Streams catchments are relatively unmodified with the streams having moderate-high habitat values. Stream channel morphology varies from wide, boulder and cobble dominated channels (e.g., Stoney Creek) to narrow, steep, cascading channels draining weathered geology (e.g., Hibernia Stream). A common feature of the upper catchments is the almost complete channel shading provided by native bush and the diverse hydrological conditions that includes riffles and chutes. Streambanks in the upper reaches can be stable but tend to show evidence of natural erosion in the form of undercuts, which provide ideal shelter for New Zealand native fish species such as eels and banded kokopu. An exception is the upper Hibernia Stream, which drains steep, soft, weathered geology and has streambanks highly susceptible to accelerated erosion and slumping. There did not appear to be

any significant changes in instream habitat conditions recorded at reference Project Twin Stream monitoring sites since 2003/04.

As the upper Opanuku and Oratia catchments give way to more open, rural, peri-urban, or urban-bush landuses, the stream channel morphology becomes wider and deeper and drains less steep topography. As a result, hydrological conditions are less turbulent, with run and pool habitats becoming more common. Streambank stability and channel shade decreases due to riparian vegetation modification (clearing) and wider channels. Streambed sediments change from predominantly boulders and bedrock to large cobbles, gravel and a higher proportion of fine sand/silt. The 2005/06 survey results suggest that streambank stability has worsened at Site G (Oratia catchment) and improved at Site C (Opanuku catchment) since 2003/04.

The instream habitat conditions within the lower urban catchments are characterised by wide and deep channels dominated by sluggish run and pool habitats. However, riffles and chutes have formed in channels with cascading bedrock streambeds or fibrous/woody tree roots encroaching on the wetted channel. The urban streams typically have bedrock and/or fine sand and silt streambed substrates that provide poor aquatic habitat conditions compared with the upper reaches. The Waikumete urban waterways (Sites L, M and N) are an exception and they have a greater proportion of coarse sediments including boulders, large cobbles and gravel. Streambank stability and channel shading was variable at urban sites due to local riparian vegetation conditions.

A common feature of Project Twin Streams monitoring sites is the lack of macrophytes and nuisance periphyton growths and the high proportion of organic matter in the form of detritus, bryophytes, woody debris and tree roots. Possible reasons for the lack of macrophytes and dense periphyton growths include turbid water conditions and poor light penetration, solid bedrock streambed preventing the establishment of roots, and flash floods scouring macrophytes and periphyton from the streambed. There is no difference in the relative proportions of organic matter recorded at upper, peri-urban and urban sites, due to the extensive riparian vegetation found at most stream sites (including both modified and unmodified sites). The presence of organic matter in the form of large woody debris is important for the lower urban reaches, as woody debris provides stable habitat for macroinvertebrates in these unstable soft-bottomed or smooth bedrock sections.

6. Riparian Vegetation

6.1 Opanuku Catchment

The riparian vegetation at Site A was a combination of mature and young native tree canopy providing approximately 85% channel shade (Fig. 6.1). The understorey comprised a thin native cover close to the stream and sparse vegetation with denser patches 5-20 m away from the channel (Fig. 6.2). The rural/native bush Site B riparian vegetation was similar to that recorded at Site A with a predominantly native tree canopy providing 60% shade but with a mixed native/exotic understorey. The riparian vegetation at the urban Site C has been significantly modified with a mixture of young and mature native trees providing 10% shade and an understorey comprising predominantly exotic grasses and shrubs. The riparian vegetation at Site D is highly modified consisting of scattered mature exotic trees (14%) and an exotic grass and shrub cover of variable density (50-100%).

6.2 Oratia Catchment

The Site E riparian vegetation 0-20 m away from the channel consisted entirely of native canopy species (e.g., tree fern sp. and nikau) providing complete stream shade (100%). The understorey was fairly open resulting in a thin growth of native groundcover species. Site F had a predominantly mature exotic tree (i.e., willow and poplar) and bamboo canopy adjacent to the stream providing 70% channel shade which thinned out further away from the channel and included scattered manuka and tree ferns. The understorey vegetation at Site F consisted predominantly of dense exotic grass and shrub species (82%). Site G had a modified canopy comprising of both mature and young exotic trees and scattered natives (i.e., tree ferns and cabbage trees) providing 60% shade. The understorey vegetation at Site G was predominantly dense exotic grass, willow weed, and scattered native shrubs. The industrial Site H riparian vegetation has been cleared (especially the true-right streambank) and comprises scattered young exotic trees and a dense exotic grass understorey that provides poor channel shading (10%). The riparian vegetation recorded at the urban Site I, although modified, is of a higher quality than that recorded at Sites G and H, and comprises native shrubs and trees (32%), and mature exotics (41%) that cover steep streambanks and provide 20% shade.

6.3 Waikumete Catchment

The riparian vegetation recorded at the reference bush Site J (Hibernia Stream) consisted of mature native vegetation (i.e., nikau) providing 95% shade and a thin native understorey. The vegetation at Site K (Hibernia Stream) has been modified through urbanisation but has retained a full canopy of mature and young native trees providing good shade (90%). Dense exotic vegetation covers approximately 50% of the streambanks at Site K.. The urban Sites L (Whakarino) and M (Waikumete) have a more open riparian vegetation than the upstream Sites J and K, as the channel drains through reserve areas at both sites. The canopy at Sites L and M provides 8-45% cover with a mixed exotic/native canopy cover 0-5 m away from the channel providing 30-50% shade. The downstream urban Site N (Waikumete) drains between residential housing and has a more complete canopy cover (100%) and greater understorey vegetation cover due to dense exotic weed growth. Site O (Waikumete) has modified riparian vegetation near the channel consisting of mature exotic trees (73%) and 50% mixed understorey vegetation with bare streambanks. Cabbage trees and flax plants have been planted 5-20 m away from the channel.

6.4 Swanson Catchment

A high proportion of mature native shrubs and trees in the canopy characterise the riparian vegetation, 0-20 m away from the stream channel at Swanson Stream sites throughout the catchment,. The canopy vegetation recorded at the urban sites contained a greater proportion of mature exotic trees such as willow. The understorey at the uppermost reference Site P contained a mixture of both thin and dense native understorey (i.e., ferns and cabbage trees). Unlike the canopy vegetation, the understorey

vegetation recorded at the urban Sites Q, R and S contained a greater density of exotic shrubs and grasses.

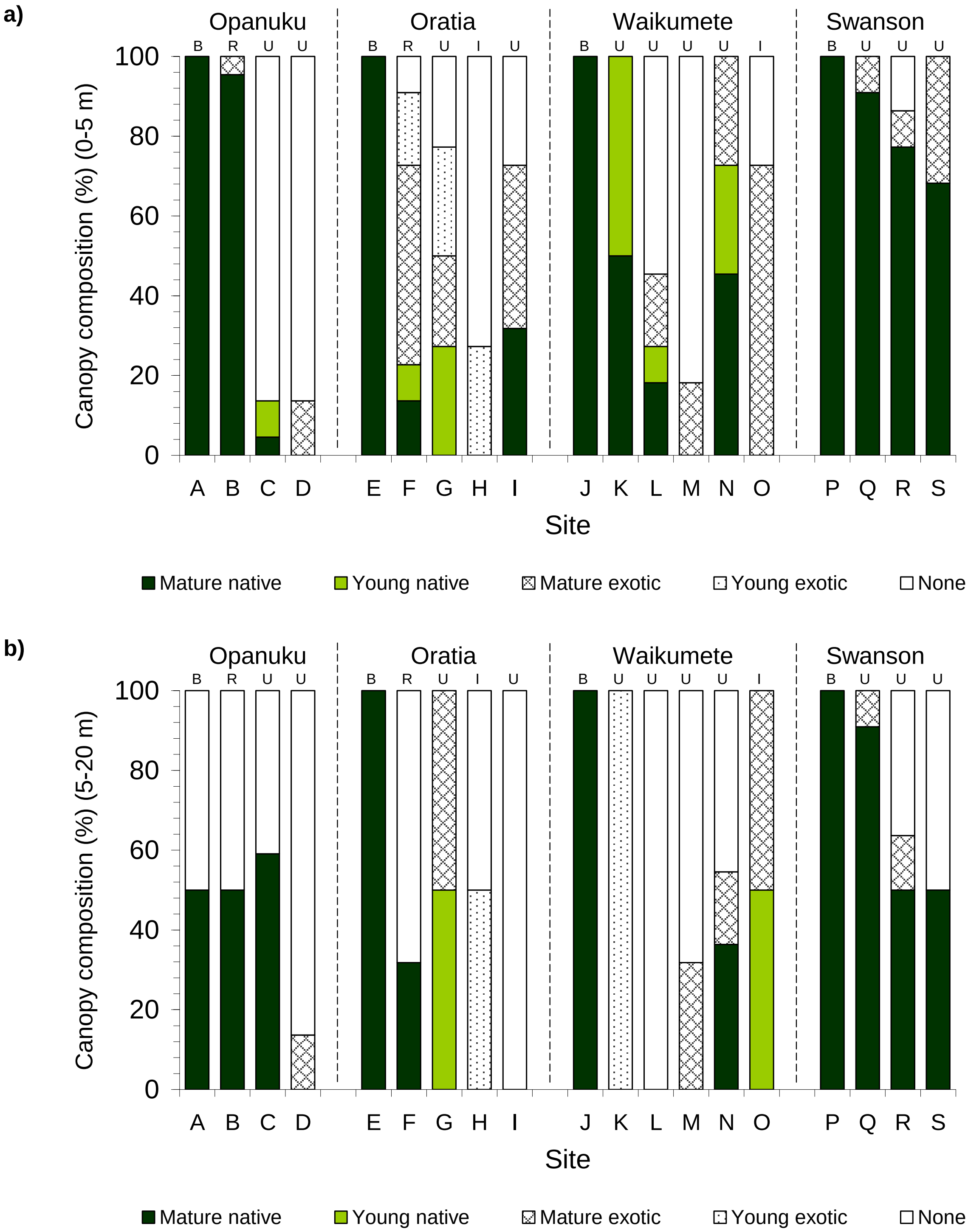


Fig. 6.1: The relative riparian canopy composition (%) recorded between a) 0-5 m and b) 5-20 m away from the stream channel at Project Twin Streams monitoring sites (B = native bush; R = rural; I = industrial; U = urban and peri-urban).

