Waipoua macroinvertebrate reassessment report; 2023 vs 1994 historical data

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Cover photo: The Waipoua River, upstream of the State Highway 12 bridge crossing. Photo: Steve Pohe.

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1. Introduction

There is an increasing mandate for government agencies to improve the knowledge and management of native biodiversity within their administrated lands. In 2019 Department of Conservation (DOC) launched the 'Ngā Awa River Restoration Programme' to restore freshwater biodiversity of 14 priority catchments from mountains to sea. The Waipoua River in Northland was one catchment selected for inclusion in the programme, and is being done in partnership with local iwi Te Roroa who hold mana whenua in the region. The goal for the Waipoua project is "to restore the river and add to the significant long-term restoration work that is already being carried out in the catchment" (DOC website).

In combination with other restoration activities, river health monitoring was undertaken from 2020 to 2023 to establish a baseline of ecological state, and a report was prepared by Cawthron Institute (Eveleens & Kelly 2023). Part of this ecological work included surveillance monitoring of freshwater macroinvertebrates which can be used to detect changes in the aquatic environment resulting from human-induced stresses e.g. contaminants entering the waterway. Macroinvertebrates are normally abundant in lotic (running water) ecosystems, and are commonly used in the assessment of water quality as their diverse communities provide varied responses to changing environmental conditions (Boothroyd & Stark 2000). They are good indicators of local conditions because they tend to be limited in their in-stream movements, thus are effected by the environmental conditions over an extended period of time, unlike water quality measurements, which are snapshots of the waterway at that point, at that moment.

This report presents results of an extension study to the river health monitoring programme. It assesses macroinvertebrate communities at 13 Waipoua catchment sites and three sites in neighbouring forest catchments (all collected in May 2023), and compares them with results from the same sites assessed ~30 years earlier (Seitzer 1994). Pohe Environmental was contracted to process and identify the macroinvertebrate samples supplied by DOC, and produce a short report of methods and key findings.

2. Methods

2.1 Macroinvertebrate sampling and processing

Benthic samples were collected by Department of Conservation (DOC) contractor Tom Donovan from 16 sites previously sampled by Seitzer (1994), from the Waipoua River catchment and the wider Northland region (Table 1, Appendix 1). The present samples were collected during May 2023 and for comparative purposes, sampling followed the methods reported by Seitzer (1994), who followed the nationally recognised methods of Stark (1985). In brief, all sampling sites were hard-bottomed and kick samples were taken from riffles comprising four subsamples (a composite sample), with the streambed area disturbed being 0.5 m in front of the net, and the net being 0.35 m wide (0.7 m^2 of streambed). Samples were preserved in 95% isopropyl alcohol in the field.

In the laboratory, sample processing followed the protocols of Smith (2021), which were developed specifically for DOC based on the draft National Environmental Monitoring Standards for macroinvertebrates (NEMS 2020), but with an increased rigour of taxonomic identification, particularly for the more taxonomically informative Ephemeroptera, Plecoptera and Trichoptera (EPT taxa). Each sample was rinsed thoroughly through stacked 8, 2 and 0.5 mm Endecotts sieves, placed in Bogorov counting chambers and specimens picked, identified and counted under a Leica M205 dissecting microscope. Identification followed the taxonomic keys of Chapman et al. (2011), Winterbourn et al. (2006) and Winterbourn (2021), and published species descriptions.

Table 1. Site names, sampling dates and coordinates for the 16 sites surveyed in 1994 and May 2023 (upper table) and for seven sites surveyed by Department of Conservation Freshwater Monitoring (DOC FWM) in March 2023 (lower table). Also see map provided in Appendix 1.

