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Spatial and Temporal Patterns in the Condition of Waikato Streams Based on the Regional Ecological Monitoring of Streams (REMS) Programme

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Summary

Environment Waikato has been carrying out annual assessments of invertebrate community composition in streams and rivers since 1994 as part of the Regional Ecological Monitoring of Streams (REMS) programme. These sites include wadeable high-gradient streams with stony beds, low-gradient wadeable streams dominated by soft sediments, and some larger non-wadeable streams with long term records that have been retained while appropriate sampling protocols are developed. From 2005, sampling has included a network of 23 wadeable 'reference sites' in undeveloped catchments to provide a baseline against which to measure change, and a range of sites representing low, moderate and high levels of pastoral land-cover ('land-cover sites'). Sampling at 46 'long-term sites', including three reference sites, has been conducted for more than 10 years using consistent protocols that have enabled assessment of temporal trends in ecological condition at these sites. Condition is assessed using four stream macroinvertebrate-based measures derived from 200+ counts of individuals: number of different types of mayflies, stoneflies and caddisflies (excluding algal-piercing Hydroptilidae)—EPT* richness; the percent abundance of these sensitive insects—%EPT*; a measure of tolerance to organic pollution—the Macroinvertebrate Community Index or MCI; and an integrative score of all three metrics—Average Score Per Metric or ASPM. Metrics were also calculated reflecting (i) habitat quality based on qualitative assessments of nine riparian, bank and channel attributes, and (ii) instream plant cover and proliferation.

Of the 43 non-reference 'long-term sites' monitored for over 10 years, 15 (35%) showed trends over time using two methods of analysis. No trends were detected at the remainder of sites which can be considered 'stable' in terms of macroinvertebrate community indicators. The different metrics showed variable responses over time, presumably reflecting differential sensitivity to various stressors or enhancements. Three sites showed increasing relative abundance of sensitive species (%EPT*) at an average rate of +7% per year (Relative Kendall Sen Estimator—RKSE), while this metric declined at one site by -9% per year. All trends in MCI were negative (nine sites; mean RKSE -2% per year), whereas the ASPM trends indicated three sites declining in condition (mean RKSE -3% per year) and five sites improving in condition (mean RKSE +5% per year).

There was a clear and consistent pattern over multiple years (2005–08) showing that macroinvertebrate metrics were lower where there were higher levels of catchment development (primarily agricultural). Thus, 'reference sites' in undeveloped catchments were in better ecological condition than those in developed catchments, where condition declined between levels of moderate (10–49% of upstream catchment modified), high (50-89%) and very high (>90%) development. Declines in condition occurred rapidly with the onset of catchment development, and were most pronounced where more than 40% of the catchment was developed.

A separate analysis of data from 2005/06, when streams in Hamilton City were also sampled, indicated that on average urban streams had lower ecological condition than streams in other developed catchments, although a few urban streams did support invertebrate communities with high numbers of sensitive species. Towns and cities represent only a small area of land-cover in the Waikato region (around 1%), compared to pasture (58%) for example, so the net effect of urbanisation on regional stream health is much less than for agricultural development.

Metrics reflecting instream plant cover and proliferation were highly variable over time, but also indicated a significant response to increasing levels of development upstream, most noticeably for macrophytes. Habitat quality scores declined significantly across land-cover classes, and this was most evident between undeveloped to moderately developed classes, and highly developed to very highly developed classes. Habitat quality scores were significantly related to all macroinvertebrate metrics and accounted

for 49–57% of their variation, suggesting that ecological condition as reflected by macroinvertebrate communities is a function of habitat quality as well as water quality.

1 Introduction

Environment Waikato has been carrying out annual surveys of aquatic invertebrates (Regional Ecological Monitoring of Streams—REMS) since 1994 as part of its Environmental Indicators Programme to document the condition of streams and rivers in the region. The history and objectives of this monitoring programme have been reviewed by Collier (2005), and results up to 2005 were reported in Collier & Kelly (2006). The composition of aquatic invertebrate communities provides a measure of the stream's ecological condition which is influenced by local and upstream activities that affect water quality and the physical stream environment. Information on invertebrate community composition is condensed into 'metrics' that can be used to report on changes over time. Similar approaches are widely used among other regional councils in New Zealand and management agencies internationally for monitoring stream ecological condition. As invertebrate community composition reflects a range of interacting factors, it provides a holistic and cumulative understanding of ecosystem condition, and augments other measures such as water quality (e.g., chemistry, microbes). Aspects of habitat quality and instream plant cover are assessed concurrently with macroinvertebrate collections (see Collier & Kelly 2005; Collier et al. 2006). In 2005, the REMS network was modified to incorporate (i) a network of reference sites on streams in unmodified (native forest) catchments (see Collier et al. 2005a, b), and (ii) a range of sites around the region reflecting different levels of upstream catchment development (see Collier 2005). In the 2005/06 sampling season, the site network was expanded to include a range of urban and periurban sites within and around Hamilton City (see Collier et al. 2009).

Environment Waikato's REMS sampling has been of sufficient duration and frequency at some sites (annually for up to 13 years) to enable assessment of temporal trends in ecosystem health. The availability of site records of 11 or more years using consistent sampling methods was the criterion used to identify sites suitable for analysis of trends in this report, even if this record did not cover successive years. Some sites with long-term records were not considered suitable because changes in sampling protocols implemented in 2002 may have compromised the interpretation of temporal patterns (see Collier 2005 for a further discussion of this). Previous analyses of trends were conducted on data collected from eight annual monitoring occasions—this represented a relatively small dataset for interpreting trends and, partly because of this, different levels of confidence were used based on perceived ecological relevance <u>and</u> the statistical significance of any observed trends (see Collier 2006).

The principal aims of this report are to (i) identify temporal trends at sites considered to have robust, long-term data based on key invertebrate community metrics, and (ii) investigate spatial patterns in stream ecological condition in relation to catchment land-cover. It is recognised that invertebrate community metrics are one of a number of approaches to assessing ecological condition. Other approaches for regional monitoring and assessment currently under investigation are the use of fish community composition (e.g., Joy 2005) and functional indicators of ecosystem processes (e.g., decomposition rates and stream metabolism; Young 2004). Currently, invertebrate monitoring provides the only biologically-based dataset available of sufficient duration to enable the assessment of temporal trends. In addition to these principal aims, a secondary aim was to assess the influence of sampling substrate ("hard"—stones; "soft"—mainly wood and macrophytes) on macroinvertebrate community metrics (reported on in Appendix 1).

2 Sampling sites

Since the inception of the REMS programme in 1994 there have been variations in the timing of sample collection (although most sampling has been conducted sometime over mid-to-late summer), and in field protocols and laboratory processing procedures which were altered in 2002 to conform to standardised MfE protocols for wadeable stream monitoring (Stark et al. 2001). In total, 978 samples have been collected since 2002 using these protocols, with 382 samples collected over 2005–08.

Forty-six sites sampled in a consistent fashion for at least 10 years are considered suitable for analysis of long-term trends (see Table 1). These 'long-term sites' comprise eight non-wadeable sites and 38 wadeable/hard-bottomed sites that include three reference sites with undisturbed vegetation cover in upstream catchments (Table 1). Eleven of these REMS sites correspond to regional water quality monitoring sites (1249-15, 11253_9, 1293_8, 240-5, 407-1, 428-3, 556-9, 619_20, 749-10, 786-2, 976_2) reported on in Vant (2008).

In 2005, a regional network was established of wadeable stream 'reference sites' whose catchments were entirely in unmodified native vegetation. These sites are used to provide an undisturbed baseline against which to measure the magnitude of change at other sites (see Collier et al. 2005 a, b). Over 2005–08, 23 reference sites have been sampled annually. They include three long-term reference sites that have been sampled since 1995 or 1996, and three sites where samples are collected from 'hard' (stones) and 'soft' (wood and macrophytes) substrates (see Appendix 1).

In addition, a range of sites around the region has been sampled from 2005 (see Section 5.1 in Collier 2005) to represent low, moderate and high levels of catchment development ('land-cover sites') as follows:

- Moderately developed—adjacent pasture with 10–49% of upstream catchment area developed;
- Highly developed—adjacent pasture with 50–90% upstream development; and
- Very highly developed—adjacent pasture with >90% upstream development.

Upstream development consisted primarily of pastoral land-cover (26, 66 and 93% on average for moderately, highly and very highly developed classes, respectively), with exotic forestry and urban land making up less than 4% and 1%, respectively, of catchment area upstream of sampling sites. This sampling design involved 90–91 sites sampled in each year (one very highly developed site was not sampled in 2006), leading to totals of 96 samples from reference sites, 96 samples from moderately developed sites, 100 samples from highly developed sites and 71 samples from very highly developed sites. These sites were spread throughout the region but it was not always possible to find the full combination of sites in all seven management zones (Coromandel, Hauraki, Lower Waikato, Upper/middle Waikato, Waipa, West Coast and Taupo; see Figure 1) used to stratify site selection. In the 2005/06 sampling season, the site network was expanded to include a range of urban and periurban sites within and around Hamilton City (see also Collier et al. 2009) to compare rural and urban land use impacts on streams. In addition, eight sites, where restoration activities (typically riparian planting) have been carried out or are planned, are sampled annually ('restoration sites').

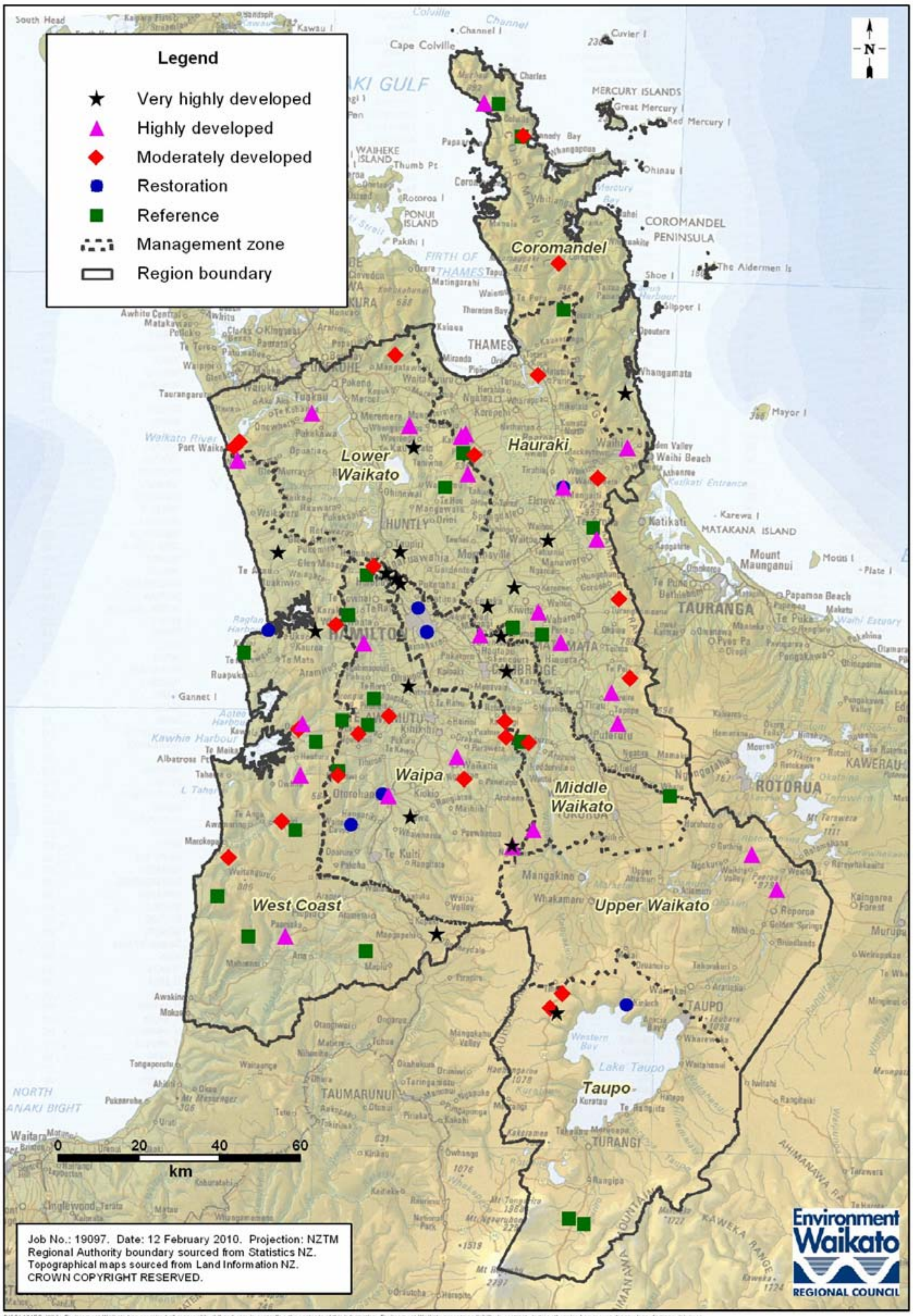

Figure 1: Location of REMS sites sampled over 2005–08 that were part of the land-cover analysis (moderately disturbed, highly-disturbed, very highly disturbed; see text for details), the reference site network, and the sites where restoration activities were planned or underway (note 2 sites in Hamilton city overlap on map).

Table 1: Description and location of 46 long-term invertebrate monitoring sites sampled for 10–13 years up to 2008.

In the located number column, ref. = reference site (100% native forest upstream); n.w. = non-wadeable; ‡, RERIMP monitoring sites reported on by Beard (2009). *, restoration site. Sites are listed by Environment Waikato management zones.

Located number	Stream/river name	Location name	Easting	Northing	Zone	Years sampled
1257_4	Waiwawa	Upstream Toranoho Stm	2746600	6468500	Coromandel	11
23_2	Apakura	Puriri Valley Rd	2747200	6439200	Coromandel	12
4_2	Five Mile	Off Tapu Coroglen Rd	2745600	6467800	Coromandel	11
619_20‡	Ohinemuri	SH25 bridge	2764100	6421300	Coromandel	12
1055_2	Torehape	Torehape West Rd	2722721	6425025	Hauraki	12
1055_3	Torehape	Torehape West Rd	2721609	6424306	Hauraki	13
1158_7	Waimakariri	Off end of Waimakariri Rd	2761526	6350704	Hauraki	12
1174_10	Waiomou	Waiomou Rd	2759900	6358600	Hauraki	12
1249_15 (n.w.)‡	Waitoa	Landsdowne Rd bridge	2751700	6378300	Hauraki	12
1252_3*	Waitoki	Rawhiti Rd	2697600	6388800	Hauraki	13
433_2	Mangapapa	Henry Watson Rd	2747000	6371500	Hauraki	12
531_4	Matatoki Stm	Matatoki Rd	2741200	6439800	Hauraki	12
749_10 (n.w.)‡	Piako	Kiwitahi	2739800	6385600	Hauraki	12
753_7 (n.w.)	Piakonui	Downstream of Paku Rd bridge	2741229	6379291	Hauraki	12
1293_8 (n.w.) ‡	Whangamarino	Jefferies Rd	2708364	6427161	Lower Waikato	12
453_8	Mangatangi	Stubbs Rd	2704800	6445100	Lower Waikato	12
481_11	Mangawara	Mangawara Rd	2723271	6414627	Lower Waikato	11
220_1	Kaiwhitwhiti	Tiverton Downs Farm	2797491	6282670	Up/Mid Waikato	12
240_5‡	Kawaunui	SH5 bridge	2802100	6308100	Up/Mid Waikato	11
407_1‡	Mangamingi	Paraonui Rd bridge	2758800	6330200	Up/Mid Waikato	11
495_1	Mangawhio trib.	Taupaki Rd	2739851	6323541	Up/Mid Waikato	11
786_2‡	Pokaiwhenua	Arapuni - Putaruru Rd	2749100	6345800	Up/Mid Waikato	13
786_22	Pokaiwhenua	Wiltsdown Rd	2757973	6334873	Up/Mid Waikato	11
124_4 (n.w.)	Firewood	Waingaro @ Ngaruawahia Rd	2697713	6388746	Waipa	11
125_4/125_15 (ref.)	Firewood trib.	Off Walkway (Hakarimata Scenic Reserve)	2693255	6324837	Waipa	11
1253_9*‡	Waitomo Stm	Tumutumu Rd	2693255	6324837	Waipa	11
1284_1	Whakarautawa	Mangati Rd	2695200	6348100	Waipa	12
429_3 (n.w.)	Mangaotama	Ryburn Rd	2708012	6360259	Waipa	12
476_1	Mangatutu	Lethbridge Rd	2722200	6336500	Waipa	12
477_14 (ref.)	Mangauika	Upstream weir	2697600	6350400	Waipa	12
477_5	Mangauika	Mangauika Rd bridge	2703000	6352700	Waipa	12

Located number	Stream/river name	Location name	Easting	Northing	Zone	Years sampled
493_1	Mangawhero trib.	Mangawhero Rd	2708413	6326725	Waipa	12
1172_6*	Wainui	Wainui Stm (Raglan) at Wainui Reserve bridge	2672168	6374702	West Coast	13
1247_3 (n.w.)	Waitetuna	Ohautira Rd	2684200	6374300	West Coast	12
1414_1 (ref)	Omanawa trib.	Pirongia West Rd	2691007	6351578	West Coast	12
195_1	Huriwai	Waikaretu Rd	2664385	6418242	West Coast	11
256_2 (n.w.)	Kiritihere	Mangatoa Rd	2661900	6316500	West Coast	12
36_1	Awaroa	Awaroa Rd	2680290	6337596	West Coast	11
365_1	Mangahoanga	Moerangi Rd	2680854	6350806	West Coast	12
413_2	Mangaokahu	Cogswell Rd (upper)	2689435	6376039	West Coast	13
428_3‡	Mangaotaki	SH3 bridge	2676400	6296300	West Coast	12
428_5	Mangaotaki	Mangaotaki Rd	2679097	6303031	West Coast	10
514_1	Marokopa	Te Anga Rd	2675500	6325700	West Coast	12
539_1	Maunurima	SH22	2684266	6375948	West Coast	12
556_9‡	Mokau	Totoro Rd recorder	2675900	6290700	West Coast	11
976_2‡	Tawarau	Speedies Rd	2671700	6324600	West Coast	11

3 Methods

3.1 Sample collection and data compilation

The history of REMS sample collection methods is outlined in Collier (2005) and Collier & Kelly (2006). Prior to 2002, field sampling protocols differed from those used currently, notably in terms of habitats sampled, net mesh size and number of invertebrates counted. From 2002–05, macroinvertebrate data were collected in line with MfE protocols as described by Stark et al. (2001) and refined for the Waikato region by Collier & Kelly (2005). This change involved focussing on 'hard'- or 'soft'-bottomed habitats at particular sites, use of a coarser mesh size for the sampling net, increasing the fixed count from 100 to 200+ individuals (and recording rare taxa), and increasing the level of taxonomic resolution (notably for Chironomidae).