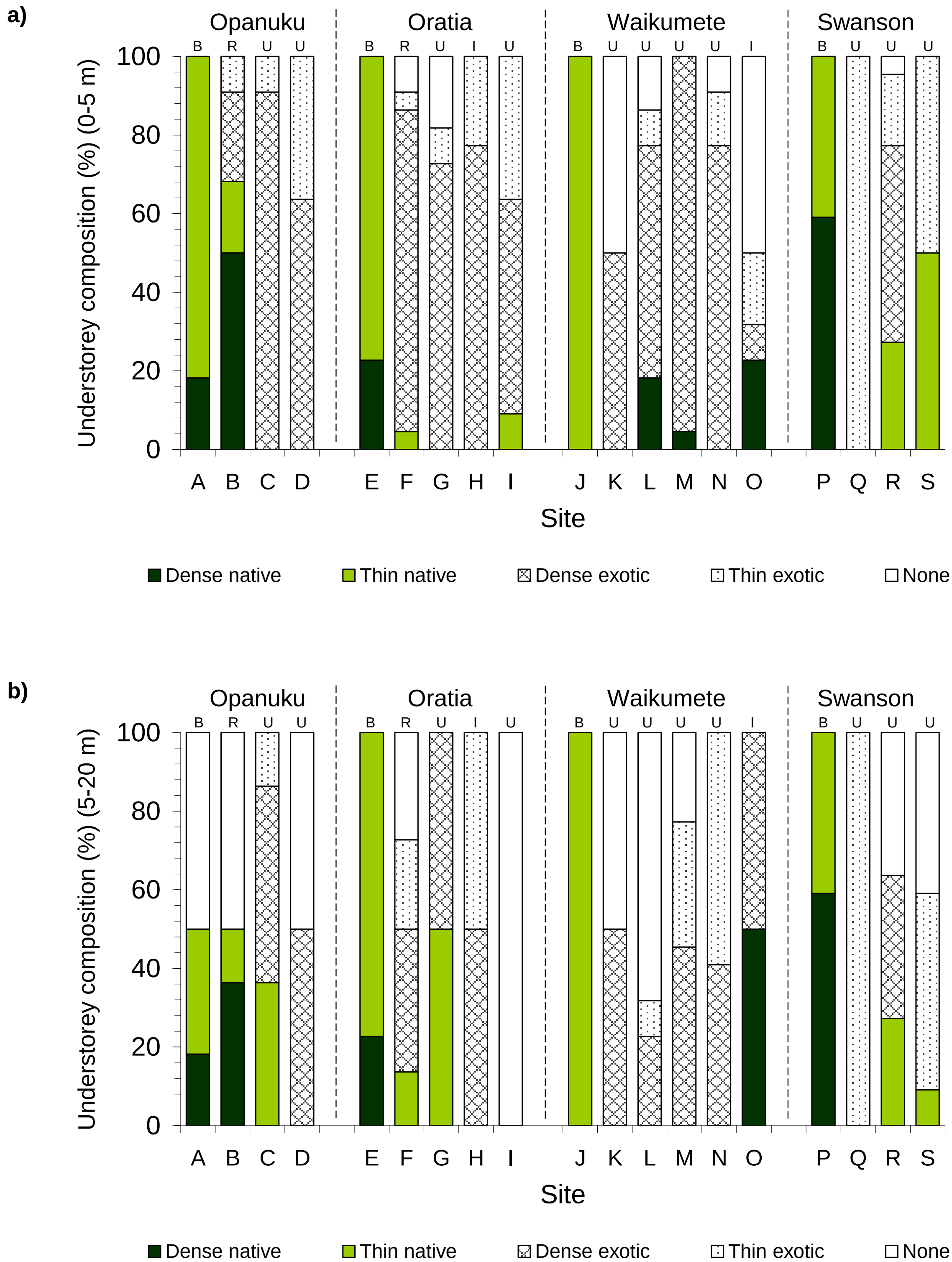


Fig. 6.2: **The relative riparian understorey composition (%) recorded between a) 0-5 m and b) 5-20 m away from the stream channel at Project Twin Streams monitoring sites (B = native bush; R = rural; I = industrial; U = urban and peri-urban).**

6.5 Summary

The Project Twin Streams monitoring sites had good quality riparian vegetation and canopy cover in the context of urban streams, which tend to have highly modified riparian vegetation. The riparian vegetation of Project Twin Streams sites generally provided good bank stability, shade, detritus and woody debris inputs, which enhances macroinvertebrate food supply and fish habitat.

The upper stream reference sites generally had a greater proportion of unmodified native canopy and understorey vegetation, and also wider riparian margins that provided complete shade. The lowermost urban sites, although modified, had a well-developed native understorey but a few native canopy species. The most modified canopy vegetation occurred in the lower Opanuku urban sites where, in a high proportion of sites, canopy vegetation was absent. The Swanson sites had the greatest proportion of native canopy vegetation throughout its catchment. The Oratia catchment had the greatest proportion of exotic canopy vegetation.

7. Macroinvertebrates

7.1 Taxonomic Richness

Overview

A total of 72 invertebrate taxa were identified from the 19 Project Twin Streams monitoring sites in 2005/06. This compares with a total of 71 taxa identified in 2003/04 from 15 sites in the Oratia, Opanuku and Waikumete catchments. An average of 18 and 17 taxa were recorded per site in 2005/06 and 2003/04, respectively. Overall, mean invertebrate taxonomic richness at the Project Twin Streams sites is greater than that found in other streams in the Auckland region, as shown in the following studies[6]:

- North Shore City: total taxa = 57; mean = 10 taxa per site (Kingett Mitchell 2001).
- Waitakere City: total taxa = 82; mean = 13 (Kingett Mitchell 2000; Allibone et al. 2001).
- Auckland urban area: total taxa = 78; mean = 10 (Kingett Mitchell 2000).
- Auckland region: total taxa = 117 in 41 sites (Stark & Maxted 2004).

The number of macroinvertebrate taxa recorded from Project Twin Streams monitoring sites in 2003/04 and 2005/06 is presented in Fig. 7.1 and discussed further under the relevant catchment headings below. The number of taxa identified from the 19 Project Twin Streams sites in 2005/06 ranged between 10 (Site J and O) and 30 taxa (Site P). This compares with a range between 8 (Site K) and 26 (Site F) taxa identified from 15 sites in 2003/04.

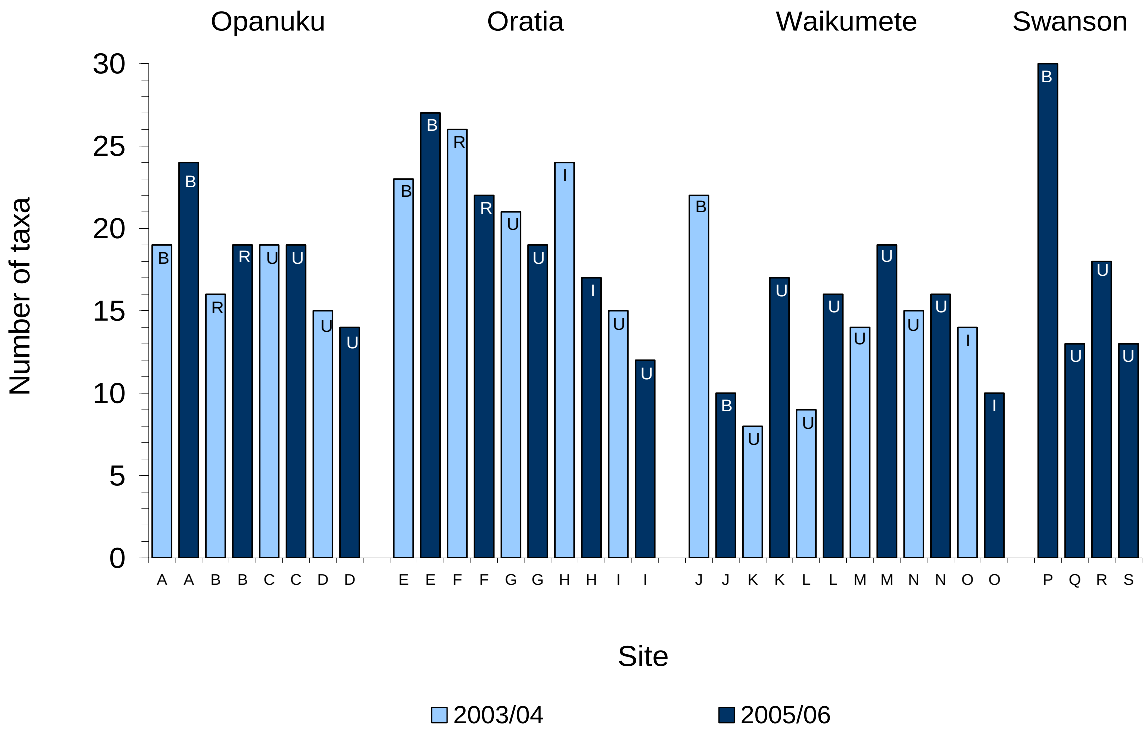


Fig. 7.1: Macroinvertebrate taxonomic richness recorded at Project Twin Streams monitoring sites for the 2003/04 and 2005/06 sampling periods (B = native bush; R = rural; I = industrial; U = urban and peri-urban).

[6] Note that these studies may have had different sampling methods and levels of taxonomic resolution; both factors that could influence taxonomic richness.

Opanuku catchment

A total of 44 taxa (mean 19 taxa per site) were identified from the four Opanuku sites in 2005/06, which was slightly greater than the total of 39 taxa (mean 17 taxa per site) recorded in 2003/04. The number of taxa identified per site in 2005/06 ranged between 14 (Site D) and 24 taxa (Site A), which is similar to the range of 12-22 taxa recorded per site in 2003/04. Taxonomic richness was greatest at the reference native bush Site A and decreased progressively with distance downstream through the rural and urban catchment. Richness was greater in 2005/06 than 2003/04 at Sites A (bush) and B (rural), but was lower at Sites C (urban) and D (urban).