Seitzer 1994 site name	River name	Sampling date	Seitzer 1994 map reference	DOC 2023 GPS coordinates	
Site 1	Waipoua River	17/05/2023	O06 561 175	-35.6432960	173.5011860
Site 2	Waipoua River	17/05/2023	O06 558 169	-35.6484270	173.4991070
Site 3	Waipoua River	17/05/2023	O06 556 171	-35.6458070	173.4963260
Site 4	Okawawa Stream	17/05/2023	O06 628 163	-35.6535650	173.5760560
Site 5	Kopai Stream	17/05/2023	O06 631 161	-35.6558480	173.5785090
Site 6	Waipoua River	17/05/2023	O06 624 165	-35.6524370	173.5711690
Site 7	Toronui Stream	24/05/2023	O06 632 192	-35.6274930	173.5791250
Site 8	Toronui Stream	24/05/2023	O06 632 193	-35.6265740	173.5790670
Site 9	Toronui Stream	24/05/2023	O06 634 191	-35.6282690	173.5815850
Site 10	Toronui Stream	24/05/2023	O06 633 190	-35.6288170	173.5801970
Site 11	Toronui Stream	24/05/2023	O06 625 179	-35.6390930	173.5718620
Site 12	Waikohatu Stream	17/05/2023	O06 612 167	-35.6501160	173.5586130
Site 13	Waipoua River	17/05/2023	O06 606 167	-35.6506420	173.5518670
Victoria	Victoria River	25/05/2023	O04 500 712	-35.1603370	173.4299830
Waipapa	Waipapa River	25/05/2023	P05 730 581	-35.2755590	173.6847800
Kaihu	Kaihu River	25/05/2023	P07 716 057	-35.7485550	173.6743470

DOC FWM site name	River name	Sampling date	Seitzer 1994 map reference	DOC 2023 GPS coordinates	
Waipoua4-5_5A	Waipoua River	23/03/2023	–	-35.6442250	173.5314190
Waipoua4-5_3B	Waipoua River	28/03/2023	–	-35.6387910	173.5287990
Waipoua3_6A	Waikohatu Stream	30/03/2023	–	-35.6488400	173.5577190
Waipoua2_3C	Kopai Stream	27/03/2023	–	-35.6567800	173.5793050
Waipoua4-5_10A	Okawawa Stream	29/03/2023	–	-35.6535950	173.5761450
Waipoua1_11B	Okawawa tributary	21/03/2023	–	-35.6826420	173.5935710
Waipoua1_4C	Waipoua tributary	22/03/2023	–	-35.6454770	173.5358900

2.2 Data analyses

Full count data (and presence for rare taxa scans) for all sites for May 2023 samples is presented in a Microsoft Excel spreadsheet provided to DOC with this report (*DOC Waipoua macroinvertebrate reassessment results 2023.xlsx*). Presence data derived from the May 2023 samples, as well as presence data obtained from the Appendix of the 1994 report (Waipoua sites only), were entered into Microsoft Excel. Both datasets (historical 1994 and May 2023) were standardised and aligned by re-entering presence data based on the current-day macroinvertebrate taxa lists and tolerance values reported in the latest National Environmental Monitoring Standards for macroinvertebrates (NEMS 2022). This standardised data was then analysed in order to describe and compare the community assemblages at each site, for both time periods. The biotic indices taxonomic richness, %EPT*, and MCI were calculated and graphically presented for most sites. However, raw data needed to calculate taxonomic richness and %EPT* values for Victoria, Waipapa and Kaihu Rivers (non-Waipoua catchments), were not reported in Seitzer (1994), thus were not able to be included.

In addition, a third Waipoua macroinvertebrate dataset (see Table 1), and a Waikanae dataset (data not included), both collected in March 2023 by the Department of Conservation for their Freshwater Monitoring Programme, and both processed and identified by the author, were also investigated. The March 2023 Waikanae data was only used to loosely compare taxa counts and abundances. The March 2023 Waipoua dataset was used for this same initial purpose, but then standardised to presence data in line with the NEMS (2022) taxa list, and the biotic indices taxonomic richness, %EPT*, and MCI also produced, for comparative purposes.