Four metrics were calculated from these data: EPT* richness, %EPT* abundance, the Macroinvertebrate Community Index (MCI), and the ASPM which is an aggregation of these three metrics calculated as described by Collier (2008). 'EPT' refers to the sensitive groups Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). EPT metrics exclude Hydroptilidae (denoted by "*") because the commonest members of this family can proliferate in degraded conditions characterised by growths of filamentous algae (Maxted et al. 2003). Scarsbrook et al. (2000) concluded that measures such as MCI, EPT richness and %EPT are appropriate biological indicators for monitoring long-term trends because they are less susceptible to fluctuations in numbers of tolerant taxa, are more robust to changes in sampling intensity, and less sensitive to changes in microscale habitat variables than many other metrics (see also Collier et al. 1998). For MCI calculations prior to 2005, tolerance scores were the same as those listed in Collier & Kelly (2005), except for the combined chironomid taxon which was allocated a tolerance score of 5 based on the average value for all Chironomidae sub-families.

Prior to 2002, metrics were calculated from 100-count data. From 2002, metrics were calculated from 200+ counts, but for the period 2002–05 they were also calculated for 100-count datasets derived using the computer program Ecosim to provide a comparison of the two sample sizes (see Collier 2008). From 2005, metrics were calculated from 200+ data only, since earlier analysis indicated that the two sample sizes had little influence on the calculation of %EPT, MCI and ASPM (r^2 = 0.91 to 0.99), although it did influence EPT richness estimates due to abundance-diversity relationships (Collier 2008). Thus graphs that illustrate trends and statistical analyses are presented only for the metrics %EPT abundance, MCI and ASPM. For assessment of trends, the highest overall metric scores at reference sites across all years were used to standardise metrics for calculation of ASPM, whereas for the land-cover analysis the highest reference site score in a particular sampling year was used for this purpose.

Assessments of habitat quality were conducted on most occasions since 1998 (94% of macroinvertebrate samples) using visual assessments of nine riparian, channel and instream variables (see Collier & Kelly 2005 for a description). Assessments of periphyton and macrophyte metrics were also made at most sites sampled since 2005, following the methods described in Collier et al. (2006).

3.2 Statistical analyses

3.2.1 Trend analysis

Collier & Kelly (2005) used a stratified Spearman correlation approach to interpret likely trends in metric data with limited temporal extent (8–10 years) (see also Collier 2006). Since then, the development of TimeTrends software (version 2.00; 2008) has promoted the use of the Mann-Kendall test for the assessment of trends based on non-seasonal data collections, as used by Stark & Fowles (2006) for analysis of trends on long-term datasets from Taranaki streams. Both methods are presented in this report. Thus temporal trends were assessed as follows:

1. Using the Mann-Kendall trend test. ‘Clear’ trends were inferred at P <0.05 and ‘borderline’ trends at P =0.05 (see Appendix 2);
2. Using the Spearman rank approach described by Collier (2006) and summarised in Table 2 below for the relevant sample size range (note only ‘probable’ and ‘clear’ tends were considered; see Appendix 3).

Table 2: Trend classes used to define ecological and statistical significance of relationships for different sample sizes using the stratified Spearman approach.

r_s = Spearman rank correlation coefficient; FDR = False Discovery Rate (McBride 2005); NA = not applicable.

	Trend class			
n	**Stable**	**Possible**	**Probable**	**Clear**
10-16	$r_s \leq 0.50$	$0.50 > r_s < r_{s(\alpha=0.05)}$	$r_{s(\alpha=0.05)} \geq r_s \leq r_{s(FDR)}$	$r_s > r_{s(FDR)}$

Collier (2006) and Stark & Fowles (2006) also raised the issue of ecological relevance versus statistical significance, whereby statistically significant trends may be detected but the magnitude of change in metric values over time may be small and within the range of variation expected naturally. Metric ranges recorded during sampling for each long-term site are provided in Appendix 4 to provide some guidance on likely ecological relevance (note that an outlier year was excluded from the reference site 125_4/15). The mean change recorded at long-term reference sites averaged around 15% for %EPT*, 25 units for MCI and 0.15 units for ASPM—these values provide a plausible basis for assessing ecological relevance. However, it should be noted that even a small increase in %EPT*, for example, may be important ecologically at a site where few previously existed, and thus assessments of ‘ecological relevance’ should be interpreted with caution.

3.2.2 Land-cover relationships

Differences in *a priori* defined land-cover classes (undeveloped, moderately developed, highly developed, very highly developed; see Section 2 Sampling sites) were tested using Repeated measures MANOVA in Systat v.11 (Systat Software Inc., 2004). Metrics were arcsine square-root (% EPT*, ASPM) or log (other metrics) transformed prior to analysis. The analysis tested for the main effects of land-cover class and interactions with sampling method (hard- or soft-bottomed) and management zone, taking account of the repeat sampling of sites over four successive years. Where duplicate hard- and soft-bottom samples were taken, the average metric scores were used, and sampling method was not specified in the statistical analysis. The 2005/06 summer data were analysed separately using ANOVA to test the effect of urban development relative to other land-cover classes.

Linear regression was used to investigate relationships between habitat quality scores and macroinvertebrate metrics. Relationships between macroinvertebrate metric values and the percentage of upstream catchment area in indigenous forest and scrub were visualised for each year using scatterplots and a LOWESS smoother with a tension of 0.4. Sample ellipses centred on the sample means were plotted at the default probability of 0.68. Estimates of upstream land-cover were derived from the Freshwaters of New Zealand (FWENZ) database for the stream segment that the sampling site occurred on. However, for some reference sites that occurred midway along segments where land-cover changed, it was necessary to convert pastoral or exotic forestry classes to indigenous forest to reflect the true nature of the catchment above the sampling point. Regression TREES were used to explore natural splits in macroinvertebrate metrics in relation to environmental data from the FWENZ database across all years combined. The maximum number of splits was set at the default of 23 with a minimum count of five allowed at any node. The minimum proportion reduction in error for the tree allowed at any split and the minimum split value at any node were set at 0.05.

4 Results

4.1 Temporal trends

Graphs of selected invertebrate metrics used in the trend analysis are presented by management zone in Appendix 5 and summarised in Figure 2. Statistics for the interpretation of trends are presented in Appendices 2 and 3, and are summarised for non-reference sites in Table 3. Sites 125_4/15, 477_14 and 1414_1 are long-term reference sites that have 100% of upstream catchment area in native forest—two of these sites showed trends. Site 125_4 was moved around 100 m upstream during the course of the study (new site 125_15) to a site more typical of reference condition (i.e., more mature native vegetation and reduced chance of recreational disturbance), and this move probably accounts for the positive trend observed at that site for %EPT* and ASPM (Appendix 5). A negative trend for MCI was detected at 1414_1—the reasons for this are unclear (see Discussion).

Of the 43 non-reference sites monitored for over 10 years, 15 (35%) displayed temporal trends over two methods of analysis (Table 3; Figure 2). No trends were detected at the remainder of sites (65%) which can be considered ‘stable’ in terms of the macroinvertebrate community indicators measured. Thirteen sites showed ‘clear’ or ‘probable’ trends using the Spearman method compared to 12 that were ‘significant’ or ‘borderline’ using the Mann-Kendall method. The Relative Kendall Sen Estimator (RKSE) was calculated for sites showing trends according to either method to indicate the relative rate of change per year, excluding one site (1055_3) which showed contradictory trends for two metrics.

Three sites showed increasing relative abundance of sensitive species (%EPT*) at an average rate of +7% per year while this metric declined at one site by -9% per year. One of the EPT trends was ‘significant’ using the Mann-Kendall test and all changes were considered ‘ecologically relevant’. All trends in MCI were negative (nine sites; mean RKSE -2% per year), with six of these trends considered ‘significant’ and four considered ‘clear’—all but one were likely to be ‘ecologically relevant’ (Table 3). The MCI is derived from scores that reflect tolerance to organic pollution and it is therefore the metric likely to be most sensitive to certain water quality changes, although it is also responsive to other factors such as habitat quality (see below). The ASPM, the integrative score of the three metrics, showed eight trends. Three of these trends indicated declining condition (mean RKSE -3% per year) and five indicated improving condition (mean RKSE +5% per year)—five of these trends were considered ‘significant’, and all but one were likely to be ‘ecologically relevant’. The variable temporal responses of different metrics may reflect differential sensitivity to various multiple stressors or enhancements (see Discussion).

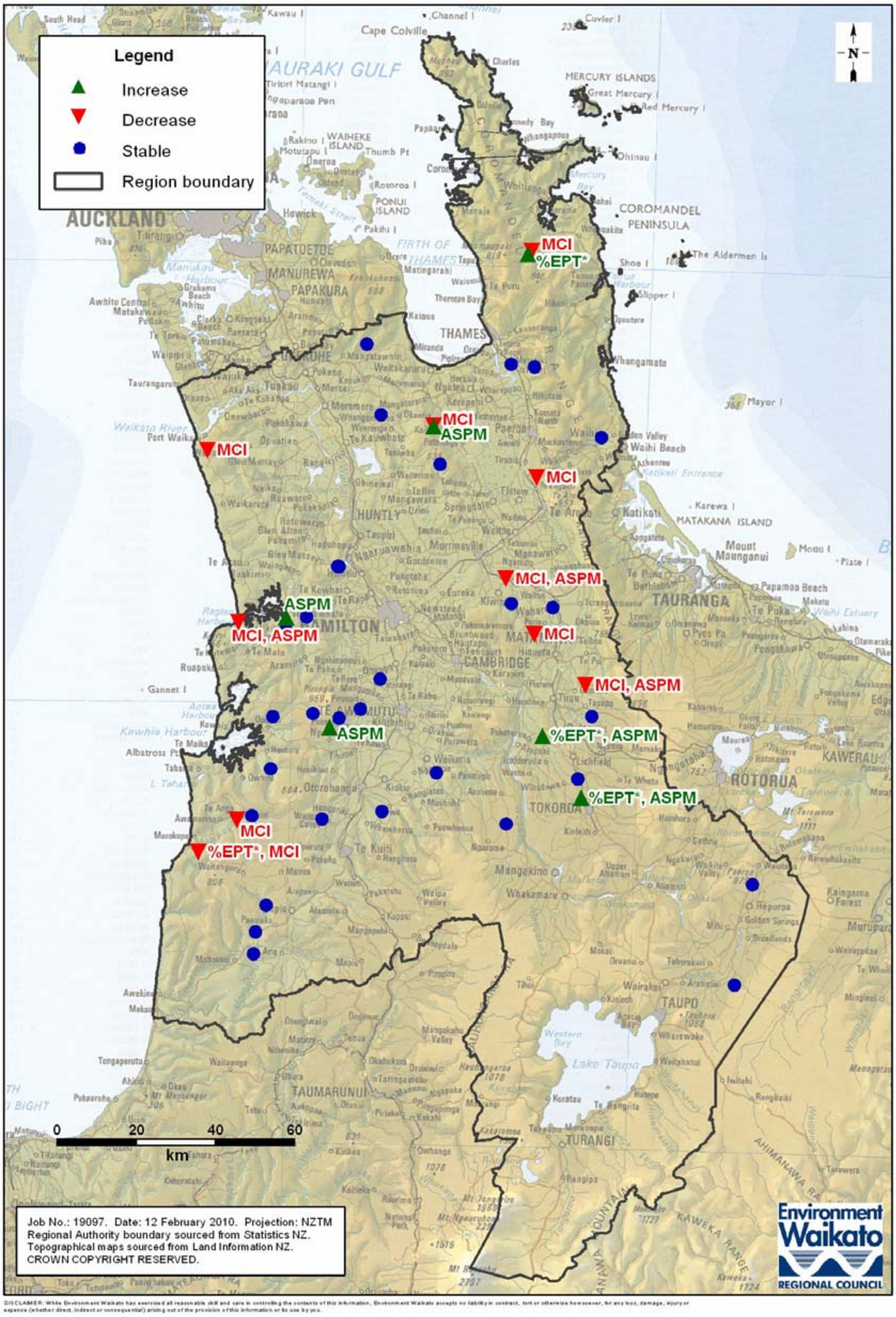

Figure 2: **Location of long-term sites sampled for more that 10 years showing sites where macroinvertebrate metrics were considered 'stable' (no evidence of change over this period; circles), or where increasing (upward pointing triangles) or decreasing (downward pointing triangles) trends were detected in the named metrics.**

Table 3: Summary of temporal trends at non-reference, long-term (>10 years record) sampling sites for three macroinvertebrate metrics not strongly influenced by changes in sample size (see Section 3.1). Empty cells indicate that a trend was not evident for a particular metric and/or analysis. Note that 'ecological relevance' (based on the difference between minimum and maximum values over the sampling period relative that typical at long-term reference sites) should be interpreted with caution.

		%EPT				MCI				ASPM			
Site		Trend	Mann-Kendall	Spearman	Ecologically relevant	Trend	Mann-Kendall	Spearman	Ecologically relevant	Trend	Mann-Kendall	Spearman	Ecologically relevant
1055_3	Torehape Stm@Torehape West Rd					Decrease	Significant	Probable	Yes	Increase		Probable	Yes
1172_6	Wainui Stm (Raglan)@Res. Bridge					Decrease	Significant	Clear	Yes	Decrease	Significant	Probable	Yes
1174_10	Waiomou Stm@Waiomou Rd					Decrease	Significant	Clear	Yes	Decrease		Probable	Yes
1252_3	Waitoki Stm@Rawhiti Rd					Decrease		Probable	Yes				
1257_4	Waiwawa River@U/S Toranoho Stm					Decrease	Significant	Clear	Yes				
1284_1	Whakarautawa Stm@Mangati Rd									Increase	Significant	Probable	Yes
195_1	Huriwai Stm@Waikaretu Rd					Decrease		Probable	Yes				
256_2	Kiritihere Stm@Mangatoa Rd	Decrease	Borderline	Probable	Yes	Decrease		Probable	Yes				
4_2	5 Mile Stm@Off Tapu Coroglen Rd	Increase		Probable	Yes								
407_1	Mangamingi Stm@Paraonui Rd Br	Increase	Significant	Probable	Yes					Increase	Significant	Probable	Yes
433_2	Mangapapa Stm@Henry Watson Rd					Decrease	Borderline		Yes				
539_1	Maunurima Stm@SH22									Increase	Borderline		Yes
749_10	Piako River@Kiwitahi					Decrease	Significant	Clear	Yes	Decrease	Significant	Probable	No
786_2	Pokaiwhenua Stm@Arapuni-Putaruru Rd	Increase	Borderline	Probable	Yes					Increase	Significant	Probable	Yes
976_2	Tawarau River@Speedies Rd					Decrease	Significant	Probable	No				

4.2 Effects of land-cover

4.2.1 Macroinvertebrate metrics

There was a clear and consistent pattern of declining macroinvertebrate metrics with increasing levels of development in the catchment upstream of the sampling site (Figure 3). Marked declines in EPT metrics and ASPM were evident between undeveloped and moderately developed classes, and between highly developed and very highly developed classes. Average metric values were similar between years within the land-cover classes (Figure 3). Repeated measures MANOVA (see Appendix 6 for detailed results) indicated highly significant effects of land-cover class (F = 127.9, P <0.001).

Strong interactions were detected between land-cover class and sampling method (F = 127.9, P <0.001), partly reflecting a predominance of soft-bottomed streams in very highly developed settings and hard-bottomed streams in less developed settings (see also Table 4). A less strong but nevertheless highly significant interaction was detected between land-cover class and zone (F = 3.6, P <0.001), suggesting spatial variation in the magnitude of land-use impacts in different parts of the region (although it is important to bear in mind that the sampling design was not spatially balanced).

A separate analysis of data from 2005/06, when urban streams in Hamilton City were also sampled, indicated that, on average, urban streams were highly degraded (Figure 4), although some urban sites did retain significant ecological values. Significant pairwise differences among all land-cover classes were detected for all metrics. Further discussion of urban stream ecological condition in Hamilton City can be found in Collier et al. (2009).

LOWESS smoothing of scatterplots for the four macroinvertebrate metrics in relation to the proportion of upstream catchment area in indigenous forest or scrub highlighted a rapid decline in %EPT*, MCI and ASPM as this land-cover declined from 100 to 80% of catchment area. This was followed by another marked reduction in all metrics when upstream forest/scrub cover declined below around 60% of upstream catchment area (Figure 5), equivalent to 40% of catchment area developed. These patterns were generally consistent among years.