Oratia catchment

A total of 46 taxa (mean of 19.taxa per site) were identified from the five Oratia sites in 2005/06, which compares with a total of 48 taxa (mean of 22 taxa per site) recorded during 2003/04. Therefore, the total and mean taxa richness was slightly lower at Oratia sites in 2005/06 than 2003/04. However, the Oratia catchment had the greatest total number and mean number of taxa recorded per site of the Project Twin Streams catchments surveyed in 2005/06. The number of taxa identified per site ranged between 12 (Sites I) and 27 taxa (Site E). This compares with a range recorded in 2003/04 of 15-26 taxa. There was a general decline in taxa richness with distance down the catchment through native bush, rural and urban landuses. Taxa richness was lower at all Oratia sites (except the bush Site E) in 2005/06 than in 2003/04. The biggest decline in taxa richness between 2003/04 and 2005/06 was recorded at Site H (from 24 to 17 taxa).

Waikumete catchment

A total of 35 taxa (mean 15 taxa per site) were recorded from the six Waikumete sites in 2005/06, which was the lowest total number recorded from the Project Twin Streams catchments during this monitoring period. The total number of taxa recorded from Waikumete sites in 2003/04 was 38 taxa (mean 14 taxa per site). The total number of taxa recorded was lower but the mean was slightly higher in 2005/06 compared with 2003/04. The number of taxa identified per site in 2005/06 ranged between 10 taxa (Sites J and O) and 19 taxa (Sites M). Sites J and O had the lowest taxonomic richness of the Project Twin Streams sites in 2005/06. Lower diversity was recorded at Sites J (bush) in 2005/06 than 2003/04 (from 22 to 10 taxa). In contrast, more taxa were recorded at the urban Sites K, L, M and N in 2005/06. The longitudinal pattern recorded across sites in 2005/06 was similar to that recorded in 2003/04 (with the exception of Site J).

Swanson catchment

A total of 44 taxa (mean 19 taxa per site) were recorded from the four Swanson sites in 2005/06. Taxa richness ranged between 13 taxa (Sites Q and S) and 30 taxa (Site P). The mean number of taxa identified from the three urban and peri-urban sites was 13 taxa. No data was collected from the Swanson catchment in 2003/04.

7.2 Community Composition

Macroinvertebrate community composition recorded at the Project Twin Streams monitoring sites in 2005/06 (and 2003/04) is presented in Figs. 7.2, 7.3, 7.4 and 7.5 and discussed below under catchment headings. Refer to Appendix 1 for complete macroinvertebrate and abundance data.

Opanuku catchment

The macroinvertebrate community recorded from Site A in 2005/06 contained equal proportions of dipterans (33%), caddisflies (Trichoptera) (32%) and molluscs (30%) (Fig. 7.2). Common taxa recorded included *Austrosimulium* blackflies, *Aoteapsyche* and *Oxyethira* caddisflies, and *Potamopyrgus* snails. The Site A community in 2005/06 differed to that of 2003/04, when dipterans (*Austrosimulium* blackflies

and chironomids) were by far the most abundant taxa (representing 73%). Sensitive Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa recorded at Site A in 2005/06 included the mayfly *Arachnocolus* and caddisflies *Olinga*, *Hydrobiosella* and *Psilochorema*. Site A was the only Project Twin Streams site in 2005/06 to contain the sensitive *Olinga* and *Hydrobiosella* caddisflies.

The mixed rural Site B and peri-urban Site C had diverse communities in 2005/06 represented by similar proportions of caddisflies (36% and 29% respectively), molluscs (21% and 25% respectively), dipterans (20% and 10% respectively), crustaceans (12% and 9% respectively) and coleopterans (4% and 13% respectively). There was an increase in the proportion of caddisflies, crustaceans and dipterans, and a decrease in the proportion of molluscs and coleopterans recorded at Sites B and C between 2003/04 and 2005/06. Abundant taxa recorded at Sites B and C in 2005/06 included *Triplectides* and *Oxyethira* (at Site B) caddisflies, *Potamopyrgus* snails, *Paratya* shrimp, and elmid beetles (at Site C). The freshwater crab *Halicarcinus* was recorded at Site C, which is of interest as this species is considered to be under increasing pressure through loss of habitat.

The community recorded from the urban Site D in 2005/06 was numerically dominated by taxa typically found in sluggish waters and included oligochaete worms and flatworms within the 'Other' category (74%). Crustaceans including *Paratya*, Tanaidacea shrimp, *Paracalliope* amphipods and ostracods represented 17%. No EPT taxa were recorded from Site D. Taxa recorded at Site D but not at upstream Opanuku sites included hemipteran bugs (*Anisops* backswimmers and *Sigara* water boatman), tanaid shrimp, ostracods and rhabdocoel worms. Dominant taxa recorded from Site D in 2003/04 (*Potamopyrgus* snails and *Paratya* shrimp) were less abundant at this site in 2005/06.

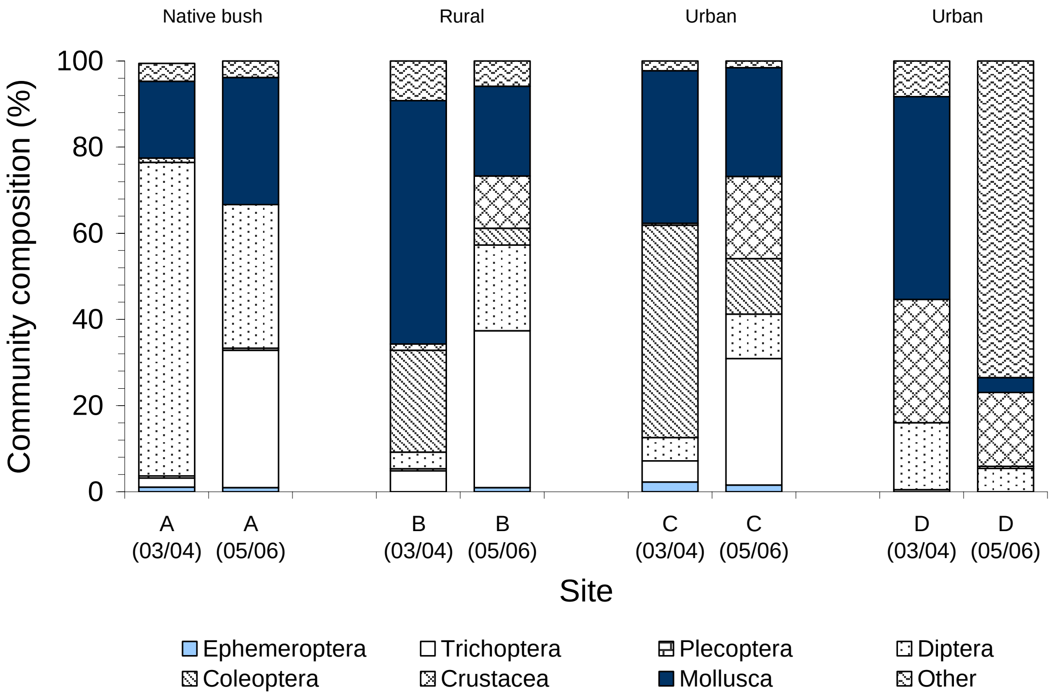


Fig. 7.2: Macroinvertebrate community composition (%) recorded at Opanuku Project Twin Streams monitoring sites in 2003/04 and 2005/06 (B = native bush; R = rural; I = industrial; U = urban and peri-urban).

Oratia catchment

The community recorded from the native bush Site E in 2005/06 contained a high proportion of sensitive EPT taxa (Fig. 7.3). Mayflies were the most abundant and diverse of the EPT groups (i.e., 8 mayfly taxa representing 63% of the community). The macroinvertebrate community recorded from Site E in 2003/04 had a similarly high proportion and diversity of mayflies (i.e., 6 mayfly taxa representing 67%). *Zephlebia*

and *Austroclima* were the most abundant mayflies in 2005/06, whilst *Deleatidium*, *Coloburiscus* and *Zephlebia* were the most abundant in 2003/04. Site E was the only Project Twin Streams site in 2005/06 containing the sensitive mayflies *Ameletopsis*, *Austronella* and *Nesameletus*. Site E was the only site containing the sensitive stonefly *Zelandoperla* and one of only two sites (the other being Site P) containing the freshwater crayfish *Paranephrops* (koura). The presence of koura at Site E is of significant interest, as koura are an iconic New Zealand species seldom found in urban streams due to a lack of hiding places, poor water quality, and the severe flash-flooding nature of urban streams fed by city stormwater networks. It is possible that koura populations in headwater streams such as Potters Stream can colonise the downstream urban sections if water and habitat quality is improved over time.

The macroinvertebrate community recorded from the rural Site F in 2005/06 contained a high proportion of caddisflies (32%). The most abundant caddisflies were *Pycnocentrodes* and *Triplectides*. Site F contained similar proportions of mayflies (18%), dipterans (18%), coleopterans (15%) and molluscs (14%) in 2005/06. In 2003/04, caddisflies were rare at Site F, representing only 1% of the community. In contrast, mayflies represented a greater proportion of the community in 2003/04 (35%) than in 2005/06 (18%). The coleopteran elmid beetle was also more abundant in 2003/04 than in 2005/06.

The urban Sites G, H and I contained a lower proportion of sensitive EPT taxa than the native bush and rural Sites E and F and contained a greater proportion of more pollution tolerant molluscs and dipterans. The peri-urban Site G community was numerically dominated by molluscs (*Potamopyrgus* snails) and was similar to the community recorded in 2003/04. Site H contained a greater proportion of dipterans (74%) and fewer molluscs (3%) in 2005/06 than in 2003/04 (38% and 40% respectively). There were fewer mayfly taxa recorded at Site H in 2005/06 (1 mayfly taxa) than in 2003/04 (5 mayfly taxa). The community at Site I contained a greater proportion of dipterans (*Polypedilum* and Orthocladiinae chironomids) in 2005/06 (representing 62%) than in 2003/04. This coincided with a decrease in the proportion of oligochaetes in 2005/06 (2%) compared with 2003/04 (37%).