Because assemblages in the macroinvertebrate samples being processed departed from what would normally be expected, which was also observed during initial data analyses, a principal coordinates analysis (PCoA) ordination, based on the Sørensen (Bray–Curtis) distance measure, was used to examine site macroinvertebrate community similarities and differences more thoroughly. Convex hulls used to aid visualisation of the different datasets. Because identification of the invertebrates in the three sampling events differed slightly in resolution (purely based on what species were encountered, and the size/life-history stage of individuals present), a measure of standardisation was employed for the ordination data whereby the datasets were degenerated to a common point (taxa not able to be identified to species because of small individuals were all pooled at the genus-level for all three datasets). Raw data expressed as presence–absence were used in the ordination; no data transformations or rare species removals were done before analysis. A joint plot was incorporated to display correlations between sites in macroinvertebrate community space and calculated macroinvertebrate indices (taxonomic richness, %EPT* and MCI). The multi-response permutation procedure (MRPP) was used to test whether macroinvertebrate stream communities from the three sampling events were significantly different.

3. Results and Discussion

3.1 Comparison of historical 1994 and 2023 datasets

The Waipoua catchment macroinvertebrate communities, as assessed by the taxonomic richness, %EPT* and MCI indices, were reasonably similar between years 1994 and May 2023 (Figure 1, blue bars). Some sites had larger differences than others but on average the differences were small (see Appendix 2 for exact site values). Average taxa richness per site in the Waipoua catchment was 25.2 in 1994 and 23.9 in May 2023. Average %EPT* per site was 56.4 in 1994 and 59.0 in May 2023. Average MCI score was 117.9 in 1994 and 121.1 in May 2023. Overall, the May 2023 data presented lower taxonomic richness, and higher %EPT* and MCI values. The non-Waipoua catchments were predominantly of poorer condition than the Waipoua sites, but for these streams only the MCI index could be compared between years, due to unavailability of some data (Figure 1, green bars), and on average May 2023 had better MCI values than 1994.