The regression TREES analysis performed across all years' data also highlighted the association between land-cover in the upstream catchment as well as at the stream segment scale and macroinvertebrate metrics (Figure 6). For the land-cover variables the proportion of upstream area in pasture (EPT* taxa richness only), and the percentage indigenous forest and scrub in the catchment of the stream segment on which the sampling site occurred (all metrics), were highlighted as important variables. The thresholds at which separations in the data were identified in the regression TREES analysis were 50% of upstream catchment area in pasture for EPT* richness, and 57% of segment catchment area in forest and scrub for other metrics (Figure 6).

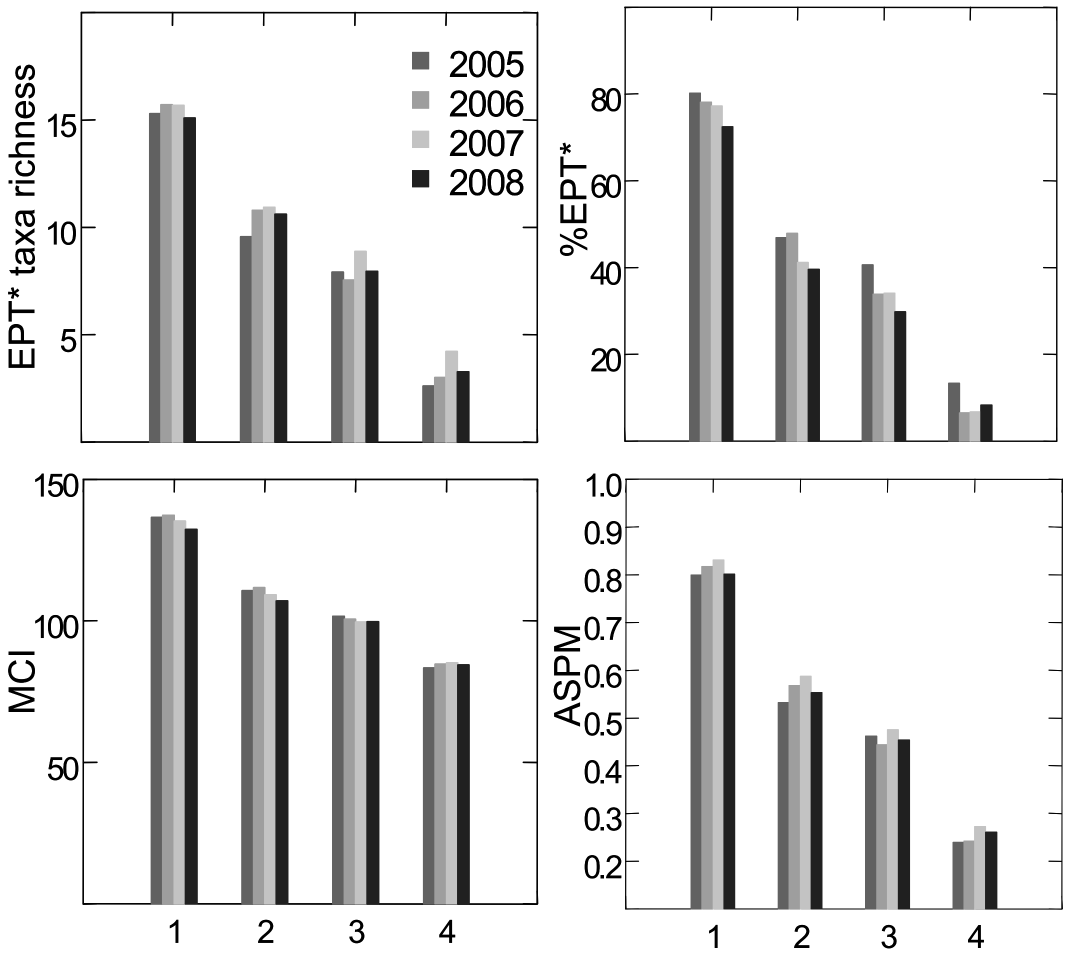

Figure 3: **Average macroinvertebrate metric scores for each year in streams draining four catchment land-cover classes. 1 = undeveloped (reference), 2 = moderately-developed; 3 = highly-developed; 4 = very highly-developed.**

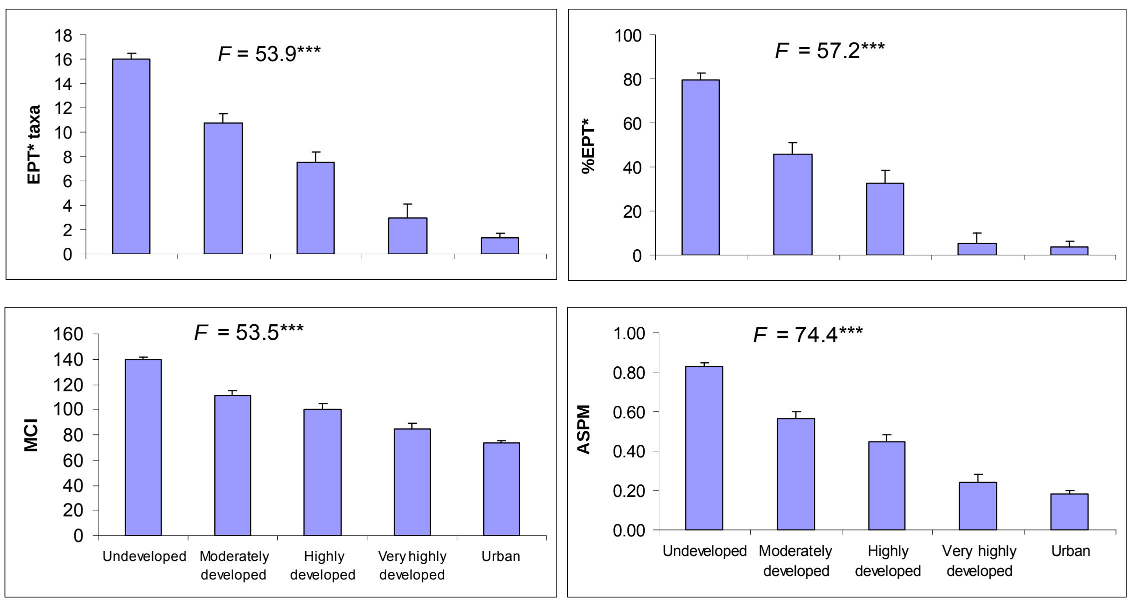

Figure 4: **Average (+1SE) metric values for undeveloped sites, three levels of catchment development (see text), and urbanised sites in Hamilton City sampled in the summer of 2005/06. *** = P <0.001 for ANOVA testing for effect of land-cover class.**

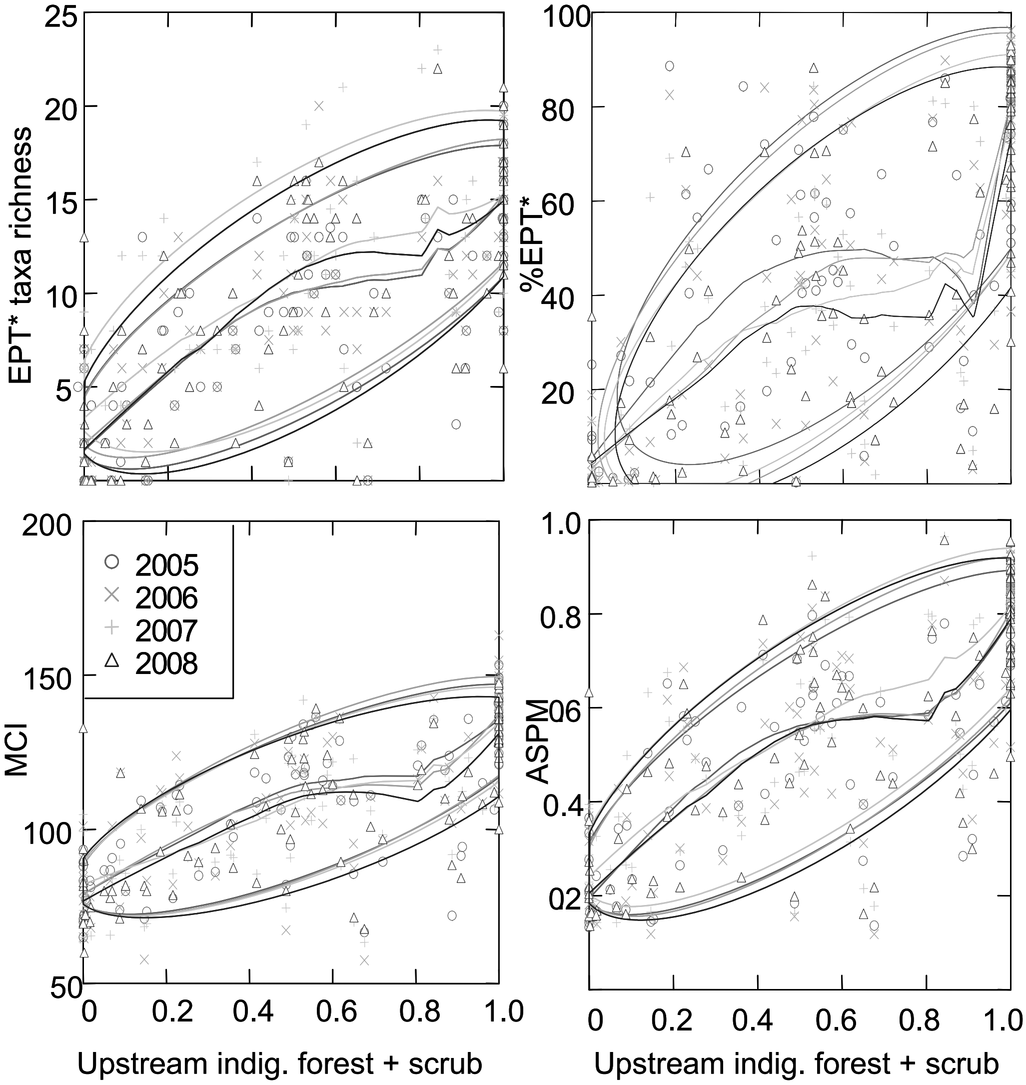

Figure 5: **Relationships between the proportion of upstream catchment area in indigenous forest and scrub (derived from the Freshwaters of New Zealand (FWENZ) database) and four macroinvertebrate metrics measured at 'land-cover sites' in the REMS network over four years. LOWESS curves and sample ellipses (*P* = 0.68) are also shown. For reference sites, pastoral and exotic forest classes assigned by FWENZ were converted to indigenous forest to represent the actual character of catchments upstream of sampling points.**

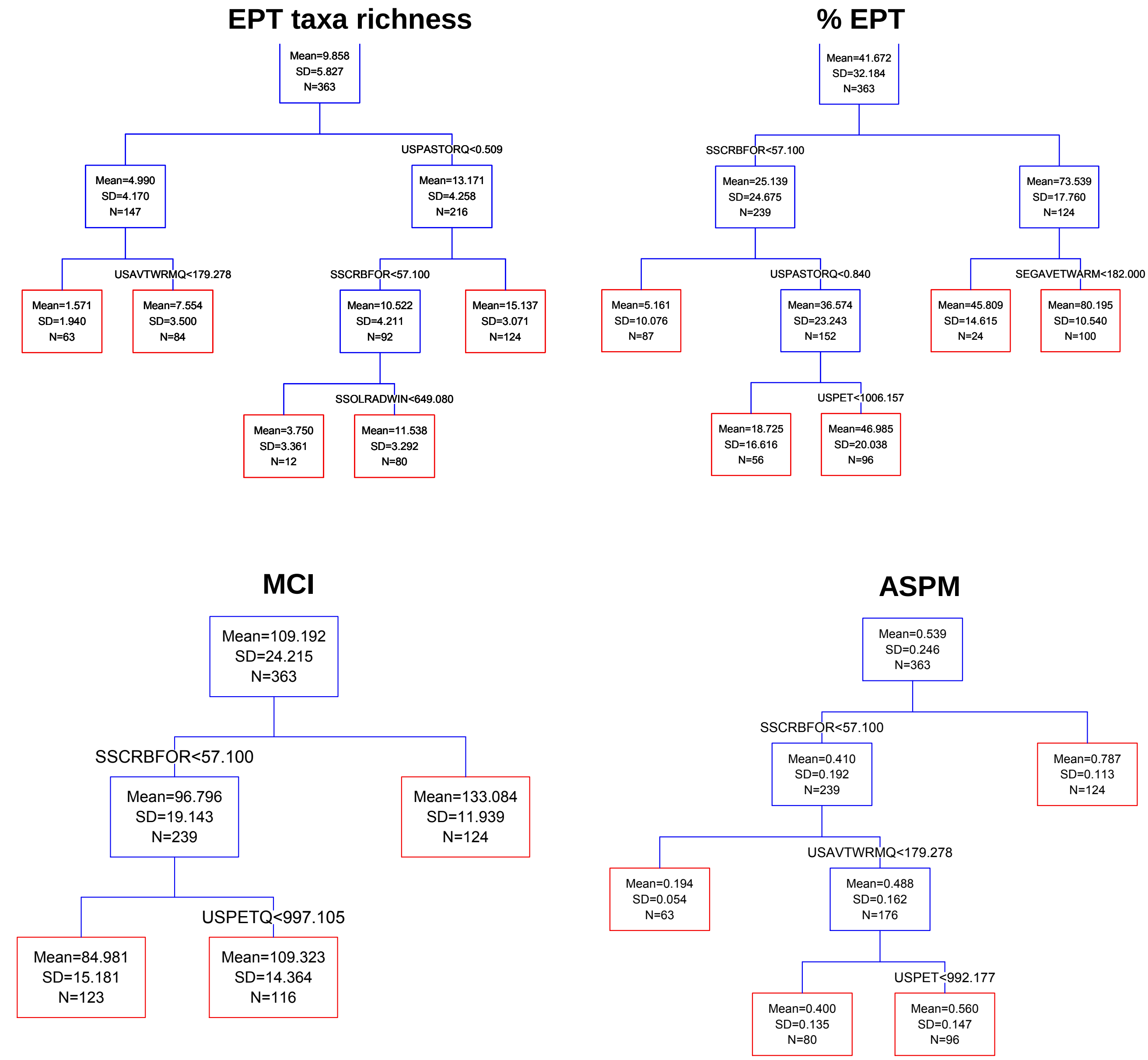

Figure 6: **Regression TREE analysis identifying natural splits in FWENZ environmental variables in relation to four macroinvertebrate metrics. For environmental variables: S preceding name = segment variable; US preceding name = upstream variable, Q following variable name = flow-weighted; SCRBFOR = combination of FWENZ indigenous forest + scrub variables; PASTOR = pasture; AVTWARM = average mean January air temperature; SOLRADWIN = average June solar radiation; PET = mean annual potential evapotranspiration.**

Table 4: **Summary statistics (number of cases, mean and standard error) for macroinvertebrate community metrics and habitat scores for 'hard'- and 'soft'-bottomed streams at sites with three levels of upstream pastoral cover (see text), and urbanised sites in Hamilton city sampled over 2005/06.**

	EPT* richness	%EPT*	MCI	ASPM	Habitat score
Moderately-developed, hard-bottomed					
N of cases	22	22	22	22	22
Mean	10.8	48.3	111.7	0.6	109.1
Std. Error	0.8	5.3	4.0	0.0	3.5
Moderately-developed, soft-bottomed					
N of cases	2	2	2	2	2
Mean	10.5	18.8	111.5	0.5	96.8
Std. Error	2.5	15.8	4.8	0.1	7.8
Highly-developed, hard-bottomed					
N of cases	18	18	18	18	18
Mean	8.9	37.4	105.7	0.5	108.6
Std. Error	0.8	6.3	4.2	0.0	3.8
Highly-developed, soft-bottomed					
N of cases	7	7	7	7	7
Mean	4.0	20.0	87.3	0.3	103.1
Std. Error	1.1	12.0	7.1	0.1	3.2
Very highly-developed, hard-bottomed					
N of cases	3	3	3	3	3
Mean	6.7	12.0	92.0	0.3	95.7
Std. Error	0.3	4.2	4.8	0.0	7.3
Very highly-developed, soft-bottomed					
N of cases	14	14	14	14	14
Mean	2.2	3.9	83.2	0.2	81.1
Std. Error	0.7	2.2	4.8	0.0	6.2
Urban, hard-bottomed					
N of cases	4	4	4	4	4
Mean	2.8	16.7	76.9	0.3	116.8
Std. Error	1.8	15.7	8.8	0.1	4.2
Urban, soft-bottomed					
N of cases	21	21	21	21	21
Mean	1.1	1.1	72.5	0.2	85.3
Std. Error	0.3	0.4	2.2	0.0	3.8

4.2.2 Instream plant metrics

Periphyton and macrophyte cover and proliferation metrics generally increased in relation to land-cover class, although there was considerable variability between years (Figure 7). This pattern was most noticeable for macrophytes which are often characteristic of low-gradient pastoral streams. Instream plant growth responds to a range of factors including nutrient and light levels, and can also be strongly influenced by preceding flows such as the time since the last flood and the duration of stable flows. Repeated measures MANOVA (see Appendix 7 for detailed results) indicated highly significant effects of land-cover class (F = 66.1, P <0.001), and strong interactions between these effects and zone (F = 3.5, P <0.001), suggesting spatial variation for instream plant responses to land-cover classes in different parts of the region. Significant effects of year and interactions among sampling year, land-cover class and zone were evident (Appendix 7).