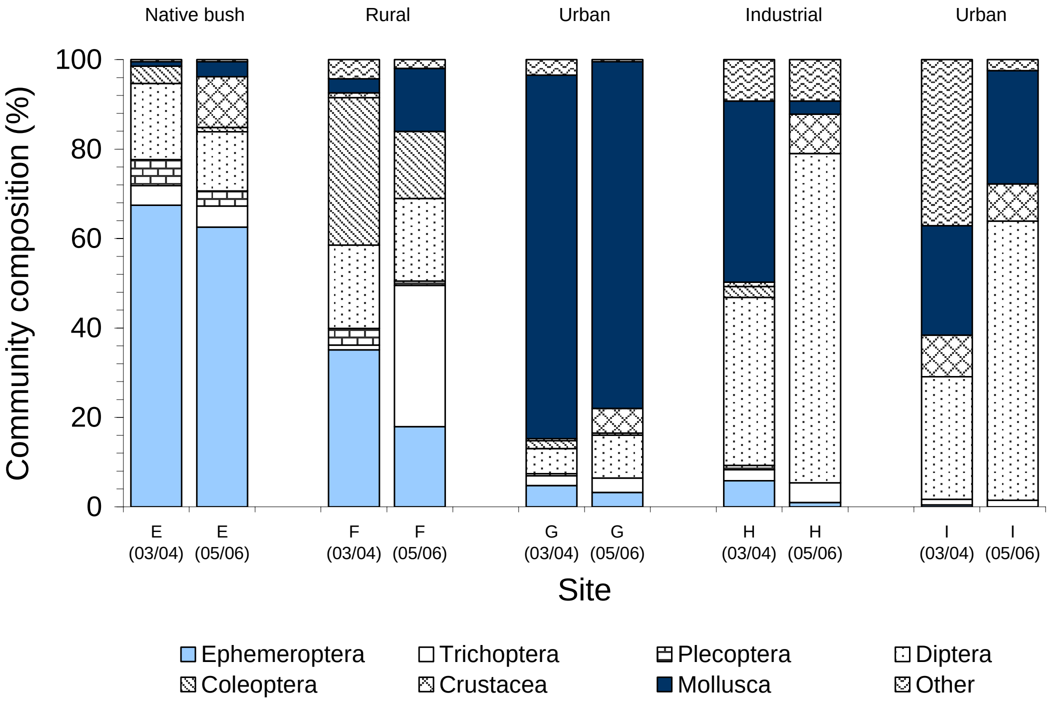


Fig. 7.3: Macroinvertebrate community composition (%) recorded at Oratia Project Twin Streams monitoring sites in 2003/04 and 2005/06 (B = native bush; R = rural; I = industrial; U = urban and peri-urban).

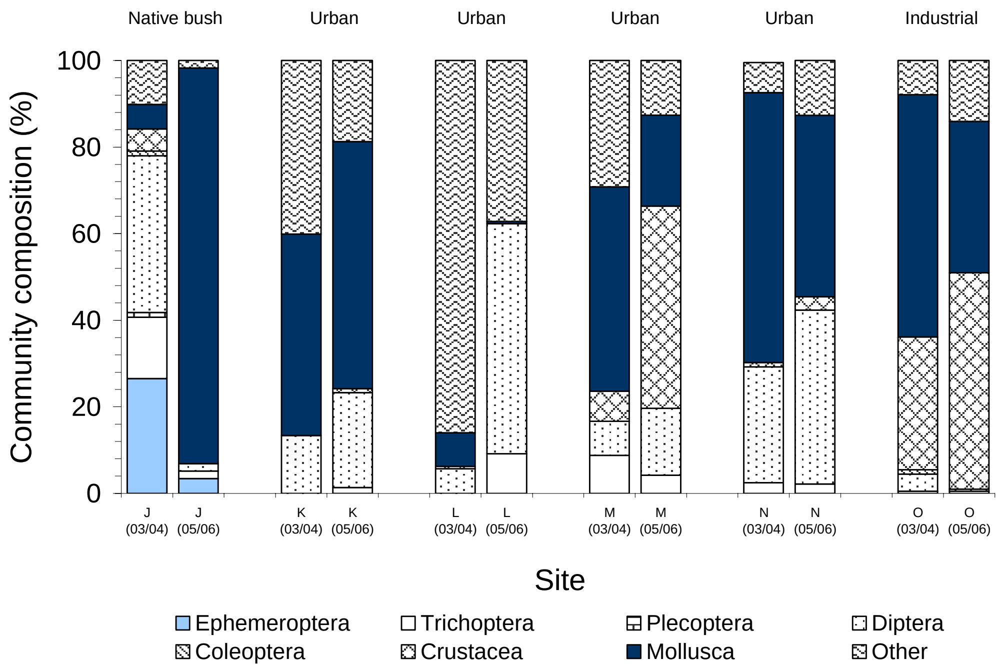


Fig. 7.4: **Macroinvertebrate community composition (%) recorded at Waikumete Project Twin Streams monitoring sites in 2003/04 and 2005/06 (B = native bush; R = rural; I = industrial; U = urban and peri-urban).**

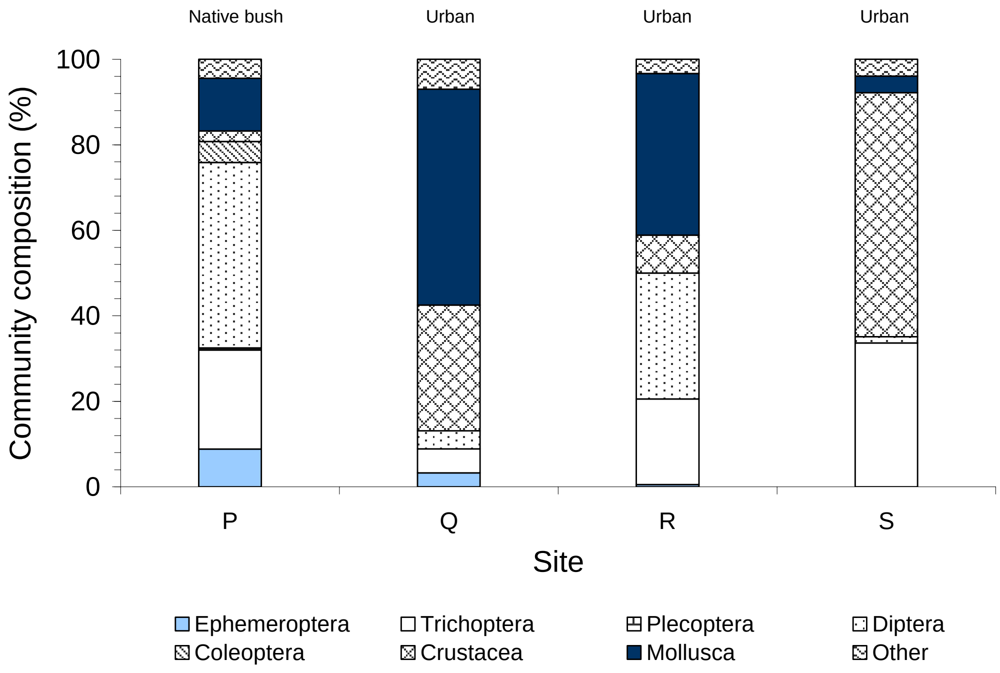


Fig. 7.5: **Macroinvertebrate community composition (%) recorded at Swanson Project Twin Streams monitoring sites in 2005/06 (B = native bush; R = rural; I = industrial; U = urban and peri-urban).**

Waikumete catchment

The invertebrate community recorded from the native bush Site J contained a significantly greater proportion of *Potamopyrgus* snails in 2005/06 (91%) than in 2003/04 (6%). The 2005/06 community was less diverse, especially with respect to the number and abundance of sensitive EPT taxa recorded (4 EPT taxa in 2005/06 compared with 9 EPT taxa in 2003/04).

The urban Site K community in 2005/06 was similar to that in 2003/04, with *Potamopyrgus* snails, chironomids and 'other' taxa (oligochaetes and *Xanthocnemis* damselflies) making up the majority of the community. Site K had low EPT taxa richness in 2003/04 (no EPT taxa) and in 2005/06 (1 EPT taxon; *Triplectides*). The urban Site L community recorded in 2005/06 contained a greater proportion of dipterans (53%) than in 2003/04 (6%). Dipterans were also the most diverse group in 2005/06 with 9 dipteran taxa recorded. The most common dipterans recorded in 2005/06 were Orthocladiinae and *Polypedilum* chironomids. The pursed caddis *Oxyethira* was not recorded in 2003/04 but represented 9% of the community in 2005/06. The presence of *Oxyethira* and a diverse dipteran community indicates a possible increase in nutrient enrichment at Site L since 2003/04.

The urban Site M community was more diverse in 2005/06 (19 taxa) than in 2003/04 (14 taxa). Crustaceans represented a greater proportion of the community in 2005/06 (47%) than in 2003/04 (7%). A greater proportion of crustaceans in 2005/06 corresponded with a decrease in the proportion of molluscs (from 47% to 21%) and 'other' taxa (from 29% to 13%). The most abundant crustacean taxa recorded in 2005/06 were *Paracalliope* amphipods. *Potamopyrgus* snails were less abundant in 2005/06 than in 2003/04, but were still the most abundant mollusc taxa recorded. Oligochaetes were also less abundant in 2005/06 than in 2003/04. The majority of dipterans recorded were chironomids (Orthocladiinae, *Polypedilum*, *Chironomus*, and Tanytarsini). The combined abundance of *Triplectides* and *Oxyethira* caddisflies represented 4% of the Site M community in 2005/06 as opposed to 9% in 2003/04.

The urban Site N and industrial Site O communities recorded in 2005/06 were similar to their 2003/04 communities. Site N was dominated by pollution tolerant dipterans (Orthocladiinae and *Polypedilum*; 40%) and molluscs (*Potamopyrgus*, *Physella* and *Gyraulus* snails; 42%). Site O was similarly dominated by pollution tolerant taxa including crustaceans (*Paracalliope*; 50%) and molluscs (*Potamopyrgus* and *Physella*; 35%). The presence of *Physella* and *Gyraulus* snails at Sites N and O is significant as these species are usually found in highly degraded or near-stagnant water. *Triplectides* caddisflies and *Halicarcinus* freshwater crabs were recorded at Sites N and O in 2005/06 but not in 2003/04.