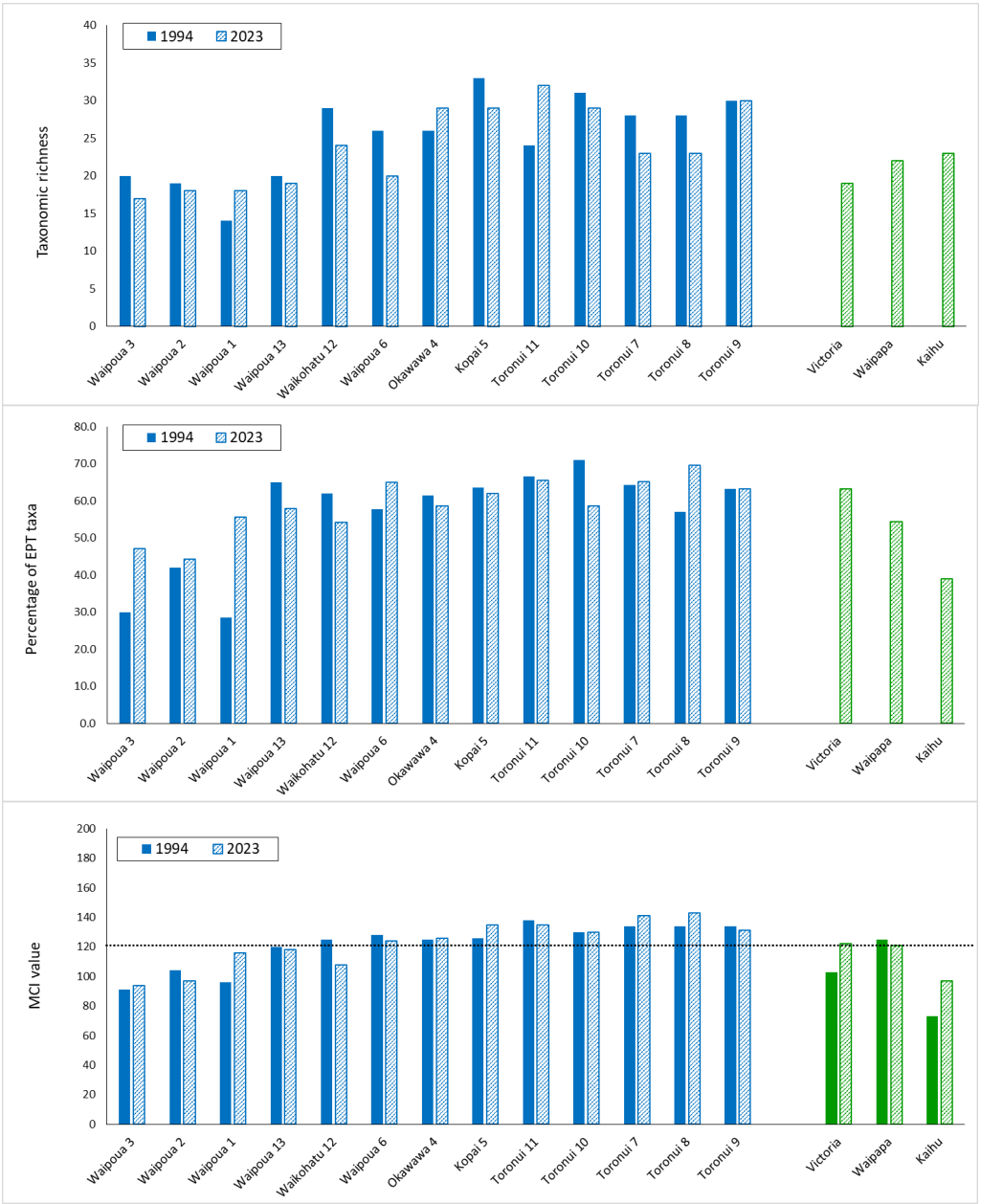

Figure 1. Macroinvertebrate biotic indices per site for the 13 Waipoua catchment sites (blue bars) and three neighbouring river catchments (green bars). Solid bars indicate historical 1994 data and diagonal hatching indicate May 2023 data. Sites are ordered by distance from the sea (downstream to upstream). Black dashed line on the MCI graph indicates lower limit of "Excellent" quality streams (Stark & Maxted 2007).

3.2 Comparison of different sampling programme results

The macroinvertebrate community indices of taxonomic richness, %EPT* and MCI are all calculated based on presence only data, and on further inspection of the species lists and full count data it appeared that abundances and taxa counts were very low relative to what would normally be expected. This was also recorded during sample processing. An exploratory analysis of other recent DOC macroinvertebrate sampling programmes revealed this observation to be correct, with considerably lower abundances and taxa counts for May 2023 (Figure 2). In addition, many common species were either absent or recorded in extremely low numbers, particularly dipteran and cased-caddisfly larvae, and snails. Either large-scale changes in the communities had occurred at many sites, or some other factor had influenced the results.