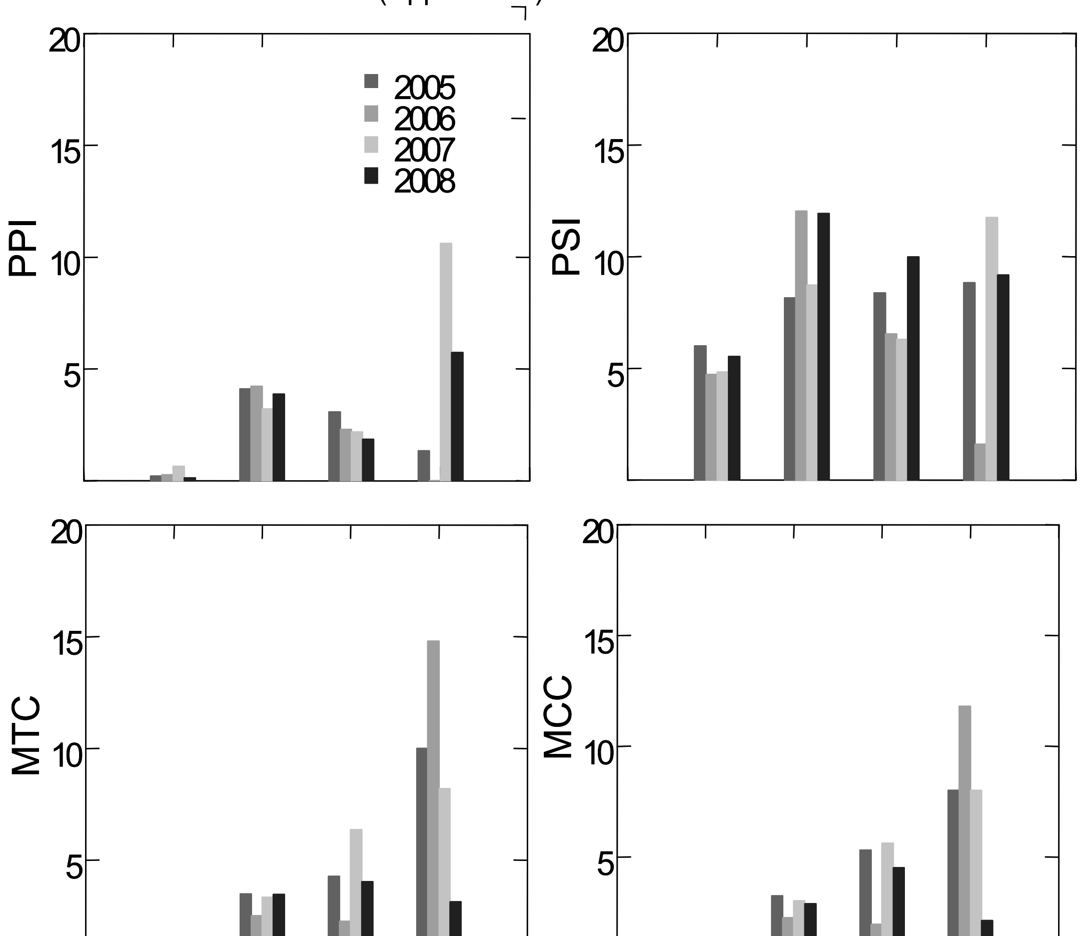

Figure 7: Average metric scores for aquatic plant cover and proliferation for each year in streams draining four catchment land-cover classes. 1 = undeveloped, 2 = moderately-developed; 3 = highly-developed; 4 = very highly-developed. PPI = Periphyton Proliferation Index; PSI = Periphyton Slimyness Index; MTC = Macrophyte Total Cover; MCC = Macrophyte Channel Clogginess (see Collier et al. 2006 for further details).

4.2.3 Habitat quality

Habitat quality scores were highest at reference sites, and generally declined with land-cover class, although average differences between moderately-developed and highly-developed sites were small (Figure 8). Highly significant effects were evident for land-cover class on habitat quality score (Generalised Linear Model; *F* = 206.4, *P* <0.001), and significant interactions were detected between these effects and zone (*F* = 3.2, *P* <0.001), suggesting spatial variation in habitat quality responses to land-cover classes in different parts of the region. Habitat quality scores explained 49–57% of variability in macroinvertebrate metrics (Figure 9).

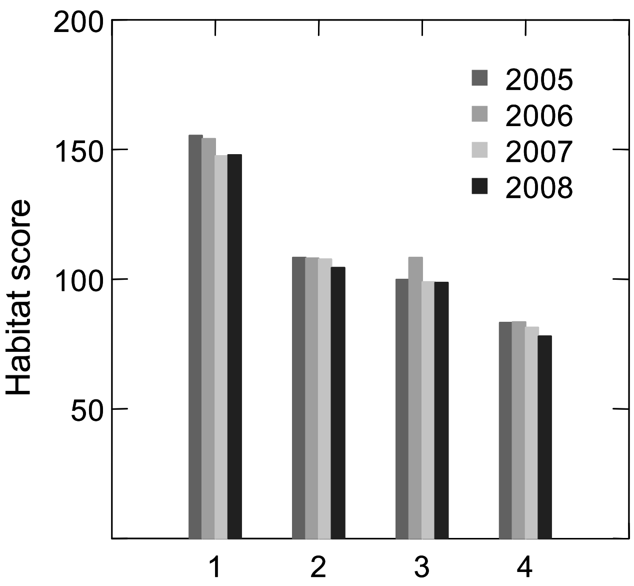

Figure 8: Average habitat quality scores for each year in streams draining four catchment land-cover classes. 1 = undeveloped, 2 = moderately-developed; 3 = highly-developed; 4 = very highly-developed.

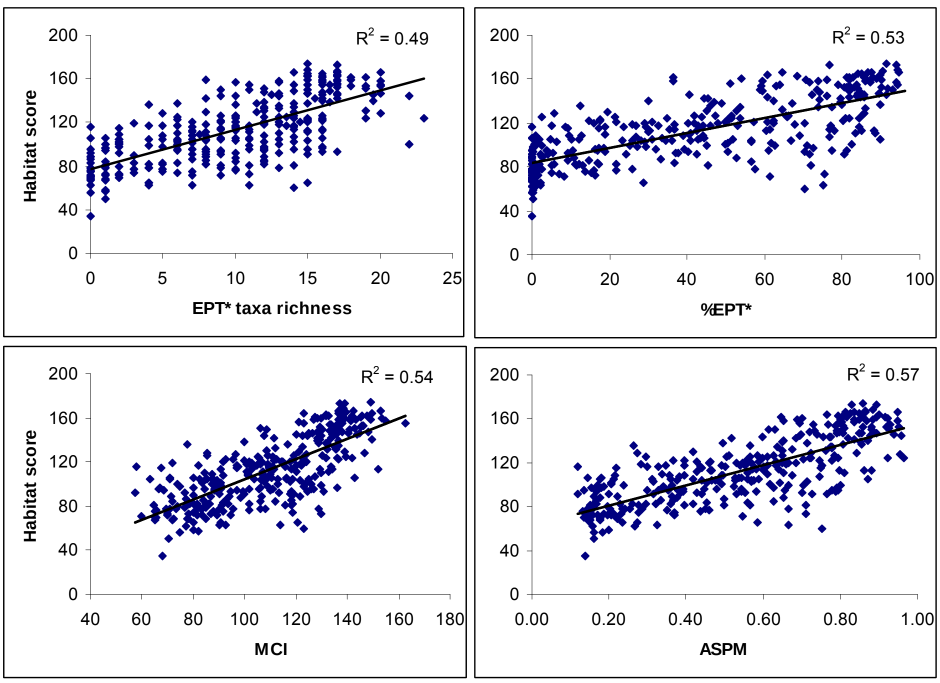

Figure 9: Relationships between habitat quality scores and macroinvertebrate metrics for all REMS data combined.

5 Discussion

5.1 Temporal trends

Around two-thirds of long-term sites were considered 'stable' in terms of macroinvertebrate indicators, similar to the analysis of Collier and Kelly (2005) who found around three-quarters of long-term sites had not changed consistently over the 8–10 years of monitoring data available at that time using the stratified Spearman approach. A range of factors can contribute to progressive changes in ecological condition over time—these factors are both natural and human-induced and can influence water quality and habitat quality. Indeed habitat quality explained almost half of the variation in metric values recorded—the remaining variation can potentially be attributed to other factors including water quality changes, biotic interactions such as effects of introduced species, flow regime and underlying natural environmental variation. Natural processes causing temporal trends include recovery from a major disturbance event such as a large flood, and long-term climatic changes such as increasing magnitude of low flows or increasing water temperatures. Changing climatic patterns occur over large spatial scales, and there is no evidence to suggest that they have consistently influenced reference sites where human induced factors are largely absent, although only three reference sites are currently available for long-term data analyses.

Potential human causes of trends at developed sites may include increasing land-use intensification, or remediation efforts such as fencing and planting. Analyses were conducted to investigate any relationships between observed trends in the REMS dataset and (i) the number of consents (discharges to and takes from water from Environment Waikato's RUAMS authorisation database), (ii) catchment stock unit density (using Agribase) upstream of sampling sites for 2001, 2004 and 2007, (iii) changes in catchment or site conditions, (iv) trends in water quality variables identified in the Environment Waikato water quality monitoring network (see Appendix 8), and (v) trends in habitat quality. No pattern was evident in relation to trend classes and consent numbers. Analysis of stock numbers suggested that sites considered stable or decreasing in ecological condition had experienced increases in stock unit density over the monitoring period, whereas those showing increases in condition typically or on average did not experience an increase in stock numbers (Appendix 8).

Few catchment or site changes were evident that corresponded to REMS trends, although stream widening and increased residential development were suggested in one catchment experiencing a decrease in trends, and increases in shading or fencing riparian vegetation growth were evident at two sites experiencing increases in condition (Appendices 8 and 9). Limited data on water quality trends were available for sites experiencing positive or negative REMS trends, and many sites that appeared stable ecologically had changing water quality trends (Appendix 8). This may partly reflect the fact that thresholds of water quality change need to be surpassed to initiate ecological responses. Limited data were available to assess trends in habitat quality, but preliminary analyses indicate trends in both macroinvertebrate metrics and habitat quality occurred for at least four sites (786_2, 407_1, 1284_1 and 1172_6). For the first three of these sites, improving ecological condition was associated with improving habitat quality. At site 1172_6 there was improving habitat quality associated with the growth of riparian plantings, but ecological condition apparently declined based on the macroinvertebrate metrics assessed (see below). Another six sites suggested improving reach-scale habitat quality (data not shown) but no ecological response, indicating that other factors may be constraining biological communities.

The cause(s) of the declining trend at site 1172_6 following riparian planting are not clear, but examination of aerial WRAPS photos indicates increased residential development over 2002–07 (see Appendices 8 and 9). Parkyn et al. (2004) did not detect a consistent positive ecological response based on macroinvertebrate community indicators following riparian planting 2–24 years earlier at various sites around the Waikato, despite improvements in water clarity and channel stability. They suggested that ecological responses may be dependent on having long buffer lengths and protecting headwater tributaries, and highlighted the need for long timescales and spatial planning to achieve expected restoration outcomes. It has also been reported elsewhere that riparian planting can initially lead to a period of bank instability and potentially declining ecological condition from sedimentation until a new 'shaded' channel morphology is achieved (Davies-Colley 1997; Collier et al. 2001). In support of this, local reports suggest that stream widening has occurred at this site over recent years (see Appendix 8). The declining MCI at a nearby reference site may also indicate that some larger-scale phenomena unrelated to human factors may have influenced changes at site 1172_6, highlighting the value of a reference site network for interpreting results. Follow-up sampling is being conducted in this catchment to investigate potential causes of decline further.

Collectively, these analyses suggest that mechanisms contributing to temporal trends in macroinvertebrate metrics can be varied and complex. Factors potentially influencing the direction and magnitude of trends include changes in land-use intensity, increased influence of residential development, increases in upstream or localised erosion, and the extent of riparian fencing and planting. The sensitivity of metrics to different combinations of multiple stressors or remedial actions is likely to be behind some metrics but not others displaying significant trends. Constraints to ecological improvement at sites where riparian planting has occurred may include continuing high water temperatures reflecting lack of shade upstream, and the absence of a nearby source of macroinvertebrate colonists where the entire upstream catchment has been developed. The increasing trend in some metrics at one reference site reflected a shift in sampling location (125_4/15), whereas the causes of the declining trend in MCI at another reference site are unknown but could potentially include effects from localised climatic events or the influence of mammalian pests in the upstream catchment. The significance of temporal trends at the long-term sites should become more apparent with continued sampling.

5.2 Land-cover relationships

Results of the REMS sampling reinforce findings from other studies that demonstrate a relationship between the extent of development in a catchment and the ecological condition of the streams draining them (e.g., Quinn and Hickey 1990; Harding et al. 1999; Black et al. 2004; Niyogi et al. 2007a; Wang et al. 2008). The REMS sampling over 2005–08 did not include streams significantly influenced by production forestry which typically provides shaded conditions similar to those in reference streams over much of the rotation. Forestry streams experience a short period of high disturbance during harvesting, or more extended disturbance when catchment clearance exceeds a particular level, followed by a period of recovery that can range from a few to several years as shade is re-established (Harding et al. 2000; Collier and Smith 2005).

The focus of the recent REMS sampling has been on sites surrounded by agriculture where catchment conditions are relatively constant over time. Instream effects of agriculture can include erosion and sedimentation, nutrient enrichment and increased light levels due to riparian disturbance—all of these factors were identified as the most widespread stressors in USA wadeable streams by Paulsen et al. (2008). Increased light levels coupled with nutrient enrichment can lead to increased growth of instream plants, as indicated for increasing levels of catchment development in the REMS results (Figure 5). However, the results for plant cover were more variable than for macroinvertebrates, in part reflecting their greater sensitivity to preceding flow conditions, and potentially the effects of spraying and mechanical clearing. It is also likely that streams with higher levels of catchment development had lower channel gradients where hydraulic regulation of plant biomass was less marked.

Some studies have reported a subsidy-stress response to agricultural impacts whereby a small level of catchment development can increase macroinvertebrate metrics by increasing habitat and trophic diversity while maintaining high water quality (Quinn 2000; Niyogi *et al.* 2007b). Recent studies have also highlighted the importance of local-scale (e.g., riparian) as well as catchment-scale vegetation cover in moderating the effects of land-use (e.g., Kratzner *et al.* 2006; Niyogi *et al.* 2007a). Black & Munn (2004) identified forested land-cover optima of 70–80% for macroinvertebrate metrics, similar to the 80–90% upstream native vegetation cover associated with MCI values indicative of clean water quality for Waikato streams sampled in 2006 (Death & Collier 2009). Death & Collier (2009) also suggested a secondary land-cover threshold of 40–60% upstream native vegetation cover to retain 80% of the mean biodiversity present in reference sites.

Analysis of the four years of REMS land-cover data in this report highlighted a rapid decline in invertebrate metrics as upstream forest/scrub cover declined, and indicated that the compositional and tolerance metrics in particular were sensitive to changes in land-cover below forested areas. Assessment of four years' data suggested dual land-cover thresholds, with a rapid decline for most macroinvertebrate metrics evident as upstream catchment cover by forest/scrub declined from 100% to 80% (Figure 5). This initial decline was followed by another rapid decline in metrics below around 60% forest/scrub cover upstream (Figure 5). Regression TREES supported the importance of upstream vegetation cover (forest and scrub) in influencing the number of sensitive taxa present, and also highlighted segment-scale land-cover over upstream land-cover in affecting composition and tolerance metrics. The primary split for most metrics of around 60% of segment area in forest and scrub was similar to the level of upstream land cover evident in the scatterplots (Figure 5). Further testing of these land-cover relationships will be developed from a new REMS study design incorporating randomly selected site locations (see following section).

In summary, the decline in macroinvertebrate metrics with increasing primarily agricultural land-cover was clear and consistent across the four-year study period. Declines in condition occurred rapidly with the onset of catchment development, and were most severe when over 40-50% of the catchment was developed. When urban sites were examined, they were on average more degraded than sites in pastoral catchments, largely reflecting the well-known effects of stormwater on urban stream health (Walsh et al. 2005), although some high value sites remained in Hamilton City. Towns and cities represent only a small percentage of land-cover in the Waikato region (around 1%) compared to pasture (58%), so the net effect of urbanisation on regional stream health is much less than for agricultural development.

5.3 Revised study design

Prior to 2005, the REMS sampling sites were selected for a variety of purposes, including to provide a broad geographic spread, to overlap with water quality flow recording sites, or to monitor conditions or activities at specific sites. The REMS study design over 2005–08 built on this initial dataset to include sampling of (i) a 'reference site' network spread around the region to provide baseline information for interpreting the magnitude of impacts, (ii) a set of 'long-term sites' that have been sampled for mostly historical reasons, (iii) several sites that have had riparian planting or where it is planned, and (iv) a series of sites stratified by zone with different levels of upstream pastoral development (land-cover sites). Over the years, some sites have served dual roles; for example some pastoral development, restoration or reference sites have also been long-term sites. Four years' data have now been collected for the pastoral development study, as analysed in this report, and this is considered sufficient to determine patterns related to land-cover. Furthermore, many of the long-term sites appear stable in terms of the metrics assessed, and therefore do not warrant continued sampling on an annual basis.

Survey designs that involve random selection of sites with known probabilities of inclusion, so-called ‘probabilistic designs’, are now used in the USA to determine the extent and condition of wadeable streams following acknowledgement that previous designs did not adequately describe the condition of waterways (Shapiro et al. 2008). Based on lessons learned from the USA (Hughes & Peck 2008) and the recent demonstration of the value of probabilistic survey designs for quantifying the features, extent and condition of wadeable streams (Olsen & Peck 2008; Paulsen et al. 2008), changes were made to the REMS programme commencing in 2009. These changes aimed to maintain key elements of the existing survey design (reference site network, restoration sites, long-term sites showing change) while incorporating a set of sites conforming to a probabilistic design that would provide an unbiased estimate of the extent and condition of non-reference, non-tidal, perennial, wadeable stream length in the Waikato region. This subset of randomly selected sites replaces the ‘land-cover sites’ analysed in this report, although the focus remains on streams in catchments with some level of development since the condition of undeveloped streams in general is derived from the reference site network sampled every year (i.e., sites in entirely native forested catchments are considered ‘non-target’ for random site selection).