Swanson catchment

The macroinvertebrate community recorded from the native bush Site P was the most diverse of the four Swanson sites and was numerically dominated by dipterans (43%) and caddisflies (23%). The dipteran fauna was diverse with 10 taxa. The majority of dipterans were dixid midges (*Paradixa*), Empididae and *Austrosimulium* blackflies. Although four chironomid (Diptera) species typical of enrichment were recorded, numbers were low, indicating Site P was not affected by organic enrichment or pollution, or a lack of suitable habitat. EPT taxonomic richness was high at Site P, with 11 EPT taxa represented by 4 mayfly taxa, 6 caddisfly taxa and a single stonefly taxon. Sensitive EPT taxa (i.e., with MCI scores ≥8) recorded at Site P included the mayflies *Arachnocolus*, *Austroclima*, *Coloburiscus*, the caddisflies *Orthopsyche* and *Polyplectropus*, and the stonefly *Austroperla*. Other taxa recorded at Site P included koura, *Archichauliodes*, elmid beetles, *Latia* limpets, *Potamopyrgus* snails, *Paratya* shrimp and koura.

Macroinvertebrate communities recorded from the urban Sites Q, R and S were numerically dominated by pollution tolerant molluscs (between 4-50%), crustaceans (between 9-57%) and dipterans (1-29%). There was a progressive decrease in EPT taxa richness with distance downstream between Sites Q, R and S (from 6 to 0 EPT taxa). Lower EPT diversity did not correspond with a decrease in %EPT as the relative proportion of caddisflies increased between Sites Q (6%) and S (34%). The increase in the proportion of caddisflies was due to higher numbers of *Triplectides* recorded at Site R and the pollution tolerant *Oxyethira* at Site S. There was a progressive decrease in the proportion of molluscs (mostly *Potamopyrgus* snails) between Sites Q (50%), R (38%) and S (4%). The most abundant crustacean

recorded at Sites Q, R and S were *Paracalliope* amphipods. High amphipod abundance corresponded with low dipteran abundance at Sites Q, R and S. Site R had relatively high dipteran diversity compared with Sites Q and S (8 dipteran taxa compared with 3 at Sites Q and S). Other taxa recorded at Sites Q, R and S included pollution tolerant or still-water taxa such as *Xanthocnemis* damselflies, *Microvelia* (bug), *Paratya* shrimp, mites, *Lymnaea* snails, oligochaetes, flatworms, nemerteans and hydroids.

7.3 Biological Indices

Biological index values recorded at Project Twin Streams monitoring sites in 2005/06 (and 2003/04) are presented in Figs. 7.6 (MCI), 7.7 (QMCI), 7.8 (EPT) and 7.9 (%EPT) and discussed below under catchment headings. Refer to Table 3.1 for interpretation of MCI and QMCI values.

Opanuku catchment

The MCI values recorded from the Opanuku sites ranged between 77 (Site D) and 96 (Site A) (Fig. 7.6). This compares with a range between 72 (Sites D) and 91 (Site C) recorded in late summer 2003/04. The MCI values were higher in 2005/06 than 2003/04 at Sites A and D, but lower at the urban Sites B and C. There was a general decline in MCI values with distance downstream as was similarly recorded in 2003/04. The MCI values did not indicate a decline in water and habitat quality at Opanuku sites between 2003/04 and 2005/06.

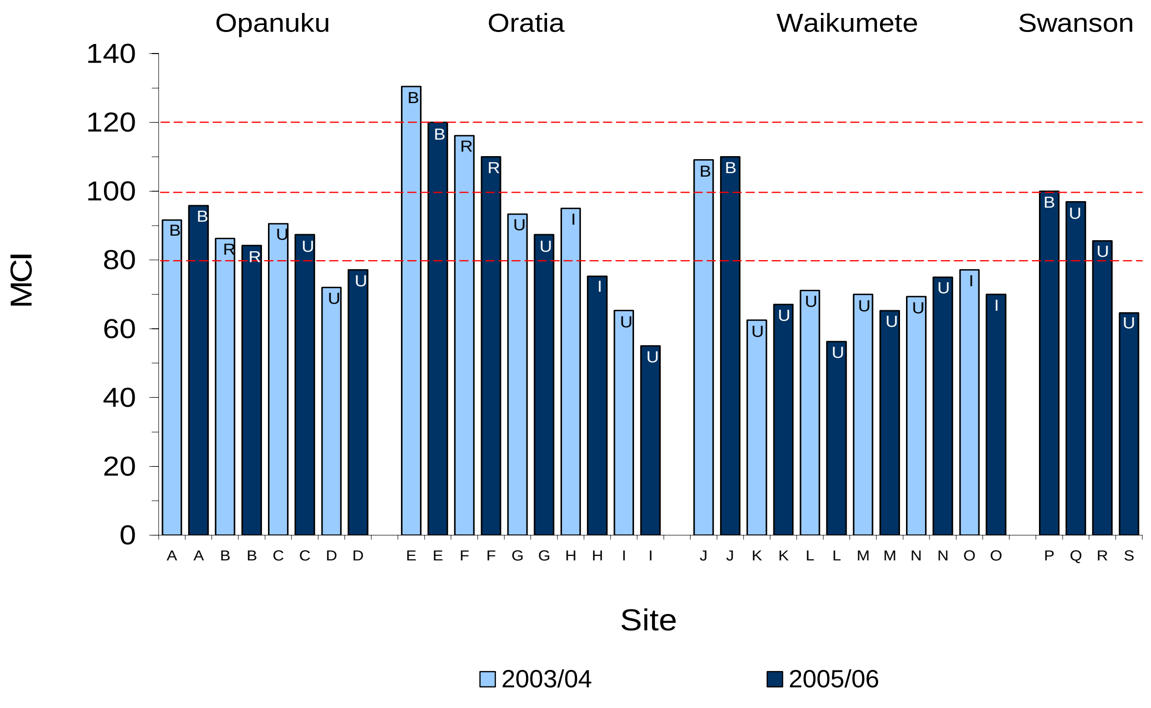


Fig. 7.6: MCI values recorded at Project Twin Streams monitoring sites for the 2003/04 and 2005/06 sampling periods (B = native bush; R = rural; I = industrial; U = urban and peri-urban).

The 2005/06 QMCI and MCI values show a different longitudinal trend along the catchment. QMCI values ranged between 2.2 (Site D) and 4.6 (Site C) in 2005/06 and between 3.1 (Site A) and 5.1 (Site C) in 2003/04 (Fig. 7.7). QMCI values were lower at all Opanuku sites except the reference Site A in 2005/06 than in 2003/04. The greatest decrease in QMCI values was recorded at Sites B and C. There was an indicative decline in water and habitat quality from fair to poor quality at Site B and a decline from good to fair quality at Site C. Although QMCI values were generally lower in 2005/06, the longitudinal trend across sites was similar to that recorded in 2003/04, thus indicating a possible catchment-wide

influence affecting macroinvertebrate communities (e.g., catchment landuse) between 2003/04 and 2005/06.

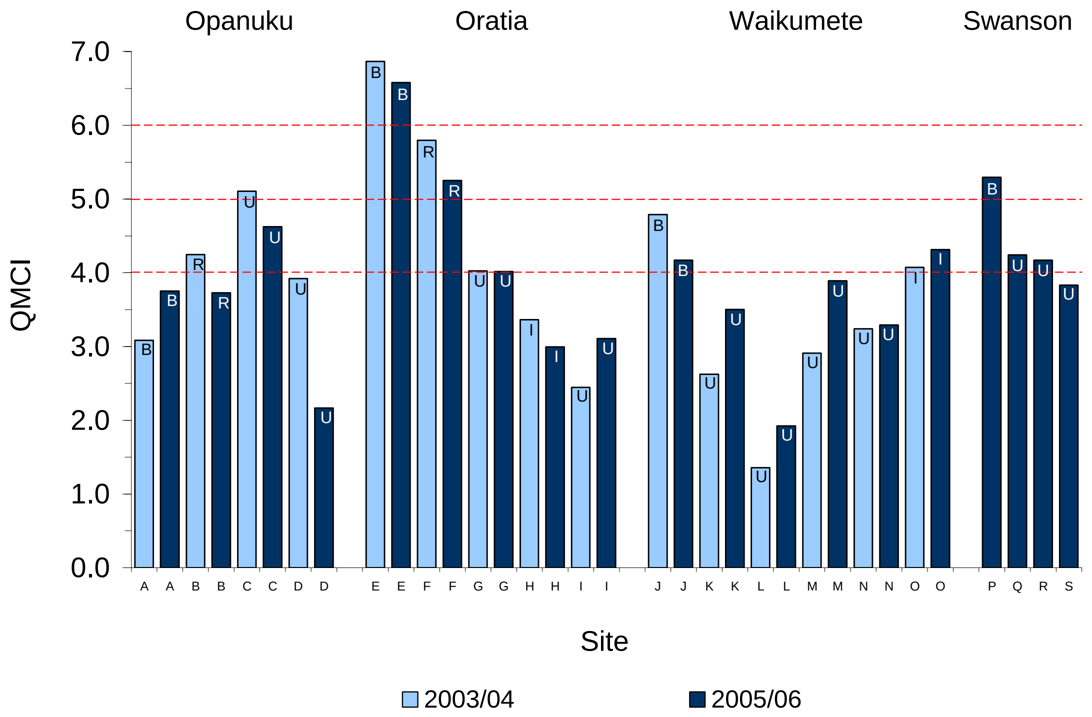


Fig. 7.7: **QMCI values recorded at Project Twin Streams monitoring sites for the 2003/04 and 2005/06 sampling periods (B = native bush; R = rural; I = industrial; U = urban and peri-urban).**