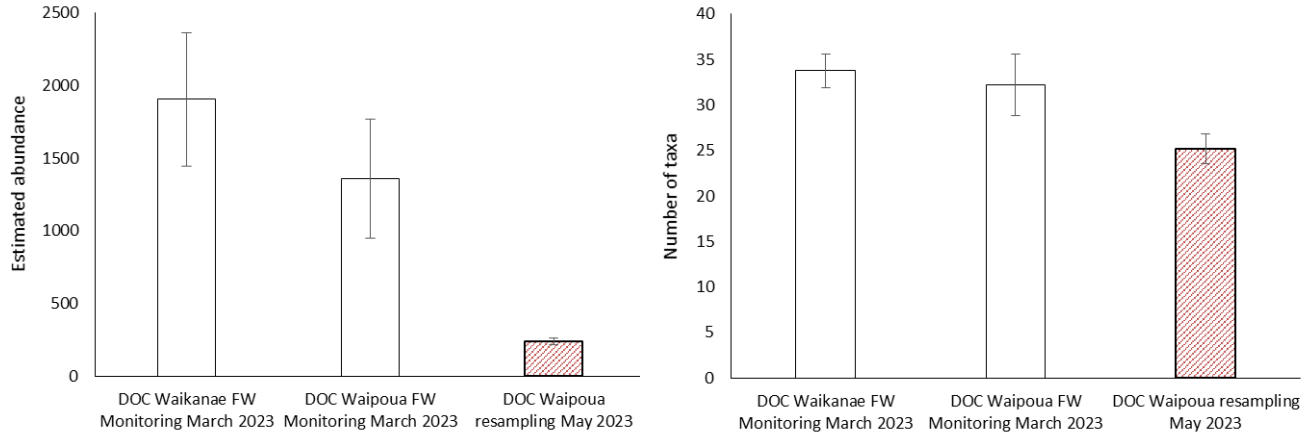

Figure 2. Estimated macroinvertebrate abundances and number of taxa per site recorded in recent DOC freshwater sampling programmes. Orange hatching indicates May 2023 reassessment.

In an effort to understand the differences being observed in macroinvertebrate communities, a principal coordinates analysis (PCoA) was used to ordinate sampling sites from the three sampling programmes in macroinvertebrate species space. The ordination generated two axes that explained 40.3% of the variation in the input data (Figure 3), which revealed gradients in the macroinvertebrate communities, and similarities and differences in the three sampling programmes. Monitoring sites in the upper Waipoua catchment (Toronui Stream) and also in low-order side tributaries (Kopai5, W2_3, W1_11B, W1_4C) plotted in the positive direction of Axis 1, strongly correlated with high taxonomic richness, MCI and %EPT index values (more diverse and 'healthier' communities on the right side of the plot). In contrast, sites in the lower reaches of Waipoua River (Waipoua1–3, W4-5_3B, W4-5_5A), the lower reaches of Okawawa Stream (Okawawa4, W4-5_10) and the lower reaches of Waikohatu Stream (Waikohatu12, W3_6A) all plotted in the negative direction of Axis 1, correlating with much lower macroinvertebrate index values (poorer quality macroinvertebrate communities on the left side of the plot).

With regard to the three sampling programmes, all sites in the May 2023 sampling event plotted in the PCoA in the positive direction of Axis 2 (upper half of the plot), while all historical 1994 and March 2023 sampling sites were well separated in the negative direction of Axis 2 (lower half of the plot). MRPP analysis indicated the differences between May 2023 and the two other sampling events were significant, but the difference between the historical 1994 and March 2023 events was not (Table 2). This clearly indicates that the observed difference in the May 2023 is not a change in stream condition over the 30-year period, as the historical 1994 and March 2023 are very similar, **essentially answering the main objective of the study and confirming there has been little change in macroinvertebrate communities since 1994**.