The revised survey design involves sampling 60 new randomly selected sites over each of three years commencing in 2009, after which the initial set of random sites is re-sampled. This three-year ‘rotating panel’ design increases the spatial spread and therefore the reliability of regional stream condition estimates for developed catchments, and over time will provide an assessment of temporal trends in wadeable stream condition. Thus, from 2009, the REMS survey sites sampled annually over summer (January-March) comprise:

- 60 randomly selected sites in developed catchments (sampled on a three-year rotating basis);
- 23 sites in undeveloped catchments (‘reference site’ network) sampled annually (these include 3–4 ‘index sites’ sampled at the beginning and end of the sampling frame to determine any changes that occurred naturally during this period);
- eight ‘restoration sites’ where riparian management has been carried out or is planned (sampled annually);
- 27 ‘long-term sites’ that include three reference sites and six restoration sites sampled annually (except for five sites that are sampled on a rotating basis biannually).

6 Conclusions

- Of the 43 non-reference 'long-term sites' sampled, around one-third were interpreted as showing trends over time using two methods of analysis, and two-thirds appeared 'stable' over time. Collectively around 15% of these sites showed evidence of improving condition and 20% showed evidence of declining condition. The reasons for these trends are expected vary between sites, and may include effects of erosion, land-use intensification, and riparian fencing and planting.

- There was a clear and consistent pattern over multiple years (2005–08) of declining ecological condition with increasing levels of development in catchments upstream of sampling sites. The ecological condition of sites in developed catchments declined significantly between levels of moderate (10–49% of upstream catchment area), high (50–90%) and very high (>90%) development. Declines in condition occurred rapidly with the onset of catchment development, and were most severe when over 40–50% of the catchment was developed.

- Urban streams had lower ecological condition than agricultural streams when sampled in 2005/06, although some high quality sites were found within Hamilton City. Towns and cities represent around 1% of land-cover in the Waikato region compared to 58% for pasture, so the net effect of urbanisation on regional stream health is much less than for agricultural development.

- Habitat quality scores declined significantly across catchment development classes, most noticeably between undeveloped to moderately developed, and highly developed to very highly developed classes. Habitat quality scores were significantly related to all macroinvertebrate metrics, suggesting that ecological condition as reflected by macroinvertebrate communities is a function of habitat quality as well as water quality.

- A revised REMS sampling design incorporating random selection of sites with known probabilities of inclusion ('probabilistic design') will enable unbiased estimates to be determined of the features, condition and extent for non-tidal, perennial, wadeable streams draining developed catchments in the Waikato region.

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Appendix 1: Effects of sampling protocols

Some REMS sites contained a mix of stony and sand/silt substrates that could be sampled using either ‘hard’- or ‘soft’-bottomed protocols. In these situations both methods were used to assess the effects on invertebrate metrics using the different protocols. Paired t-tests were used to compare macroinvertebrate metrics where samples had been collected from ‘hard’ (stones) and soft (wood, banks, macrophytes) substrates at the same time in the same streams. The sites were separated into undeveloped sites (*n* = 26 per year over 2005–08) and reference sites (*n* = 3 per year).

Comparisons of samples collected from ‘hard’ and ‘soft’ substrates in the same streams indicated that metric values were similar on the different substrate types within years in both undeveloped and developed sites. Similarities were greatest for MCI whereas EPT metrics tended to higher on hard substrates. However, this difference was only significant for EPT* richness and ASPM at developed sites in one year.

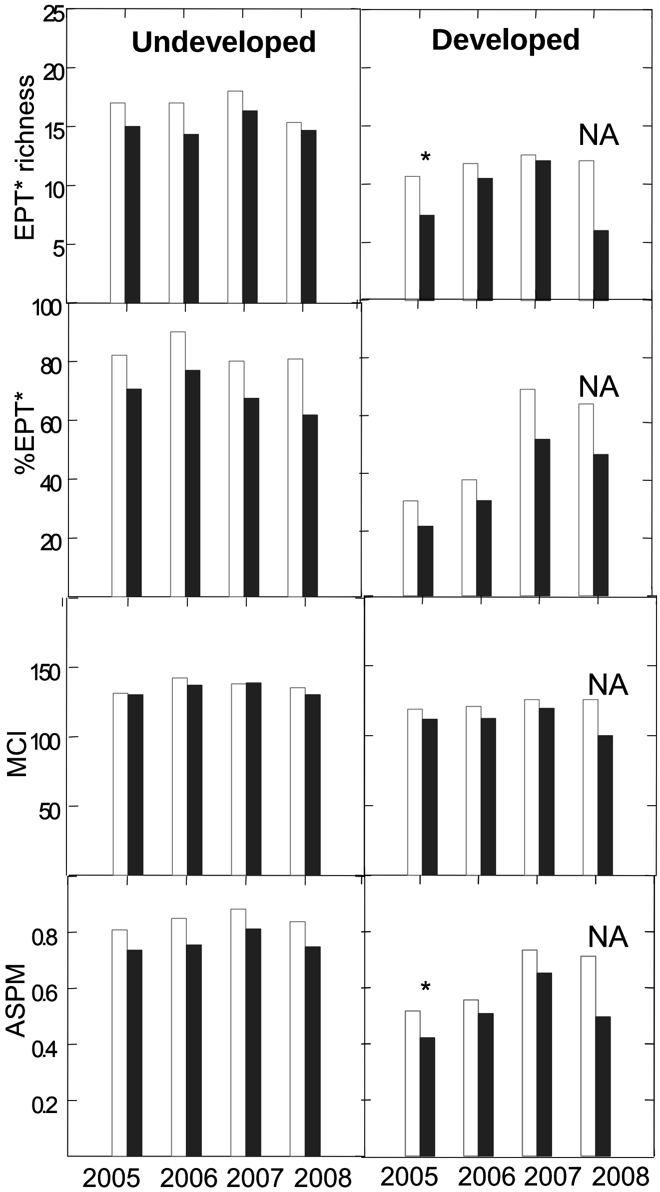


Figure A: Comparison of metrics from hard and soft bottom (hard = white bars, soft = dark bars) samples collected at the same sites in undeveloped and developed sites sampled over four years. n = 3 per year for undeveloped sites and 2–6 per year for developed sites except for 2008 when only one paired sample was taken. * = difference significant at P <0.05 using paired t-test (NA = statistical test not possible due to low sample size).

Appendix 2: Kendall-Mann trend analyses for %EPT*, MCI and ASPM calculated from the computer program TimeTrends v. 1.10 (2008).

For P values, Red = significant and Bold = borderline

Mann-Kendall test for Group 1055_2 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1055_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	16.15	-10.00	212.67	-0.62	0.54	-0.46	-1.79	0.73

Mann-Kendall test for Group 1055_3 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
13 observations from 1/01/96 to 1/01/08 with 0 ties

1055_3	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	81.00	14.00	268.67	0.79	0.43	0.51	-0.53	1.67

Mann-Kendall test for Group 1158_7 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1158_7	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	55.53	12.00	212.67	0.75	0.45	0.25	-1.65	3.33

Mann-Kendall test for Group 1172_6 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
13 observations from 1/01/96 to 1/01/08 with 1 ties

1172_6	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	38.00	-31.00	267.67	-1.83	0.07	-2.71	-3.70	-0.38

Mann-Kendall test for Group 1174_10 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1174_10	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	47.29	-8.00	212.67	-0.48	0.63	-1.46	-3.56	1.36

Mann-Kendall test for Group 1247_3 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1247_3	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	25.10	-16.00	212.67	-1.03	0.30	-1.42	-3.48	1.24

Mann-Kendall test for Group 1249_15 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1249_15	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	5.47	4.00	212.67	0.21	0.84	0.18	-1.15	0.95

Mann-Kendall test for Group 124_4 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 1 ties

124_4	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	13.00	18.00	164.00	1.33	0.18	1.93	-0.28	4.41

Mann-Kendall test for Group 1252_3 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
13 observations from 1/01/96 to 1/01/08 with 0 ties

1252_3	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	7.00	-8.00	268.67	-0.43	0.67	-0.25	-1.87	0.96

Mann-Kendall test for Group 1253_9 for %EPT*
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
11 observations from 1/01/97 to 1/01/08 with 0 ties

1253_9	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	18.88	3.00	165.00	0.16	0.88	0.37	-3.03	3.57

Mann-Kendall test for Group 1257_4 for %EPT*
Starting month = January
Period analysed 10 years and 1 months from 1998 to 2008
11 observations from 1/01/98 to 1/01/08 with 0 ties

1257_4	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	64.06	9.00	165.00	0.62	0.53	0.26	-1.17	3.50

Mann-Kendall test for Group 125_4 for %EPT*
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
11 observations from 1/01/97 to 1/01/08 with 1 ties

125_4	Median value	Kendall statistic	Variance	Z	**P**	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	70.79	28.00	164.00	2.11	**0.04**	1.60	0.22	3.71

Mann-Kendall test for Group 1284_1 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1284_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	79.35	24.00	212.67	1.58	0.11	4.26	-0.04	7.82

Mann-Kendall test for Group 1293_8 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 5 ties

1293_8	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.47	-13.00	195.00	-0.86	0.39	-0.01	-0.19	0.03

Mann-Kendall test for Group 1414_1 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1414_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	91.74	-2.00	212.67	-0.07	0.95	-0.12	-0.76	0.58

Mann-Kendall test for Group 195_1 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 0 ties

195_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	49.88	-5.00	165.00	-0.31	0.76	-0.14	-3.98	4.02

Mann-Kendall test for Group 220_1 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

220_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	61.44	4.00	212.67	0.21	0.84	0.37	-1.59	2.77

Mann-Kendall test for Group 23_2 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

23_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	27.41	8.00	212.67	0.48	0.63	0.57	-3.28	4.66

Mann-Kendall test for Group 240_5 for %EPT*
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
11 observations from 1/01/97 to 1/01/08 with 0 ties

240_5	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	63.00	1.00	165.00	0.00	1.00	0.31	-8.38	5.42

Mann-Kendall test for Group 256_2 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

256_2	Median value	Kendall statistic	Variance	Z	**P**	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	9.06	-30.00	212.67	-1.99	**0.05**	-0.85	-2.41	-0.14

Mann-Kendall test for Group 365_1 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

365_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	52.37	8.00	212.67	0.48	0.63	0.48	-1.63	3.81

Mann-Kendall test for Group 36_1 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 0 ties

36_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	43.24	-9.00	165.00	-0.62	0.53	-1.39	-4.21	3.78

Mann-Kendall test for Group 407_1 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 0 ties

407_1	Median value	Kendall statistic	Variance	Z	**P**	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	18.00	29.00	165.00	2.18	**0.03**	3.36	0.85	6.69

Mann-Kendall test for Group 413_2 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
13 observations from 1/01/96 to 1/01/08 with 0 ties

413_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	52.85	14.00	268.67	0.79	0.43	2.58	-1.50	4.43

Mann-Kendall test for Group 428_3 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

428_3	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	23.89	-12.00	212.67	-0.75	0.45	-1.09	-3.50	1.32

Mann-Kendall test for Group 428_5 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
10 observations from 1/01/96 to 1/01/08 with 0 ties

428_5	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	45.17	1.00	125.00	0.00	1.00	0.11	-2.37	3.96

Mann-Kendall test for Group 429_3 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 9 ties

429_3	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.00	-1.00	87.67	0.00	1.00	0.00	0.00	0.00

Mann-Kendall test for Group 433_2 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

433_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	34.54	12.00	212.67	0.75	0.45	0.96	-1.64	3.61

Mann-Kendall test for Group 453_8 for %EPT*
Starting month = January
Period analysed 13 years and 1 months from 1995 to 2008
12 observations from 1/01/95 to 1/01/08 with 0 ties

453_8	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	34.67	-2.00	212.67	-0.07	0.95	-0.14	-2.36	2.06

Mann-Kendall test for Group 476_1 for %EPT*
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
12 observations from 1/01/97 to 1/01/08 with 0 ties

476_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	30.27	4.00	212.67	0.21	0.84	0.73	-1.64	3.04

Mann-Kendall test for Group 477_14 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 1 ties

477_14	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	88.12	15.00	211.67	0.96	0.34	0.38	-0.54	1.37

Mann-Kendall test for Group 477_5 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

477_5	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	38.23	16.00	212.67	1.03	0.30	1.95	-2.61	5.00

Mann-Kendall test for Group 481_11 for %EPT*
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
11 observations from 1/01/97 to 1/01/08 with 0 ties

481_11	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	26.78	-9.00	165.00	-0.62	0.53	-0.41	-3.68	2.26

Mann-Kendall test for Group 493_1 for %EPT*
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
12 observations from 1/01/97 to 1/01/08 with 1 ties

493_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.96	-25.00	211.67	-1.65	0.10	-0.22	-0.64	0.00

Mann-Kendall test for Group 495_1 for %EPT*
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
11 observations from 1/01/97 to 1/01/08 with 0 ties

495_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	49.01	1.00	165.00	0.00	1.00	0.09	-3.75	3.73

Mann-Kendall test for Group 4_2 for %EPT*
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
11 observations from 1/01/97 to 1/01/08 with 0 ties

4_2	Median value	Kendall statistic	Variance	Z	**P**	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	66.00	27.00	165.00	2.02	**0.04**	3.94	1.07	5.86

Mann-Kendall test for Group 514_1 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

514_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	38.89	-4.00	212.67	-0.21	0.84	-0.51	-3.47	4.87

Mann-Kendall test for Group 531_4 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

531_4	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	17.56	-16.00	212.67	-1.03	0.30	-0.99	-3.06	1.05

Mann-Kendall test for Group 539_1 for %EPT*
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
12 observations from 1/01/97 to 1/01/08 with 0 ties

539_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	26.50	28.00	212.67	1.85	0.06	3.14	0.38	5.29

Mann-Kendall test for Group 556_9 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 0 ties

556_9	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	30.27	7.00	165.00	0.47	0.64	1.08	-1.74	3.54

Mann-Kendall test for Group 619_20 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

619_20	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	20.83	24.00	212.67	1.58	0.11	1.70	-0.03	3.15

Mann-Kendall test for Group 749_10 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 6 ties

749_10	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.00	-17.00	168.33	-1.23	0.22	0.00	-0.12	0.00

Mann-Kendall test for Group 753_7 for %EPT*
Starting month = January
Period analysed 13 years and 1 months from 1995 to 2008
12 observations from 1/01/95 to 1/01/08 with 0 ties

753_7	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	23.00	-24.00	212.67	-1.58	0.11	-1.89	-3.66	0.99

Mann-Kendall test for Group 786_2 for %EPT*
Starting month = January
Period analysed 13 years and 1 months from 1995 to 2008
13 observations from 1/01/95 to 1/01/08 with 1 ties

786_2	Median value	Kendall statistic	Variance	Z	**P**	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	38.00	33.00	267.67	1.96	**0.05**	4.50	0.69	7.14

Mann-Kendall test for Group 786_22 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 0 ties

786_22	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	34.43	9.00	165.00	0.62	0.53	1.67	-3.20	8.83

Mann-Kendall test for Group 976_2 for %EPT*
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 0 ties

976_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	28.00	-1.00	165.00	0.00	1.00	-0.03	-0.98	1.86

Mann-Kendall test for Group 1055_2 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1055_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	98.75	-20.00	212.67	-1.30	0.19	-0.69	-1.61	0.18

Mann-Kendall test for Group 1055_3 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
13 observations from 1/01/96 to 1/01/08 with 0 ties

1055_3	Median value	Kendall statistic	Variance	Z	**P**	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	138.18	-40.00	268.67	-2.38	**0.02**	-1.20	-1.59	-0.33

Mann-Kendall test for Group 1158_7 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1158_7	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	122.03	2.00	212.67	0.07	0.95	0.18	-1.26	1.61

Mann-Kendall test for Group 1172_6 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
13 observations from 1/01/96 to 1/01/08 with 0 ties

1172_6	Median value	Kendall statistic	Variance	Z	**P**	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	110.53	-52.00	268.67	-3.11	**0.00**	-2.02	-2.63	-1.23

Mann-Kendall test for Group 1174_10 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 1 ties

1174_10	Median value	Kendall statistic	Variance	Z	**P**	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	103.39	-43.00	211.67	-2.89	**0.00**	-2.24	-3.02	-1.28

Mann-Kendall test for Group 1247_3 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1247_3	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	111.01	-10.00	212.67	-0.62	0.54	-0.46	-1.27	0.75

Mann-Kendall test for Group 1249_15 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 1 ties

1249_15	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	83.22	-7.00	211.67	-0.41	0.68	-0.46	-1.90	0.85

Mann-Kendall test for Group 124_4 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 1 ties

124_4	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	116.00	4.00	164.00	0.23	0.81	0.33	-1.00	1.15

Mann-Kendall test for Group 1252_3 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
13 observations from 1/01/96 to 1/01/08 with 1 ties

1252_3	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	86.67	-27.00	267.67	-1.59	0.11	-1.25	-3.44	0.10

Mann-Kendall test for Group 1253_9 for MCI
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
11 observations from 1/01/97 to 1/01/08 with 0 ties

1253_9	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	110.00	3.00	165.00	0.16	0.88	0.36	-2.95	2.28

Mann-Kendall test for Group 1257_4 for MCI
Starting month = January
Period analysed 10 years and 1 months from 1998 to 2008
11 observations from 1/01/98 to 1/01/08 with 0 ties