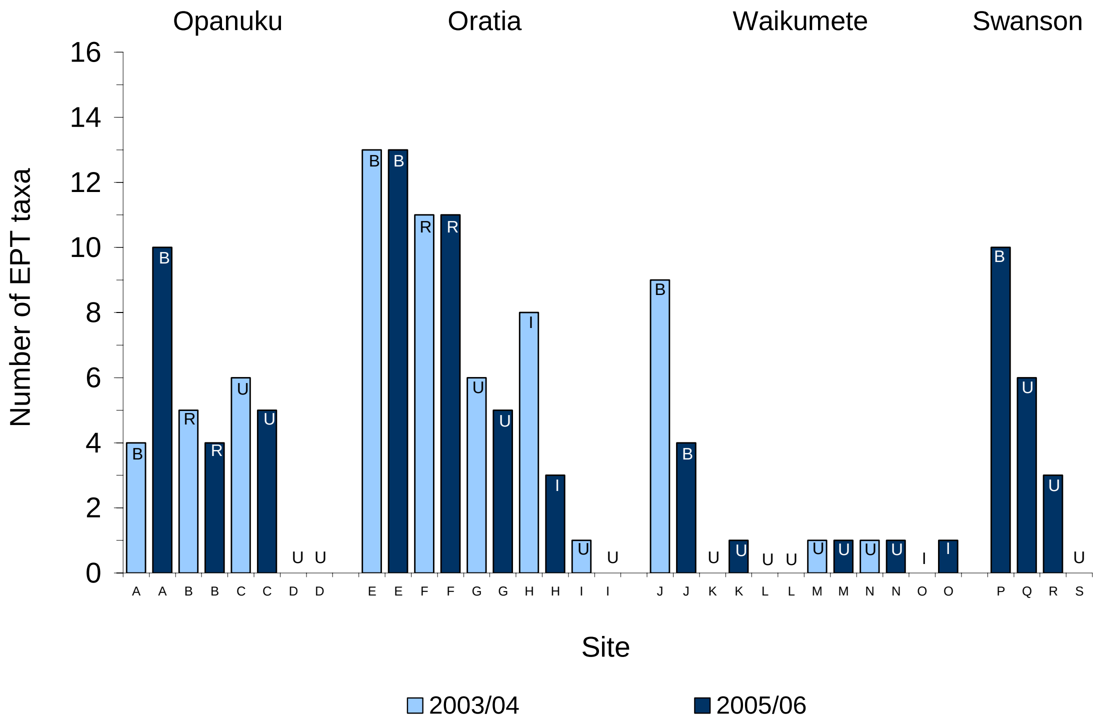


Fig. 7.8: **Number of EPT taxa recorded at Project Twin Streams monitoring sites for the 2003/04 and 2005/06 sampling periods (B = native bush; R = rural; I = industrial; U = urban and peri-urban).**

The number of sensitive EPT taxa recorded at Opanuku sites in 2005/06 ranged between 0 (Site D) and 10 (Site A) EPT taxa (Fig. 7.8). Fewer EPT taxa were recorded in 2003/04 (maximum of 6 EPT taxa at Site C). The majority of the EPT taxa recorded in 2005/06 and 2003/04 were caddisflies. However, there were fewer EPT taxa recorded at the rural Site B and urban Site C in 2005/06 than in 2003/04. Although EPT taxa richness was lower at Sites B and C in 2005/06, EPT taxa made up a significantly greater proportion of their respective communities in 2005/06 (17% and 31% respectively) than 2003/04 (4% and 7% respectively) (Fig. 7.9).

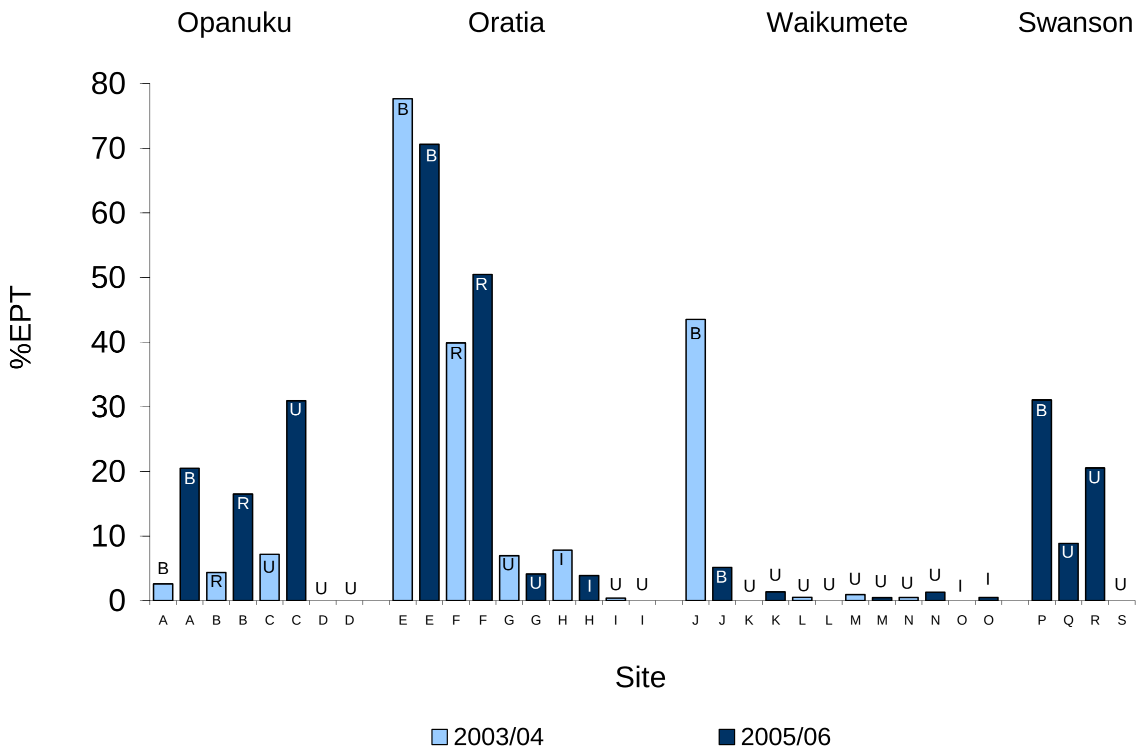


Fig. 7.9: **%EPT taxa recorded at Project Twin Streams monitoring sites for the 2003/04 and 2005/06 sampling periods (B = native bush; R = rural; I = industrial; U = urban and peri-urban).**

Oratia catchment

The MCI values recorded at Oratia sites in 2005/06 ranged between a relatively low 55 at the lowermost urban Site I and 120 at the uppermost native bush Site A. The Oratia catchment had the greatest range in MCI values recorded of the Project Twin Streams catchments in both 2003/04 and 2005/06. There was a general decrease in MCI values with distance downstream from pristine conditions in the upper catchment through good (Site F), fair (Site G) and poor conditions in the lower urban catchment (Sites H and I). The longitudinal trend in MCI values recorded in 2005/06 was similar to that recorded in 2003/04. Of interest was that MCI values at all Oratia sites were lower in 2005/06 than 2003/04.

The QMCI and MCI values showed a similar longitudinal trend with both indices decreasing progressively with distance downstream. As with the MCI values, QMCI values recorded at Oratia sites were generally lower in 2005/06 than in 2003/04 (the exception being the lowermost Site I).

The number of sensitive EPT taxa recorded at Oratia sites ranged between 0 (Site I) and 13 EPT taxa (Site E). The number of EPT taxa recorded at sites decreased progressively with distance downstream. The biggest loss of EPT taxa occurred between the rural Site F (11 EPT taxa) and the first downstream urban Site G (5 EPT taxa) due to the loss of caddisfly and stonefly taxa. This also corresponded with a decline in %EPT from 50% (Site F) to 4% (Site G). EPT taxa richness was lower at all Oratia sites in 2005/06 compared with 2003/04. The biggest decline in the number of EPT taxa recorded per site

between 2003/04 and 2005/06 occurred at Site H (from 8 to 3 EPT taxa) due to a loss of mayfly taxa (from 5 to 1 mayfly taxa). The %EPT was lower at all Oratia sites except Site F in 2005/06 than 2003/04. The %EPT recorded at Site F increased from 40% (2003/04) to 50% (2005/06) due to an increase in the number of *Triplectides* and *Pycnocentrodes* caddisflies, and *Austroclima* mayflies recorded.

Waikumete catchment

The MCI values recorded at Waikumete sites in 2005/06 ranged between 56 (urban Site L) and 110 at the native bush Site J. There was a significant decrease in MCI values between Site J (110) and the first downstream urban Site K (67), which indicates a significant decline in water and habitat conditions between these sites (from good to poor quality). All sites below and including Site K had MCI values indicative of poor water and habitat quality and severe organic enrichment.

The Waikumete QMCI values showed a slightly different longitudinal trend to the MCI values. The decline in QMCI values between Sites J (4.2) and K (3.5) was not as wide as for the MCI values. The highest QMCI value in 2005/06 was recorded at the lowermost urban Site O (4.3). The low QMCI value recorded at Site L (1.4) was the lowest value recorded from Project Twin Stream sites in 2005/06. Unlike the MCI values, QMCI values recorded at all urban Waikumete sites (between Sites K and O) were higher in 2005/06 than 2003/04. There was a decline in indicative water and habitat quality conditions at the upper bush Site J between 2003/04 and 2005/06 from good to fair, but an improvement at Site O from poor to fair resulting from a greater abundance of some higher scoring taxa.

The number of EPT taxa recorded from Waikumete sites in 2005/06 was low (between 1-4 EPT taxa) and lowest of the monitored Project Twin Streams catchments. There was a significant decline in the number and abundance of EPT taxa recorded at the uppermost native bush Site J from 9 EPT taxa (representing 44%) in 2003/04 to 4 EPT taxa (representing 5%) in 2005/06. No mayflies and stoneflies were recorded from the urban Waikumete sites. The only sensitive EPT taxa recorded at urban sites was *Triplectides* caddisflies in low abundances (less than 3 individuals per site).

Swanson catchment

The MCI values recorded from the Swanson sites in 2005/06 ranged between 65 at the lowermost Site S and 100 from the upper native bush Site P. The MCI values for Sites P, Q and R were indicative of fair to poor water quality and habitat conditions. The lowermost Site S had significantly lower MCI scores than recorded from the upstream sites, and was indicative of poor water quality and habitat conditions. Apart from the QMCI value for Site P (5.3) indicating good environmental conditions, the QMCI values at other Swanson sites were indicative of similar water and habitat quality as suggested by the MCI values. The high QMCI value for Site P was due to the relatively high abundance of *Orthopsyche* (MCI score = 9) caddisflies and *Arachnocolus* (MCI = 8) mayflies.

There was a progressive decline in the number of EPT taxa recorded at Swanson sites with distance downstream. Greatest EPT taxa richness was recorded at Site P (4 mayfly, 6 caddisfly and a single stonefly taxa). No sensitive EPT taxa were recorded at the lowermost urban Site S. The relative abundance of EPT taxa ranged between 31% (Site P) and zero (Site S), with caddisflies the most abundant of the sensitive EPT groups.