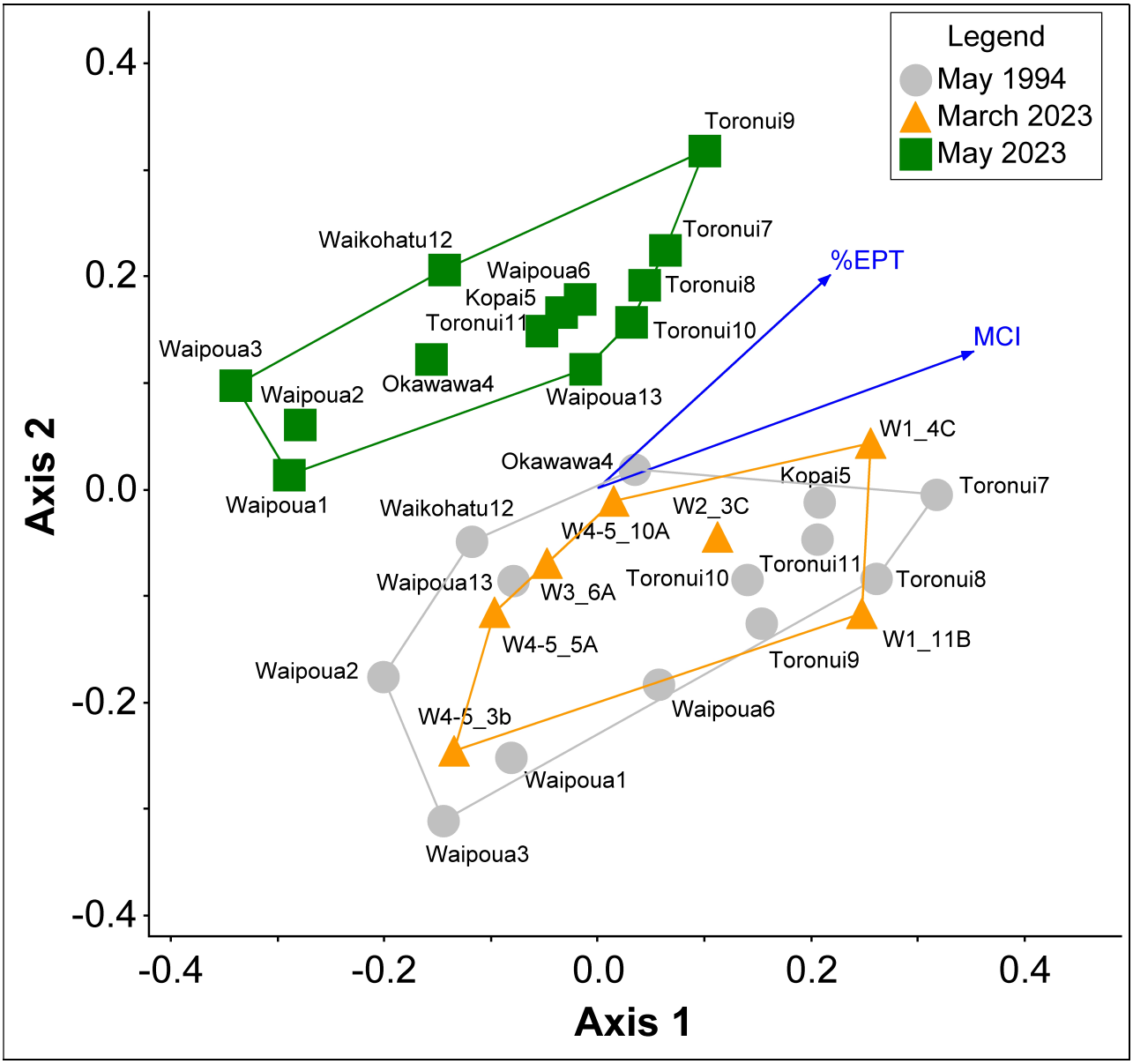

Figure 3. Principal coordinates analysis (PCoA) plot of the Waipoua sampling sites for three different environmental monitoring programmes showing the relationship between the ordination scores of sites in macroinvertebrate community species space (Axis 1 = 22.1%; Axis 2 = 18.2%). Blue vectors indicate the strength and direction of correlations between macroinvertebrate index values and ordination axes scores (Pearson's r^2 cut-off = 0.4). The vector of taxonomic richness was removed for clarity but it was similar in strength to MCI, and bearing approximately 090° i.e. parallel to Axis 1.