1257_4	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	114.48	-37.00	165.00	-2.80	0.01	-2.44	-3.74	-1.14

Mann-Kendall test for Group 125_4 for MCI
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
11 observations from 1/01/97 to 1/01/08 with 0 ties

125_4	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	135.33	21.00	165.00	1.56	0.12	1.89	-0.14	2.95

Mann-Kendall test for Group 1284_1 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1284_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	135.89	14.00	212.67	0.89	0.37	1.12	-0.65	2.45

Mann-Kendall test for Group 1293_8 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1293_8	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	78.57	-18.00	212.67	-1.17	0.24	-1.10	-1.75	0.82

Mann-Kendall test for Group 1414_1 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1414_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	147.92	-38.00	212.67	-2.54	**0.01**	-1.52	-2.32	-0.80

Mann-Kendall test for Group 195_1 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 0 ties

195_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	105.33	-25.00	165.00	-1.87	0.06	-2.35	-3.75	-0.82

Mann-Kendall test for Group 220_1 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 1 ties

220_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	130.21	-27.00	211.67	-1.79	0.07	-1.25	-2.46	-0.04

Mann-Kendall test for Group 23_2 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 2 ties

23_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	111.05	-7.00	209.00	-0.42	0.68	-0.73	-2.93	1.18

Mann-Kendall test for Group 240_5 for MCI
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
11 observations from 1/01/97 to 1/01/08 with 0 ties

240_5	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	107.06	-23.00	165.00	-1.71	0.09	-2.88	-4.70	-0.22

Mann-Kendall test for Group 256_2 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

256_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	106.90	-28.00	212.67	-1.85	0.06	-2.13	-3.17	-0.21

Mann-Kendall test for Group 365_1 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 2 ties

365_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	123.38	-20.00	210.67	-1.31	0.19	-0.61	-1.51	0.21

Mann-Kendall test for Group 36_1 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 0 ties

36_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	118.18	-23.00	165.00	-1.71	0.09	-1.66	-3.99	-0.04

Mann-Kendall test for Group 407_1 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 2 ties

407_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	75.00	-14.00	161.33	-1.02	0.31	-0.22	-1.30	0.59

Mann-Kendall test for Group 413_2 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
13 observations from 1/01/96 to 1/01/08 with 1 ties

413_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	127.50	-9.00	267.67	-0.49	0.62	-0.57	-2.15	0.77

Mann-Kendall test for Group 428_3 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

428_3	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	102.88	-28.00	212.67	-1.85	0.06	-1.20	-2.50	-0.21

Mann-Kendall test for Group 428_5 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
10 observations from 1/01/96 to 1/01/08 with 0 ties

428_5	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	115.72	-15.00	125.00	-1.25	0.21	-1.26	-2.32	0.55

Mann-Kendall test for Group 429_3 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

429_3	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	66.14	-14.00	212.67	-0.89	0.37	-0.51	-1.59	0.38

Mann-Kendall test for Group 433_2 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 1 ties

433_2	Median value	Kendall statistic	Variance	Z	**P**	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	91.87	-29.00	211.67	-1.92	**0.05**	-1.44	-2.32	-0.41

Mann-Kendall test for Group 453_8 for MCI
Starting month = January
Period analysed 13 years and 1 months from 1995 to 2008
12 observations from 1/01/95 to 1/01/08 with 1 ties

453_8	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	95.03	27.00	211.67	1.79	0.07	0.67	0.01	2.19

Mann-Kendall test for Group 476_1 for MCI
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
12 observations from 1/01/97 to 1/01/08 with 0 ties

476_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	111.63	-8.00	212.67	-0.48	0.63	-0.62	-2.64	1.32

Mann-Kendall test for Group 477_14 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

477_14	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	146.02	-6.00	212.67	-0.34	0.73	-0.34	-2.52	1.07

Mann-Kendall test for Group 477_5 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

477_5	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	103.68	4.00	212.67	0.21	0.84	0.31	-1.12	2.00

Mann-Kendall test for Group 481_11 for MCI
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
11 observations from 1/01/97 to 1/01/08 with 1 ties

481_11	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	106.36	-22.00	164.00	-1.64	0.10	-2.00	-3.83	0.01

Mann-Kendall test for Group 493_1 for MCI
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
12 observations from 1/01/97 to 1/01/08 with 1 ties

493_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	83.33	-13.00	211.67	-0.82	0.41	-0.69	-2.52	1.00

Mann-Kendall test for Group 495_1 for MCI
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
11 observations from 1/01/97 to 1/01/08 with 0 ties

495_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	125.19	7.00	165.00	0.47	0.64	0.59	-1.21	2.09

Mann-Kendall test for Group 4_2 for MCI
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
11 observations from 1/01/97 to 1/01/08 with 0 ties

4_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	113.64	-21.00	165.00	-1.56	0.12	-1.39	-3.34	0.10

Mann-Kendall test for Group 514_1 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 1 ties

514_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	133.17	11.00	211.67	0.69	0.49	0.29	-0.64	1.36

Mann-Kendall test for Group 531_4 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

531_4	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	93.76	-10.00	212.67	-0.62	0.54	-1.09	-4.06	2.24

Mann-Kendall test for Group 539_1 for MCI
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
12 observations from 1/01/97 to 1/01/08 with 0 ties

539_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	104.90	-6.00	212.67	-0.34	0.73	-0.34	-2.40	2.22

Mann-Kendall test for Group 556_9 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 0 ties

556_9	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	103.53	-13.00	165.00	-0.93	0.35	-0.84	-3.24	0.34

Mann-Kendall test for Group 619_20 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

619_20	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	86.06	-4.00	212.67	-0.21	0.84	-0.34	-1.77	2.22

Mann-Kendall test for Group 749_10 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 1 ties

749_10	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	73.16	-43.00	211.67	-2.89	**0.00**	-2.29	-3.34	-1.35

Mann-Kendall test for Group 753_7 for MCI
Starting month = January
Period analysed 13 years and 1 months from 1995 to 2008
12 observations from 1/01/95 to 1/01/08 with 1 ties

753_7	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	95.06	-5.00	211.67	-0.27	0.78	-0.30	-1.81	0.97

Mann-Kendall test for Group 786_2 for MCI
Starting month = January
Period analysed 13 years and 1 months from 1995 to 2008
13 observations from 1/01/95 to 1/01/08 with 0 ties

786_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	98.18	24.00	268.67	1.40	0.16	1.60	-0.35	3.02

Mann-Kendall test for Group 786_22 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 0 ties

786_22	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	86.67	19.00	165.00	1.40	0.16	1.11	-0.70	2.60

Mann-Kendall test for Group 976_2 for MCI
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 0 ties

976_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	118.82	-33.00	165.00	-2.49	**0.01**	-1.44	-2.12	-0.77

Mann-Kendall test for Group 1055_2 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1055_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.36	18.00	212.67	1.17	0.24	0.00	0.00	0.01

Mann-Kendall test for Group 1055_3 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
13 observations from 1/01/96 to 1/01/08 with 0 ties

1055_3	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.77	34.00	268.67	2.01	**0.04**	0.00	0.00	0.01

Mann-Kendall test for Group 1158_7 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1158_7	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.62	20.00	212.67	1.30	0.19	0.01	0.00	0.03

Mann-Kendall test for Group 1172_6 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
13 observations from 1/01/96 to 1/01/08 with 0 ties

1172_6	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.46	-40.00	268.67	-2.38	**0.02**	-0.01	-0.02	-0.01

Mann-Kendall test for Group 1174_10 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1174_10	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.50	-14.00	212.67	-0.89	0.37	-0.01	-0.02	0.01

Mann-Kendall test for Group 1247_3 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1247_3	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.42	-4.00	212.67	-0.21	0.84	0.00	-0.02	0.01

Mann-Kendall test for Group 1249_15 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1249_15	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.25	4.00	212.67	0.21	0.84	0.00	-0.01	0.01

Mann-Kendall test for Group 124_4 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 0 ties

124_4	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.42	23.00	165.00	1.71	0.09	0.01	0.00	0.03

Mann-Kendall test for Group 1252_3 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
13 observations from 1/01/96 to 1/01/08 with 0 ties

1252_3	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.26	-6.00	268.67	-0.31	0.76	0.00	-0.02	0.01

Mann-Kendall test for Group 1253_9 for ASPM
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
11 observations from 1/01/97 to 1/01/08 with 0 ties

1253_9	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.41	17.00	165.00	1.25	0.21	0.02	0.00	0.04

Mann-Kendall test for Group 1257_4 for ASPM
Starting month = January
Period analysed 10 years and 1 months from 1998 to 2008
11 observations from 1/01/98 to 1/01/08 with 0 ties

1257_4	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.61	7.00	165.00	0.47	0.64	0.00	-0.01	0.01

Mann-Kendall test for Group 125_4 for ASPM
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
11 observations from 1/01/97 to 1/01/08 with 0 ties

125_4	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.74	25.00	165.00	1.87	0.06	0.02	0.00	0.04

Mann-Kendall test for Group 1284_1 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1284_1	Median value	Kendall statistic	Variance	Z	**P**	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.80	38.00	212.67	2.54	**0.01**	0.04	0.01	0.06

Mann-Kendall test for Group 1293_8 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1293_8	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.18	-8.00	212.67	-0.48	0.63	0.00	-0.01	0.01

Mann-Kendall test for Group 1414_1 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

1414_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.84	20.00	212.67	1.30	0.19	0.00	0.00	0.01

Mann-Kendall test for Group 195_1 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 0 ties

195_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.47	-3.00	165.00	-0.16	0.88	0.00	-0.02	0.01

Mann-Kendall test for Group 220_1 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

220_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.65	4.00	212.67	0.21	0.84	0.00	-0.01	0.01

Mann-Kendall test for Group 23_2 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

23_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.45	14.00	212.67	0.89	0.37	0.01	-0.02	0.03

Mann-Kendall test for Group 240_5 for ASPM
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
11 observations from 1/01/97 to 1/01/08 with 0 ties

240_5	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.52	3.00	165.00	0.16	0.88	0.00	-0.03	0.02

Mann-Kendall test for Group 256_2 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

256_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.34	-14.00	212.67	-0.89	0.37	-0.01	-0.01	0.00

Mann-Kendall test for Group 365_1 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

365_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.61	26.00	212.67	1.71	0.09	0.01	0.00	0.02

Mann-Kendall test for Group 36_1 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 0 ties

36_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.55	3.00	165.00	0.16	0.88	0.00	-0.02	0.02

Mann-Kendall test for Group 407_1 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 0 ties

407_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.24	31.00	165.00	2.34	0.02	0.01	0.00	0.02

Mann-Kendall test for Group 413_2 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
13 observations from 1/01/96 to 1/01/08 with 0 ties

413_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.61	20.00	268.67	1.16	0.25	0.01	-0.01	0.02

Mann-Kendall test for Group 428_3 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

428_3	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.41	-10.00	212.67	-0.62	0.54	0.00	-0.02	0.01

Mann-Kendall test for Group 428_5 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
10 observations from 1/01/96 to 1/01/08 with 0 ties

428_5	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.52	7.00	125.00	0.54	0.59	0.00	-0.01	0.02

Mann-Kendall test for Group 429_3 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

429_3	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.14	-12.00	212.67	-0.75	0.45	0.00	0.00	0.00

Mann-Kendall test for Group 433_2 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

433_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.39	10.00	212.67	0.62	0.54	0.00	-0.01	0.01

Mann-Kendall test for Group 453_8 for ASPM
Starting month = January
Period analysed 13 years and 1 months from 1995 to 2008
12 observations from 1/01/95 to 1/01/08 with 0 ties

453_8	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.42	26.00	212.67	1.71	0.09	0.01	0.00	0.02

Mann-Kendall test for Group 476_1 for ASPM
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
12 observations from 1/01/97 to 1/01/08 with 0 ties

476_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.48	6.00	212.67	0.34	0.73	0.00	-0.01	0.02

Mann-Kendall test for Group 477_14 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

477_14	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.82	20.00	212.67	1.30	0.19	0.01	0.00	0.01

Mann-Kendall test for Group 477_5 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

477_5	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.45	20.00	212.67	1.30	0.19	0.02	0.00	0.03

Mann-Kendall test for Group 481_11 for ASPM
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
11 observations from 1/01/97 to 1/01/08 with 0 ties

481_11	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.44	-5.00	165.00	-0.31	0.76	0.00	-0.02	0.02

Mann-Kendall test for Group 493_1 for ASPM
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
12 observations from 1/01/97 to 1/01/08 with 0 ties

493_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.22	-4.00	212.67	-0.21	0.84	0.00	-0.01	0.01

Mann-Kendall test for Group 495_1 for ASPM
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
11 observations from 1/01/97 to 1/01/08 with 0 ties

495_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.62	11.00	165.00	0.78	0.44	0.02	-0.01	0.03

Mann-Kendall test for Group 4_2 for ASPM
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
11 observations from 1/01/97 to 1/01/08 with 0 ties

4_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.64	21.00	165.00	1.56	0.12	0.02	0.00	0.03

Mann-Kendall test for Group 514_1 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

514_1	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.60	28.00	212.67	1.85	0.06	0.01	0.00	0.03

Mann-Kendall test for Group 531_4 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

531_4	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.33	-10.00	212.67	-0.62	0.54	-0.01	-0.03	0.01

Mann-Kendall test for Group 539_1 for ASPM
Starting month = January
Period analysed 11 years and 1 months from 1997 to 2008
12 observations from 1/01/97 to 1/01/08 with 0 ties

539_1	Median value	Kendall statistic	Variance	Z	**P**	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.40	30.00	212.67	1.99	**0.05**	0.01	0.00	0.02

Mann-Kendall test for Group 556_9 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 0 ties

556_9	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.39	11.00	165.00	0.78	0.44	0.01	-0.01	0.02

Mann-Kendall test for Group 619_20 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 0 ties

619_20	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.32	24.00	212.67	1.58	0.11	0.01	-0.01	0.02

Mann-Kendall test for Group 749_10 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
12 observations from 1/01/96 to 1/01/08 with 1 ties

749_10	Median value	Kendall statistic	Variance	Z	**P**	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.16	-35.00	211.67	-2.34	**0.02**	-0.01	-0.01	0.00

Mann-Kendall test for Group 753_7 for ASPM
Starting month = January
Period analysed 13 years and 1 months from 1995 to 2008
12 observations from 1/01/95 to 1/01/08 with 0 ties

753_7	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.35	-14.00	212.67	-0.89	0.37	-0.01	-0.03	0.01

Mann-Kendall test for Group 786_2 for ASPM
Starting month = January
Period analysed 13 years and 1 months from 1995 to 2008
13 observations from 1/01/95 to 1/01/08 with 0 ties

786_2	Median value	Kendall statistic	Variance	Z	**P**	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.47	40.00	268.67	2.38	**0.02**	0.02	0.01	0.04

Mann-Kendall test for Group 786_22 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 0 ties

786_22	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.37	9.00	165.00	0.62	0.53	0.01	0.00	0.04

Mann-Kendall test for Group 976_2 for ASPM
Starting month = January
Period analysed 12 years and 1 months from 1996 to 2008
11 observations from 1/01/96 to 1/01/08 with 0 ties

976_2	Median value	Kendall statistic	Variance	Z	P	Sen slope median annual	5% confidence limit	95% confidence limit
Unadjusted	0.49	21.00	165.00	1.56	0.12	0.01	0.00	0.02

Appendix 3: Spearman rank correlation coefficients between three macroinvertebrate metrics and sampling year (summer).

Red italics = 'probable'; Red bold = 'clear'

Site	%EPT*	MCI	ASPM
1055_2	-0.21	-0.413	0.336
	12	12	12
1055_3	0.159	*-0.632*	*0.604*
	13	13	13
1158_7	0.266	0.049	0.476
	12	12	12
1172_6	-0.525	**-0.824**	*-0.681*
	13	13	13
1174_10	-0.231	**-0.834**	-0.329
	12	12	12
124_4	0.451	0	0.473
	11	11	11
1247_3	-0.35	-0.217	-0.077
	12	12	12
1249_15	-0.007	-0.228	0.049
	12	12	12
125_15 & 125_4	*0.638*	0.464	*0.645*
(ref)	11	11	11
1252_3	-0.071	*-0.578*	-0.071
	13	13	13
1253_9	0.073	0.036	0.364
	11	11	11
1257_4	0.2	**-0.855**	0.218
	11	11	11
1284_1	0.51	0.364	*0.776*
	12	12	12
1293_8	-0.294	-0.364	-0.196
	12	12	12
1414_1	-0.035	*-0.706*	0.517
(ref)	12	12	12
195_1	-0.109	*-0.664*	-0.082
	11	11	11
220_1	0.105	-0.557	0.084
	12	12	12
23_2	0.168	-0.113	0.287
	12	12	12
240_5	0.073	-0.6	0.127
	11	11	11
256_2	*-0.636*	*-0.65*	-0.294
	12	12	12
36_1	-0.318	-0.564	-0.082
	11	11	11
365_1	0.168	-0.347	0.559
	12	12	12
4_2	*0.673*	-0.482	0.455
	11	11	11

Site	%EPT*	MCI	ASPM
407_1	*0.745*	-0.385	*0.773*
	11	11	11
413_2	0.154	-0.151	0.335
	13	13	13
428_3	-0.098	-0.552	-0.105
	12	12	12
428_5	0.067	-0.479	0.152
	10	10	10
429_3	-0.038	-0.287	-0.21
	12	12	12
433_2	0.175	-0.483	0.196
	12	12	12
453_8	-0.035	0.515	0.531
	12	12	12
476_1	0.14	-0.189	0.189
	12	12	12
477_14	0.424	0.014	0.392
	12	12	12
477_5	0.308	0.168	0.406
	12	12	12
481_11	-0.218	-0.487	-0.155
	11	11	11
493_1	-0.48	-0.242	-0.07
	12	12	12
495_1	0.036	0.127	0.245
	11	11	11
514_1	-0.175	0.214	0.517
	12	12	12
531_4	-0.266	-0.259	-0.175
	12	12	12
539_1	0.448	-0.105	0.566
	12	12	12
556_9	0.145	-0.291	0.255
	11	11	11
619_20	0.483	-0.07	0.497
	12	12	12
749_10	-0.367	**-0.767**	*-0.683*
	12	12	12
753_7	-0.469	-0.182	-0.301
	12	12	12
786_2	*0.635*	0.467	*0.747*
	13	13	13
786_22	0.127	0.491	0.227
	11	11	11
976_2	0.109	*-0.727*	0.545
	11	11	11

Appendix 4: Differences between minimum and maximum metric values recorded over the duration of sampling.