7.4 Summary

The mean number of macroinvertebrate taxa recorded from the Project Twin Streams monitoring sites in 2003/04 and 2005/06 was similar, and is greater than average for catchments within the Auckland region. The mean number of taxa recorded per site was greater in 2005/06 than 2003/04 at Opanuku and Waikumete sites but lower at Oratia sites. Taxonomic richness was greatest at native bush reference sites and generally decreased with distance down the catchment through rural/peri-urban to urban/industrial landuses.

Macroinvertebrate communities recorded from the upper native bush and rural sites within the Opanuku, Oratia and Swanson catchments were diverse and contained a high number and proportion of sensitive EPT taxa (i.e., mayflies and caddisflies). The high proportion of EPT taxa recorded from headwater reaches will provide an important source of colonisers to downstream reaches. In contrast, *Potamopyrgus* snails numerically dominated the upper Waikumete reference site community. Of significant interest was the presence of koura at the upper Oratia and Swanson sites. These populations of koura may provide a source of colonisers to downstream sections if environmental conditions improve over time.

Macroinvertebrate communities recorded from the urban sites contained fewer EPT taxa and a greater proportion of taxa typically associated with sluggish and degraded habitats (i.e., chironomids, snails, oligochaetes, amphipods). An increase in the proportion of pollution tolerant dipterans at the urban Sites H (Oratia), I (Oratia), L (Waikumete) and oligochaetes at Site D (Opanuku) since 2003/04 may indicate a degradation of water or habitat quality at these sites. However, the only urban sites where biological indices indicated a decline in water/habitat quality since 2003/04 were Sites H (MCI change from fair to poor quality) and C (QMCI change from good to fair quality). Based on invertebrate index scores, there was no overall improvement in water quality or habitat in 2005/06 compared to 2003/04.

8. Conclusions

This report presents results from the second round of aquatic ecological monitoring of Project Twin Streams monitoring sites. During early and late summer 2003/04, 15 sites within the Opanuku and Oratia catchments (including the Waikumete sub-catchment) were surveyed for the first time as part of Project Twin Streams. In 2005/06, the aquatic ecology at all 15 existing sites plus an additional four located within the Swanson Stream catchment were re-surveyed. Water and sediment quality monitoring of Project Twin Streams catchments has also been undertaken in 2005/06 with results presented in separate reports. The following summarise the ecological component of the Project Twin Streams programme in 2005/06 and changes since 2003/04:

- The Opanuku, Oratia and Swanson catchments have a relatively low proportion of impervious surface areas (between 10-17%). The Waikumete catchment has a greater proportion of impervious surface areas (32%).
- The upper reaches of the Project Twin Streams catchments are relatively unmodified and have moderate to high ecological values. A common feature of the upper catchments is complete channel shading and the diverse hydrological conditions provided by native bush. No significant changes in aquatic habitat quality were recorded at reference sites since 2003/04.
- The rural, peri-urban and urban-bush stream sections are wider, deeper and drain less steep topography than the upper reaches. Hydrological conditions are less diverse (i.e., predominantly more runs/pools) and there is a greater proportion of fine sands/silt. Streambank stability and channel shade decreases downstream due to riparian vegetation modification. Streambank stability had decreased at Site G (Oratia) but improved at Site C (Opanuku) since 2003/04.
- Instream habitat conditions within the lower urban catchments are characterised by homogeneous wide and deep channels containing sluggish run/pool habitats and bedrock and/or fine sand/silt streambed sediments that provide relatively poor aquatic habitat. Streambank stability and channel shading is variable between urban catchments and sites due to localised differences in channel morphology and riparian vegetation characteristics. Riparian vegetation has an important functional role within the urban Project Twin Streams catchments and provides valuable shade, woody debris inputs and streambank stability to many of the urban sites.
- Macrophytes and dense periphyton growths are uncommon within the Project Twin Streams catchments, possibly due to turbid water conditions and poor light penetration, solid bedrock streambeds in the lower catchments preventing the establishment of roots, and flash floods scouring macrophytes and periphyton from the streambed.
- Project Twin Streams catchments generally contain a high proportion of coarse organic matter in the form of detritus, bryophytes, woody debris and tree roots from the extensive riparian vegetation throughout the catchments. Large woody debris provides important habitat and food for macroinvertebrates within the lower urban reaches, which have unstable soft-bottomed or smooth bedrock streambed substrates that do not provide ideal habitat.
- The average number of macroinvertebrate taxa recorded from Project Twin Streams monitoring sites in 2003/04 and 2005/06 was similar and greater than average for catchments within the Auckland region.
- The mean number of taxa recorded per site was greater in 2005/06 than 2003/04 at Opanuku and Waikumete sites but lower at Oratia sites. Taxonomic richness was greatest at native bush reference sites and generally decreased with distance down the catchments through rural/peri-urban to urban/industrial landuses.
- Macroinvertebrate communities recorded from the upper native bush and rural sites within the Opanuku, Oratia and Swanson catchments were diverse and contained a high number and proportion of sensitive EPT taxa (i.e., mayflies and caddisflies). In contrast, *Potamopyrgus* snails numerically dominated the upper Waikumete reference site community.
- Koura recorded from the upper Oratia (Potters Stream) and Swanson catchments was significant as koura are an iconic New Zealand species seldom found in urban streams due to a lack of hiding places, poor water quality, and the severe flash-flooding nature of urban streams fed by city

stormwater networks. It is possible that koura populations in these headwater catchments will colonise the downstream urban catchments if water and habitat conditions improve over time.

- Macroinvertebrate communities recorded from the urban catchments contained fewer EPT taxa and a greater proportion of taxa typically associated with sluggish and degraded habitats (i.e., chironomids, snails, oligochaetes, amphipods).
- An increase in the proportion of pollution tolerant dipterans at the urban Sites H (Oratia), I (Oratia), L (Waikumete), and oligochaetes at Site D (Opanuku) since 2003/04 may indicate degradation of water or habitat quality at these sites. However, the only urban sites where biological indices indicated a decline in water/habitat quality since 2003/04 were Sites H (MCI change from fair to poor quality) and C (QMCI change from good to fair quality).
- No indicative improvements in water quality or habitat based on biological indices were recorded within the Project Twin Streams catchment since 2003/04.

9. References

Allibone, R.; Horrox, J.; Parkyn, S. 2001: Stream classification and instream objectives for Auckland's urban streams. A report prepared for Auckland Regional Council. NIWA Client Report ARCC00257, May 2001.

ARC 2002: Revised ARC habitat assessment field sheets. ARC, September 2002.

Arnold, C. L. Jnr.; Gibbons, C. J. 1996: Impervious surface coverage the emergence of a key environmental indicator. Journal of the American Planning Association 62 243-258.

Boothroyd, I. K. G.; Stark, J. D. 2000: Use of invertebrates in Monitoring In: New Zealand Stream Invertebrates: Ecology and implications for management. Collier, K. & Winterbourn, M. J. eds. New Zealand Limnological Society, Christchurch. Pp. 344-373.

EVA 2003a: Project Twin Streams. Part II: aquatic monitoring programme. Prepared for Ecowater Solutions, Waitakere City Council May 2003 by: Enviro-Venture Ltd, Diffuse Sources Ltd and Kingett Mitchell Ltd. May 2003.

EVA 2003b: Project Twin Streams. Part I: Pressure, State, Response investigation – aquatic environment. Prepared for Ecowater Solutions, Waitakere City Council May 2003 by: Enviro-Venture Ltd, Diffuse Sources Ltd and Kingett Mitchell Ltd. May 2003.

Kingett Mitchell 2000: Comprehensive Urban Stormwater Management Action Strategy - Preliminary Receiving Environment Study. A report prepared for Waitakere City Council, March 2000.

Kingett Mitchell 2001: Ecological characteristics and ecosystem objectives for North Shore City streams. A report prepared for North Shore City Council, August 2001.

Lenat, D. R. 1988: Water quality assessment of streams using a qualitative collection method for benthic invertebrates. Journal of the North American Benthological Society 7: 222-233.

Reeves, P.; Collier, K.; Suren, A. 2004: Aquatic and riparian vegetation of rivers and streams. In: Harding, J. S.; Mosely, M. P.; Pearson, C. P.; Sorrel, B. K. eds. Freshwaters of New Zealand. New Zealand Hydrological Society Inc. and New Zealand Limnological Society Inc., Christchurch, New Zealand. Pp 14.1-14.16.

Schueler, T. R.; Claytor, D.; Zielinski, J. 1999: Better design as a stormwater management practice. Proceedings of the comprehensive stormwater and aquatic ecosystem management conference, February 22-26, Auckland. New Zealand Wastes and Water Association, Auckland. Pp. 11-23.

Schueler, T. R. 1994: The importance of imperviousness. Watershed Protection techniques 1 100-111.

Stark, J. D. 1993: Performance of the macroinvertebrate community index: effects of sampling methods, sample replication, water depth, current velocity and substratum on index values. New Zealand Journal of Marine and Freshwater Research 27: 463-478.

Stark, J. D.; Boothroyd, I. K. G.; Harding, J. S.; Maxted, J. R.; Scarsbrook, M. R. 2001: Protocols for sampling macroinvertebrates in wadeable streams. New Zealand Macroinvertebrate Working Group Report No. 1. Prepared for the Ministry for the Environment.

Stark, J. D.; Maxted, J. R. 2004: Macroinvertebrate Community Indices for Auckland's soft bottomed streams and applications to SOE reporting. Prepared for Auckland Regional Council, December 2004.

Suren, A.; Elliot, E. 2004: Impacts of urbanization on streams. In: Harding, J. S.; Mosely, M. P.; Pearson, C. P.; Sorrel, B. K. eds., 2004. Freshwaters of New Zealand. New Zealand Hydrological Society Inc. and New Zealand Limnological Society Inc., Christchurch, New Zealand. Pp 35.1-35.18.

Winterbourn, M. J. 2004: Stream invertebrates. In: Harding, J. S.; Mosely, M. P.; Pearson, C. P.; Sorrel, B. K. eds. Freshwaters of New Zealand. New Zealand Hydrological Society Inc. and New Zealand Limnological Society Inc., Christchurch, New Zealand. Pp 16.1-16.14.