What is more perplexing and seemingly contradictory at first glance is that the May 2023 event presented higher %EPT* and MCI values than the other two sampling events. However, the May 2023 event also presented much lower taxonomic richness values. Invertebrate communities in New Zealand streams are usually relatively stable over time, despite the flashy nature of our climate and regular disturbance events (Scarsbrook 2002). However, severe disturbance events are well-known to disrupt macroinvertebrate communities, reducing densities and diversity, but the communities generally recover within 6–8 months (Scrimgeour et al. 1988; Collier & Quinn 2003). Stark and Maxted (2007) indicated that increased MCI values may be significantly correlated with flood events, suggesting the high flows may elevate MCI values by washing higher scoring taxa from "better" habitat upstream into sites of lower quality and by flushing away lower-scoring taxa from sites of higher quality. This imbalance of many high scoring taxa and few low scoring taxa would certainly inflate MCI and %EPT scores, while reducing taxonomic richness, and is likely to

well-explain the May 2023 results. Further investigation into the timing of the May 2023 sampling revealed a large flood occurred just days prior to sampling (see Appendix 3), which is likely to have caused the misleading results.

Table 2. Pairwise comparisons of differences in benthic macroinvertebrate communities between sampling events using the multi-response permutation procedure (MRPP).

Sampling events (Groups)	Test statistic (T)	Homogeneity (A)	*P*-value
May 1994 vs. May 2023	-9.15	0.23	**< 0.001**
March 2023 vs. May 2023	-6.59	0.21	**< 0.001**
May 1994 vs. March 2023	-1.54	0.05	0.08

4. Conclusions

What started out as a simple apples vs apples comparison of May 1994 historical data with newly generated May 2023 data, turned out to be an apples vs oranges analysis. Due to the sampling being undertaken directly after a flood event, macroinvertebrate communities from May 2023 samples presented with lower than expected taxonomic richness, and inflated MCI and %EPT* values. The data generated from the May 2023 samples is unrepresentative of macroinvertebrate communities occurring historically (1994) and in the present (March 2023), and should not be used in future analyses. However, due to the availability of the March 2023 data collected by DOC, and by the presence of the many good-scoring taxa in the May 2023 samples, we can be confident that many sites across the Waipoua catchment are still in good condition, which was the initial intent of the present monitoring exercise.

While the May 2023 sampling results are not reliable for comparative purposes, the lower catchment sites in the main-stem Waipoua River (Waipoua1–3) did consistently present the lowest scoring health index values and this is worthy of consideration, even though it is unclear whether that is due to lower quality water or more severe flood disturbance.

5. References

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6. Acknowledgements

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7. Appendix 1

Figure A1. Map of sample collection sites for Waipoua River catchment and wider Northland region. Map produced by Dave West, Department of Conservation.

8. Appendix 2

Table A2. Summary of macroinvertebrate biotic indices MCI, taxonomic richness and %EPT* for all sites sampled in 1994, and resampled in May 2023. MCI scores are standardised based on taxa and tolerance values listed in NEMS 2022 so 1994 values may differ from the original report. Waipoua catchments sites are ordered by distance from the sea (i.e. downstream to upstream).

	MCI		Taxonomic richness		%EPT*	
Site	**1994**	**2023**	**1994**	**2023**	**1994**	**2023**
Waipoua catchment						
Waipoua 3	91	94	20	17	30.0	47.1
Waipoua 2	104	97	19	18	42.1	44.4
Waipoua 1	96	116	14	18	28.6	55.6
Waipoua 13	120	118	20	19	65.0	57.9
Waikohatu 12	125	108	29	24	62.1	54.2
Waipoua 6	128	124	26	20	57.7	65.0
Okawawa 4	125	126	26	29	61.5	58.6
Kopai 5	126	135	33	29	63.6	62.1
Toronui 11	138	135	24	32	66.7	65.6
Toronui 10	130	130	31	29	71.0	58.6
Toronui 7	134	141	28	23	64.3	65.2
Toronui 8	134	143	28	23	57.1	69.6
Toronui 9	134	131	30	30	63.3	63.3
Neighbouring catchments						
Victoria	103	122	-	19	-	63.2
Waipapa	125	121	-	22	-	54.5
Kaihu	73	97	-	23	-	39.1
Average (all sites)	117.9	121.1	25.2	23.4	56.4	57.8
Average (Waipoua sites only)	121.9	122.9	25.2	23.9	56.4	59.0