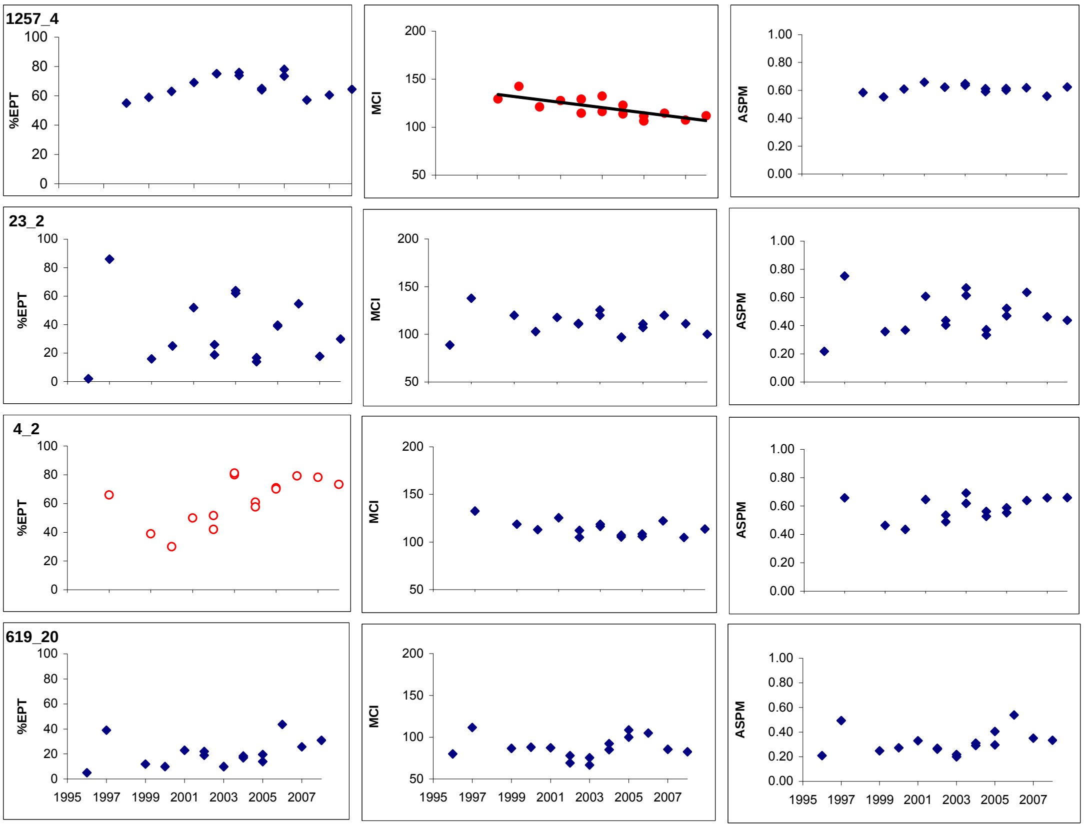
Site	%EPT	MCI	ASPM
1055_2	23.3	21.3	0.14
1055_3	40.0	21.2	0.32
1158_7	57.0	27.5	0.29
1172_6	37.7	31.5	0.20
1174_10	55.1	32.6	0.31
124_4	37.3	16.0	0.29
1247_3	42.4	26.4	0.25
1249_15	21	28.5	0.17
125_4 & 125_15 (ref)*	**20.1**	**22.5**	**0.16**
1252_3	40.3	38.1	0.33
1253_9	47.6	44.4	0.33
1257_4	20.1	36.1	0.11
1284_1	79.0	46.2	0.55
1293_8	32.0	24.8	0.22
1414_1 (ref)	**19.0**	**27.9**	**0.11**
195_1	64.5	36.4	0.31
220_1	38.4	24.8	0.18
23_2	84.0	48.9	0.54
240_5	88.6	70.34	0.51
256_2	27.0	41.5	0.19
36_1	73.4	33.0	0.34
365_1	45.8	14.7	0.24
4_2	51.3	27.8	0.25
407_1	60.1	15.6	0.21
413_2	78.5	27.8	0.46
428_3	52.0	31.0	0.27
428_5	37.8	23.9	0.20
429_3	1.0	18.7	0.06
433_2	56.7	25.0	0.24
453_8	37.5	23.8	0.23
476_1	43.5	36.0	0.25
477_14 (ref)	**13.4**	**26.2**	**0.15**
477_5	56	27.0	0.32
481_11	51.1	38.0	0.33
493_1	7.0	28.3	0.16
495_1	58.7	31.5	0.29
514_1	52.0	17.3	0.32
531_4	33.0	50.0	0.28
539_1	56.0	46.7	0.37
556_9	39.0	32.0	0.21
619_20	38.7	42.4	0.33
749_10	2.0	34.3	0.11
753_7	81.	38.6	0.37
786_2	75.3	36.3	0.42
786_22	74.0	36.1	0.32
976_2	23.3	19.3	0.19

*, excludes 1999 data when very low values recorded

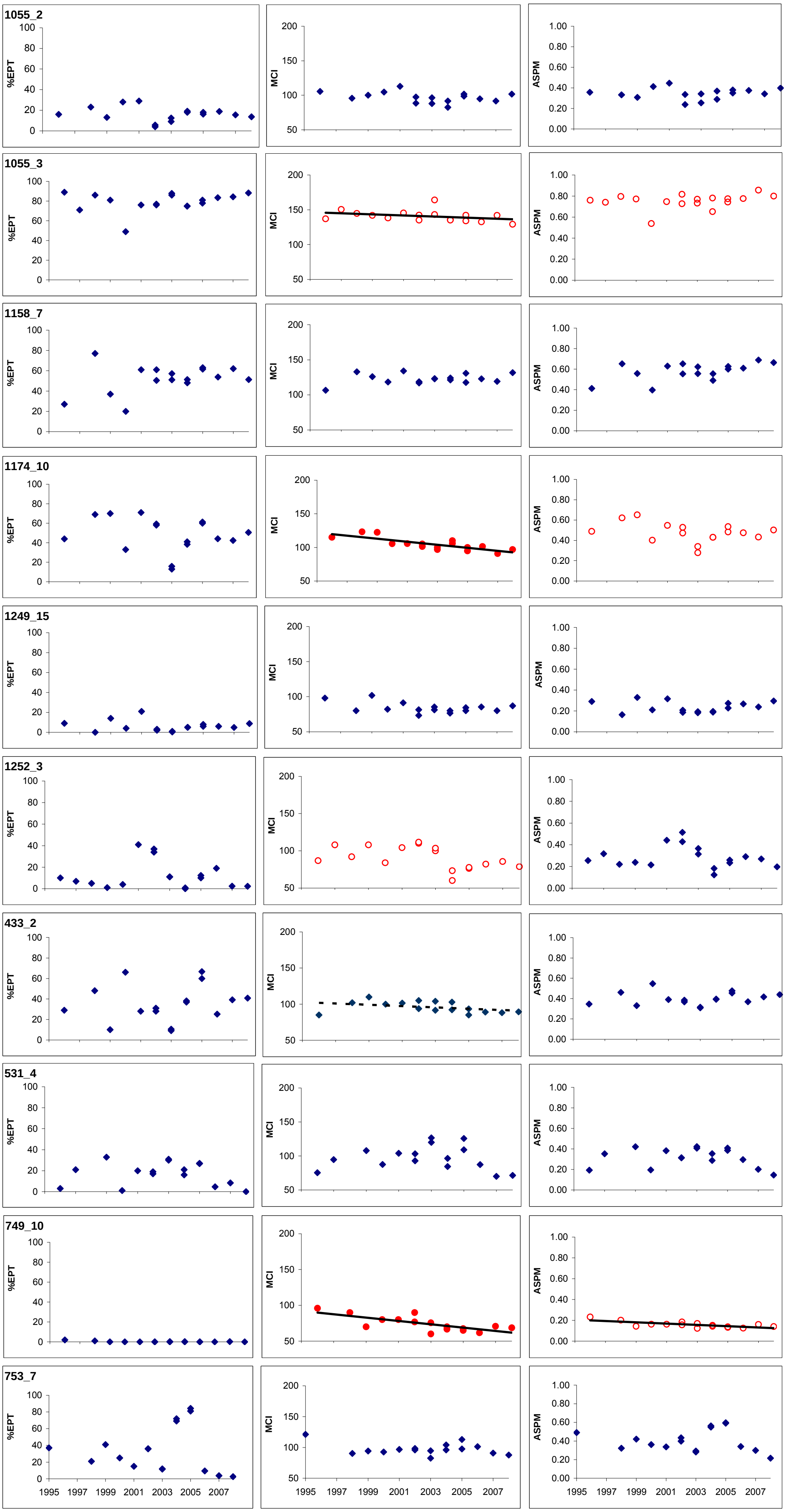
Appendix 5: Plots of selected invertebrate community metrics over time (summer).

Linear interpolations are shown for sites interpreted as showing temporal trends based on the Mann-Kendall test at $P<0.05$ (‘significant’; solid lines) or P = 0.05 (‘borderline’; dashed lines). Circles indicate trends suggested using the Spearman method: solid = ‘clear’, open = ‘probable’. Duplicate points shown in any year compare metrics derived from 100 and 200+ sample counts (see Methods)

COROMANDEL



HAURAKI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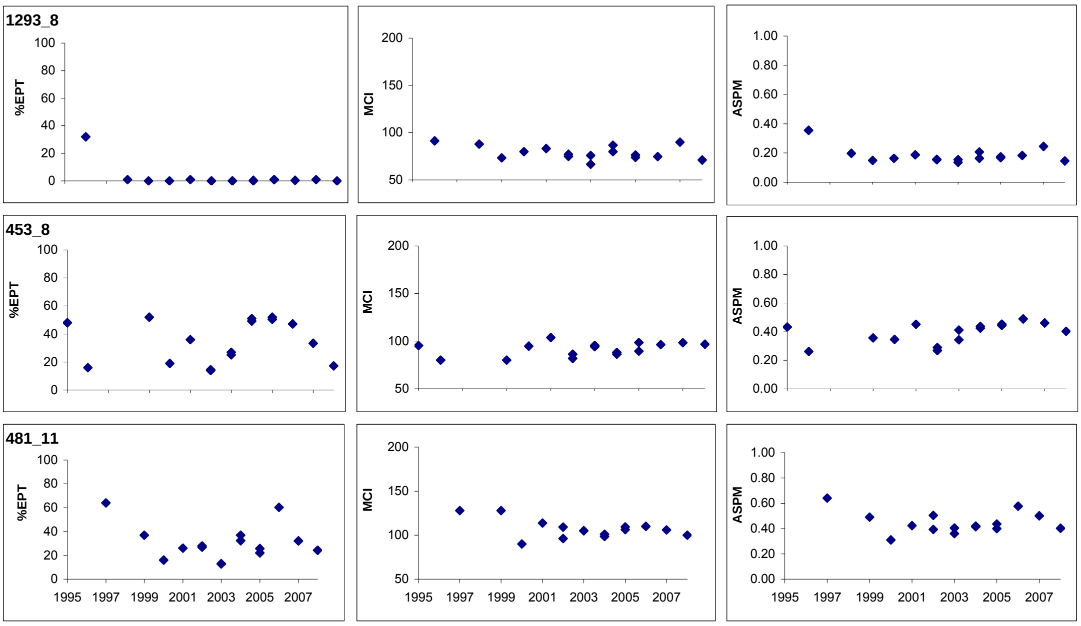
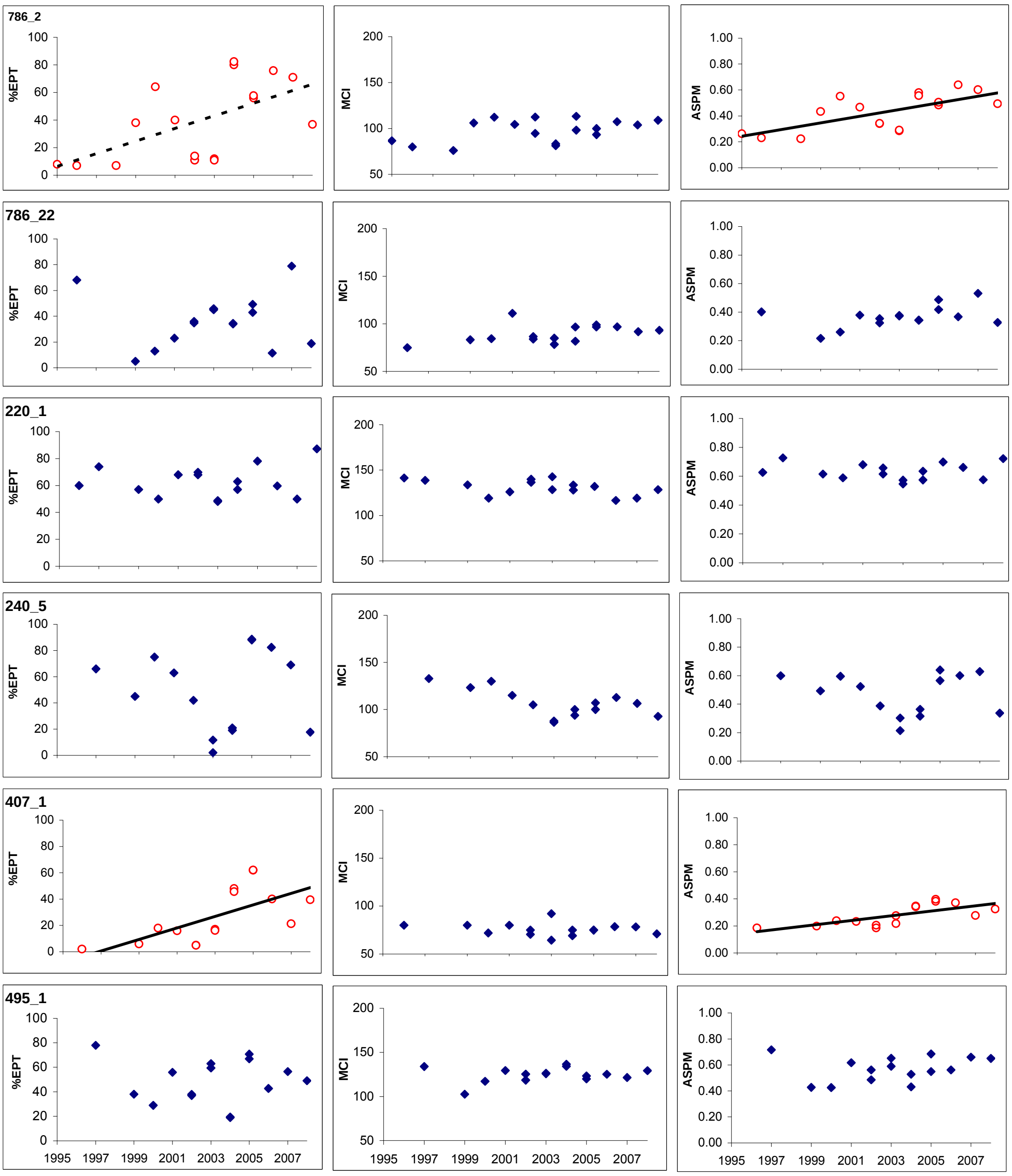
1055_3
1158_7
1174_10
1249_15
1252_3
433_2
531_4
749_10
753_7
%EPT
MCI
ASPM
1995
1997
1999
2001
2003
2005
2007