Macroinvertebrate Sample Results, March 2006, KML, Twin Streams

Taxa	MCI score	MCI-sb score	Site A	Site B	Site C	Site D	Site E	Site F	Site G	Site H	Site I	Site J	Site K	Site L	Site M	Site N	Site O	Site P	Site Q	Site R	Site S
Mayfly *Acanthophlebia*	5	9																			
Mayfly *Ameletopsis*	10	10					1														
Mayfly *Arachnocolus*	8	8		1			5		p									7			
Mayfly *Atalophlebioides*	9	9																			
Mayfly *Austroclima*	9	6					23	13	1			1						1	4		
Mayfly *Austronella*	7	5					6														
Mayfly *Coloburiscus*	9	8	1				1	1										1			
Mayfly *Deleatidium*	8	6					6	7													
Mayfly *Ichthybotus*	8	8																			
Mayfly *Mauiulus*	5	4																			
Mayfly *Neozephlebia*	7	7										1									
Mayfly *Nesameletus*	9	9					1														
Mayfly *Oniscigaster*	10	10																			
Mayfly *Rallidens*	9	5																			
Mayfly *Zephlebia*	7	8	1	1	3		89	16	5	2		4						9	3	1	
Stonefly *Acroperla*	5	5																			
Stonefly *Austroperla*	9	9					5											1			
Stonefly *Cristaperla*	8	8																			
Stonefly *Megaleptoperla*	9	7																			
Stonefly *Spaniocerca*	8	8																			
Stonefly *Stenoperla*	10	10																			
Stonefly *Taraperla*	7	7																			
Stonefly *Zelandobius*	5	6	p					2													
Stonefly *Zelandoperla*	10	9					2														
Caddisfly *Alloecentrella*	9	9																			
Caddisfly *Aoteapsyche*	4	6	24		19			6	p	1								2			
Caddisfly *Beraeoptera*	8	8																			
Caddisfly *Confluens*	5	5																			
Caddisfly *Costachorema*	7	7	5															1			
Caddisfly Ecnomidae	8	8																	1	1	
Caddisfly *Edpercivalia*	9	9																			
Caddisfly *Helicopsyche*	10	8																			
Caddisfly *Hudsonema*	6	7			2																
Caddisfly *Hydrobiosella*	9	9	1																		
Caddisfly *Hydrobiosis*	5	6	1		3			5											1		
Caddisfly *Hydrochorema*	9	9																			
Caddisfly *Neurochorema*	6	5						5													
Caddisfly *Oecetis*	4	7																			
Caddisfly Oeconesidae	9	6																			
Caddisfly *Olinga*	9	8	4																		
Caddisfly *Orthopsyche*	9	7					2											36			
Caddisfly *Oxyethira*	2	2	27	43					5	3	3			19	8	2		3			69
Caddisfly *Paroxyethira*	2	4																			
Caddisfly *Philorheithrus*	8	8																			
Caddisfly *Plectrocnemia*	8	8																			

Caddisfly *Polyplectropus*	8	8					6					3						4	p		
Caddisfly *Psilochorema*	8	7	2					1													
Caddisfly *Pycnocentrella*	**9**	**9**																			
Caddisfly *Pycnocentria*	7	7																			
Caddisfly *Pycnocentrodes*	5	5		2				25													
Caddisfly *Tiphobiosis*	**6**	**6**																			
Caddisfly *Triplectides*	5	5	3	30	33		2	23	p	5			3		1	3	1	1	9	35	
Caddisfly *Zelolessica*	**10**	**10**																			
Damselfly *Austrolestes*	6	2																			
Damselfly *Ischnura*	**6**	**6**																			
Damselfly *Xanthocnemis*	5	2			1	1				1		1	18			15	9			5	p
Dragonfly *Antipodochlora*	6	6																			
Dragonfly *Hemicordulia*	5	2																			
Dragonfly *Procordulia*	**6**	**6**																			
Bug *Anisops*	5	3				5															
Bug *Diaprepocoris*	**5**	**5**																			
Bug *Microvelia*	5	5					1			1		1								1	
Bug *Sigara*	5	3				2									2						
Dobsonfly *Archichauliodes*	7	7	2	6	2			3										5			
Scorpionfly *Nannochorista*	**7**	**7**																			
Beetle *Antiporus*	5	5																			
Beetle *Berosus*	**5**	**5**																			
Beetle Dytiscidae	**5**	**5**																			
Beetle Elmidae	6	7		8	25	1	2	30	p									10			
Beetle Hydraenidae	**8**	**8**																			
Beetle Hydrophilidae	5	6																			
Beetle *Liodessus*	**5**	**5**																			
Beetle Ptilodactylidae	8	7						1													
Beetle *Rhantus*	5	2																			
Beetle Scirtidae	8	6																			
Beetle Staphylinidae	5	6																			
True Fly *Aphrophila*	5	6	16	1	3			5	p									8			
True Fly *Austrosimulium*	3	4	22	13			1	1	4	1				6				10	3		
True Fly Blephariceridae	**7**	**7**																			
True Fly Ceratopogonidae	3	7																1			
True Fly *Chironomus*	1	4							1	1			4	5	1					1	
True Fly Culicidae	3	3									1									1	
True Fly Empididae	3	7	1				1	1	p		2		1	1				13			1
True Fly Ephydridae	**4**	**4**																			
True Fly Eriopterini	9	8																			
True Fly *Harrisius*	6	5														4				1	
True Fly Hexatomini	5	7																			
True Fly *Limonia*	6	6												1							
True Fly *Lobodiamesa*	5	8																			
True Fly *Maoridiamesa*	3	5																			
True Fly *Mischoderus*	4	5																			
True Fly *Molophilus*	5	7																		1	
True Fly Muscidae	3	3												2	1					1	

True Fly *Nothodixa*	5	5																			
True Fly Orthocladiinae	2	3	10	4	6	9	2	12	4	63	24	2	24	65	24	44		1	3	1	p
True Fly *Paradixa*	4	8			8		14	9		16								41		21	
True Fly *Paralimnophila*	6	7																			
True Fly Pelecorhynchidae	9	9																			
True Fly Podominae	8	8																			
True Fly *Polypedilum*	3	7	5	15	2	2	8		8	70	92	1	17	23	6	38	1	7	3	26	p
True Fly Psychodidae	1	8			1		1				9			1				2			
True Fly Sciomyzidae	3	4																			
True Fly *Stictocladius*	8	8																			
True Fly Stratiomyidae	5	3																			
True Fly Syrphidae	1	1																			
True Fly Tabanidae	3	7																			
True Fly Tanypodinae	5	6	1										2	6		6		1			
True Fly Tanytarsini	3	4	15	8			1	10	2						1			4			
True Fly *Zelandotipula*	6	4																			
Moth *Hygraula*	4	2																			
Crustacea Cladocera	5	5																			
Crustacea Copepoda	5	5											1								
Crustacea *Halicarcinus* crabs	3	3			3					2	3					4	5				
Crustacea Isopoda	5	5																			
Crustacea Mysid shrimps	5	5																			
Crustacea *Orchestia*	5	5					1														
Crustacea Ostracoda	3	3				2							1		2						
Crustacea *Paracalliope*	5	5			11	5			1	6					97	1	98		63	15	117
Crustacea *Paraleptamphopus*	5	5					19														
Crustacea *Paranephrops*	5	8					3											2			
Crustacea *Paratya*	5	4		25	23	17	p		11	10	14				1	2		3		1	
Crustacea *Phreatogammarus*	5	5																			
Crustacea Tanaidacea	4	4				11															
MITES	5	5		1				1	p	6		1	2		2	4		2			1
Mollusc *Ferrissia*	3	3	1								1										
Mollusc *Glyptophysa*	5	5																			
Mollusc *Gyraulus*	3	3													1	10					
Mollusc *Hyridella*	3	6																			
Mollusc *Latia*	3	6	2	5	1													7		2	
Mollusc Lymnaeidae	3	2		1																	p
Mollusc *Melanopsis*	3	3																			
Mollusc *Physella*	3	1		5					1		2		13	1	1	31	15		1	1	
Mollusc *Potamopyrgus*	4	2	59	32	47	7	7	29	168	6	49	160	110		43	55	57	18	107	65	7
Mollusc Sphaeriidae	3	3			p								2								
OLIGOCHAETES	1	4	5	5		121				11	5		10	71	12	8	1		15		2
PADDLEWORMS	3	3																			
FLATWORMS	3	2				19							5	1	6	2	18	1			1
Rhabdocoel Flatworms	3	2				2															
NEMATODES	3	3																			
NEMERTEANS	3	3	1											2	3		1	1			1
NEMATOMORPHS	3	4																			

LEECHES	3	2										3	1	2							
HYDROIDS	**3**	**3**										3	2								2
BRYOZOA	**4**	**4**																			
Number of Taxa			23	19	18	14	26	22	12	17	12	10	17	16	19	16	10	30	12	18	9
Total counted			209	206	193	204	210	206	211	205	205	175	219	207	214	229	206	203	213	180	201
EPT Value			10	5	5	0	13	11	3	4	1	4	1	1	2	2	1	11	5	3	1
% EPT (taxa number)			43%	26%	28%	0%	50%	50%	25%	24%	8%	40%	6%	6%	11%	13%	10%	37%	42%	17%	11%
%EPT (numbers of individuals)			33%	37%	31%	0%	71%	50%	5%	5%	1%	5%	1%	9%	4%	2%	0%	33%	8%	21%	34%
Sum of recorded taxa scores			110	80	80	54	157	121	47	64	33	55	57	45	62	60	35	150	55	77	29
MCI Value			96	84	89	77	121	110	78	75	55	110	67	56	65	75	70	100	92	86	64
Sum of abundance loaded scores			783	768	894	442	1383	1082	840	614	637	730	767	398	833	754	889	1075	900	751	773
QMCI Value			3.7	3.7	4.6	2.2	6.6	5.3	4.0	3.0	3.1	4.2	3.5	1.9	3.9	3.3	4.3	5.3	4.2	4.2	3.8
MCI-sb Value			111	95	111	73	132	116	83	91	78	106	75	81	68	74	68	119	98	96	73
QMCI-sb			3.9	3.8	4.7	3.7	7.0	5.3	2.5	5.1	4.9	2.4	2.7	3.9	3.8	3.3	3.4	6.4	3.5	4.5	3.8