9. Appendix 3

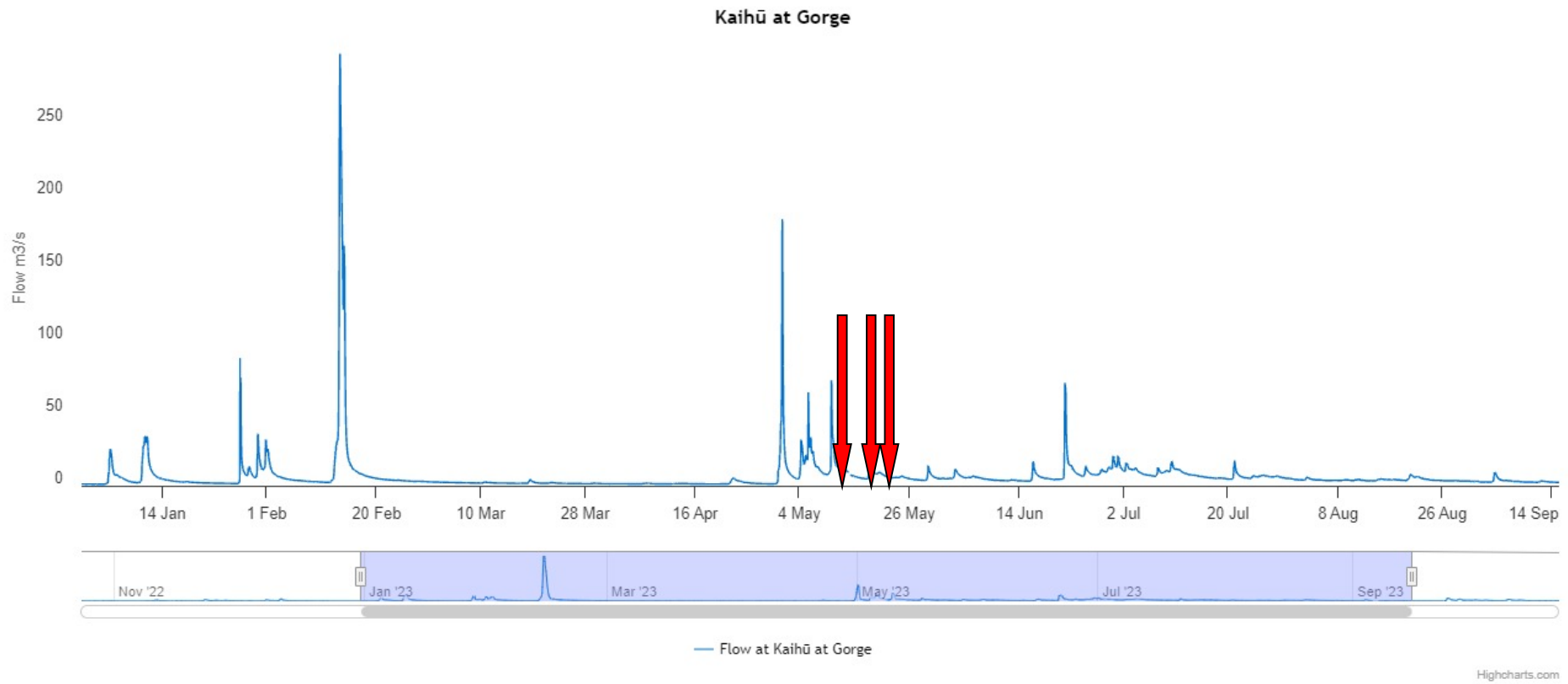

Figure A3. River flows in the neighbouring Kaihu River for January to September 2023, which would have been representative of rain events (and thus river flows) in the wider Northland region. Red arrows indicate approximate dates of May 2023 macroinvertebate sampling. Data source: Northland Regional Council river flows online.