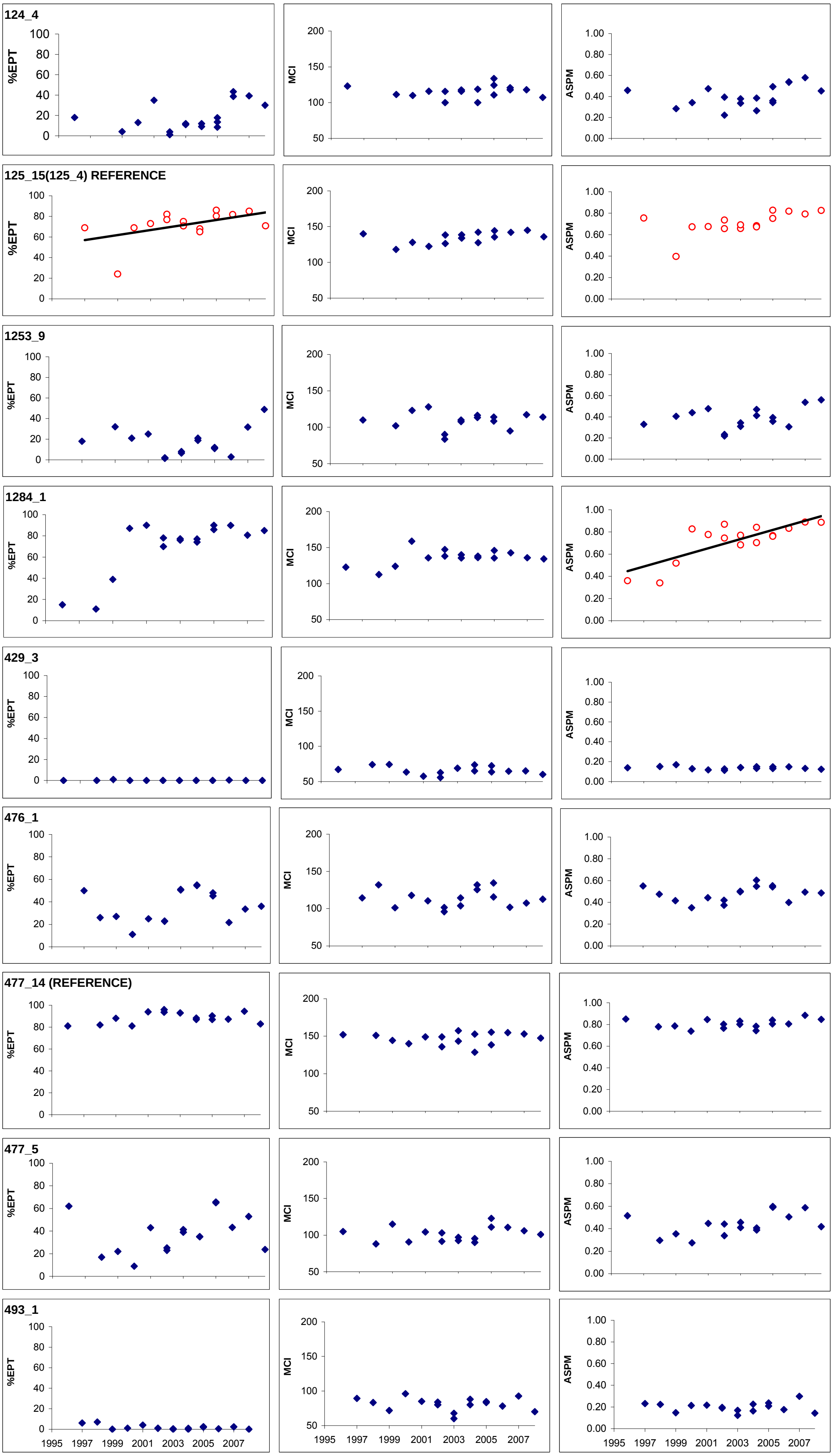
LOWER WAIKATO



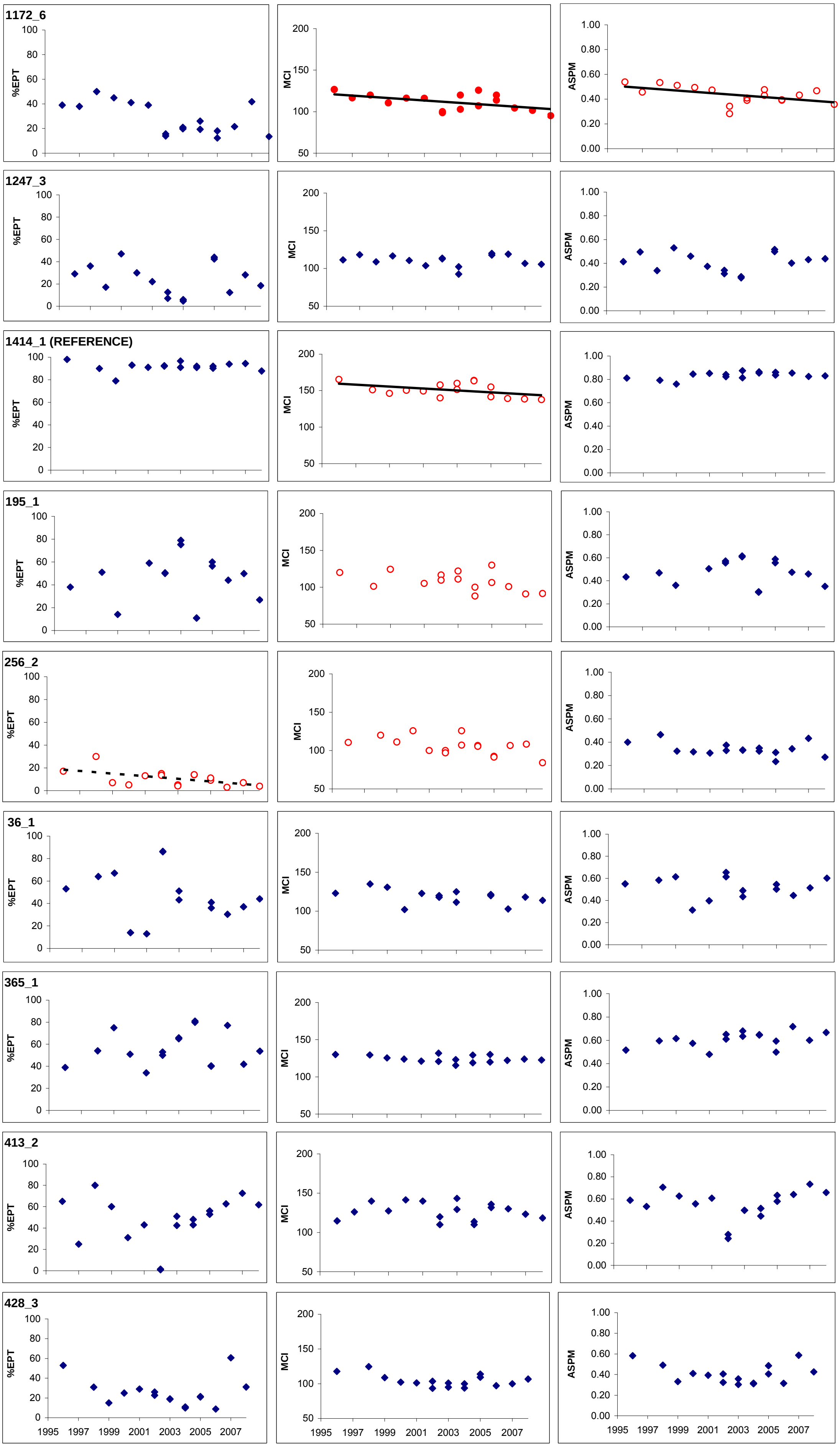
UPPER/MIDDLE WAIKATO



WAIPA


124_4
125_15(125_4) REFERENCE
1253_9
1284_1
429_3
476_1
477_14 (REFERENCE)
477_5
493_1
%EPT
MCI
ASPM
1995 1997 1999 2001 2003 2005 2007

WEST COAST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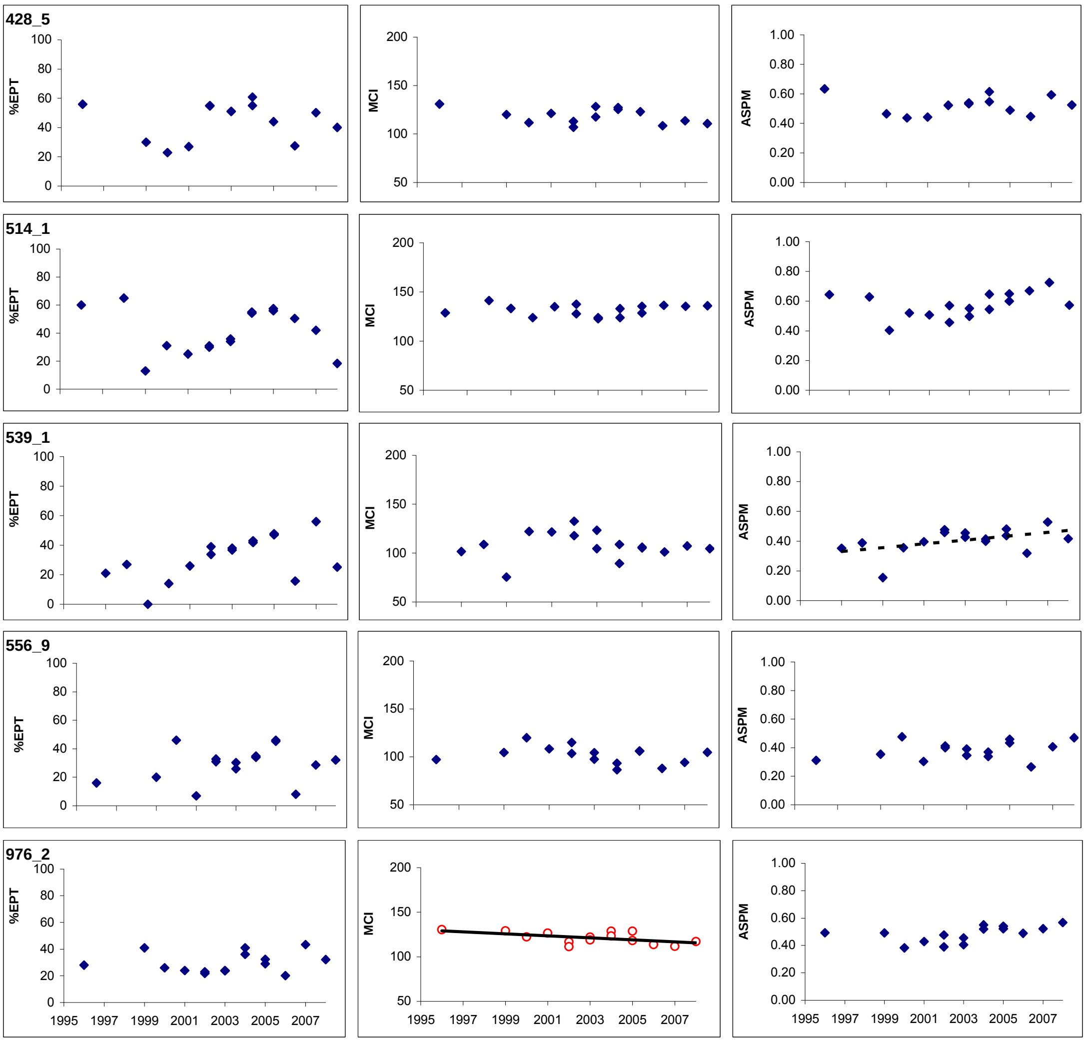
1414_1 (REFERENCE)
195_1
256_2
36_1
365_1
413_2
428_3
%EPT
MCI
ASPM
0
20
40
60
80
100
50
100
150
200
0.00
0.20
0.40
0.60
0.80
1.00
1995
1997
1999
2001
2003
2005
2007

WEST COAST continued



Appendix 6: Results of repeated measures MANOVA for macroinvertebrate metrics

```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
TREATMENT$ (4 levels)
   PFH, PFL, PP, R
ZONE$ (7 levels)
   Coromandel, Hauraki, Lower Waikat, Taupo, UpMid Waikat, Waipa, West Coast
S_METHO (2 levels)
          4,        5
19 case(s) deleted due to missing data.
Number of cases processed: 344

Dependent variable means
```

ASVEPT	LEPTTAXA	LMCI	ASASPM
0.638	2.094	4.656	0.818

```
Repeated measures factors and levels
                 Dependent Variables
```

Within factor	1	2	3	4
YEAR2	1.000	2.000	3.000	4.000

```
Univariate and multivariate Repeated Measures Analysis
Between Subjects
```

Source	SS	df	MS	F	P
TREATMENT$	99.094	3	33.031	127.877	0.000
TREATMENT$*ZONE$	16.784	18	0.932	3.610	0.000
TREATMENT$*S_METHO	15.333	3	5.111	19.786	0.000
Error	82.399	319	0.258		

Within Subjects

Source	SS	df	MS	F	P	G-G	H-F
YEAR2	1518.604	3	506.201	9215.682	0.000	0.000	0.000
YEAR2*TREATMENT$	34.804	9	3.867	70.404	0.000	0.000	0.000
YEAR2*TREATMENT$*ZONE$	8.313	54	0.154	2.803	0.000	0.000	0.000
YEAR2*TREATMENT$*S_METHO	11.009	9	1.223	22.269	0.000	0.000	0.000
Error	52.566	957	0.055				

Greenhouse-Geisser Epsilon: 0.4155
Huynh-Feldt Epsilon : 0.4477

Multivariate repeated measures analysis

Test of: YEAR2

Statistic	Value	Hypoth. df	Error df	F	P
Wilks' Lambda	0.001	3	317	125862.225	0.000
Pillai Trace	0.999	3	317	125862.225	0.000
H-L Trace	1191.125	3	317	125862.225	0.000

Test of: YEAR2*TREATMENT$

Statistic	Value	Hypoth. df	Error df	F	P
Wilks' Lambda	0.448	9	771	33.482	0.000
Pillai Trace	0.602	9	957	26.717	0.000
H-L Trace	1.118	9	947	39.222	0.000

HETA	S	M	N	P
0. 502	3	-0.5	157.5	0. 000

Test of: YEAR2*TREATMENT$*ZONE$

Statistic	Value	Hypoth. df	Error df	F	P
Wilks' Lambda	0.699	54	945	2.232	0.000
Pillai Trace	0.331	54	957	2.199	0.000
H-L Trace	0.387	54	947	2.263	0.000

HETA	S	M	N	P
0.168	3	7.0	157.5	0.000

Test of: YEAR2*TREATMENT$*S_METHO

Statistic	Value	Hypoth. df	Error df	F	P
Wilks' Lambda	0.771	9	771	9.685	0.000
Pillai Trace	0.238	9	957	9.146	0.000
H-L Trace	0.287	9	947	10.058	0.000

HETA	S	M	N	P
0.195	3	-0.5	157.5	0.000

Pairwise comparisons between levels of within-subjects factor: YEAR2

Within Subjects Factor Comparing Levels		Mean Difference Between Levels	Std. Err. of Difference	p-value*	95% Confidence Interval* >From	To
1 /	2	-1.455	0.025	0.000	-1.521	-1.389
1 /	3	-4.018	0.010	0.000	-4.044	-3.992
1 /	4	-0.180	0.007	0.000	-0.199	-0.160
2 /	3	-2.563	0.025	0.000	-2.630	-2.495
2 /	4	1.276	0.025	0.000	1.209	1.342
3 /	4	3.838	0.004	0.000	3.826	3.850

*Applying Bonferroni correction for multiple comparisons.
Bonferroni p-values are approximations and can be meaningfully used
only when uncorrected p-values are very small.

Test for effect called: TREATMENT$
Univariate F Tests

Source	SS	df	MS	F	P
ASVEPT	21.233	3	7.078	119.905	0.000
Error	18.830	319	0.059		
LEPTTAXA	96.826	3	32.275	101.352	0.000
Error	101.584	319	0.318		
LMCI	6.518	3	2.173	100.900	0.000
Error	6.869	319	0.022		
ASASPM	9.322	3	3.107	129.015	0.000
Error	7.683	319	0.024		

Multivariate Test Statistics

Statistic	Value	F-Statistic	df	Prob
Wilks' Lambda	0.379	30.908	12, 836	0.000
Pillai Trace	0.703	24.321	12, 954	0.000
Hotelling-Lawley Trace	1.432	37.540	12, 944	0.000

HETA	S	M	N	Prob
0.561	3	0.0	157.0	0.000

Appendix 7: Results of repeated measures MANOVA for metrics of instream plant cover and proliferation.

```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
TREATMENT$ (4 levels)
   PFH, PFL, PP, R
ZONE$ (7 levels)
   Coromandel, Hauraki, Lower Waikat, Taupo, UpMid Waikat, Waipa, West Coast
43 case(s) deleted due to missing data.
Number of cases processed: 321
```

Dependent variable means

LPPI	LPSI	LMTC	LMCC
0.840	1.658	1.532	1.474

Repeated measures factors and levels
Dependent Variables

Within factor	1	2	3	4
YEAR2	1.000	2.000	3.000	4.000

Univariate and multivariate Repeated Measures Analysis

Between Subjects

Source	SS	df	MS	F	P
TREATMENT$	455.164	3	151.721	66.122	0.000
TREATMENT$*ZONE$	143.754	18	7.986	3.481	0.000
Error	686.075	299	2.295		

Within Subjects

Source	SS	df	MS	F	P	G-G	H-F
YEAR2	138.088	3	46.029	51.438	0.000	0.000	0.000
YEAR2*TREATMENT$	496.003	9	55.111	61.587	0.000	0.000	0.000
YEAR2*TREATMENT$*ZONE$	100.356	54	1.858	2.077	0.000	0.003	0.002
Error	802.685	897	0.895				

Greenhouse-Geisser Epsilon: 0.4240
Huynh-Feldt Epsilon : 0.4549

Multivariate repeated measures analysis

Test of: YEAR2

Statistic	Value	Hypoth. df	Error df	F	P
Wilks' Lambda	0.453	3	297	119.398	0.000
Pillai Trace	0.547	3	297	119.398	0.000
H-L Trace	1.206	3	297	119.398	0.000

Test of: YEAR2*TREATMENT$

Statistic	Value	Hypoth. df	Error df	F	P
Wilks' Lambda	0.538	9	722	23.340	0.000
Pillai Trace	0.477	9	897	18.859	0.000
H-L Trace	0.833	9	887	27.356	0.000

THETA	S	M	N	P
0.444	3	-0.5	147.5	0.000

Test of: YEAR2*TREATMENT$*ZONE$

Statistic	Value	Hypoth. df	Error df	F	P
Wilks' Lambda	0.731	54	885	1.820	0.000
Pillai Trace	0.296	54	897	1.817	0.000
H-L Trace	0.333	54	887	1.822	0.000

THETA	S	M	N	P
0.137	3	7.0	147.5	0.008

Pairwise comparisons between levels of within-subjects factor: YEAR2

Within Subjects Factor Comparing Levels		Mean Difference Between Levels	Std. Err. of Difference	p-value*	95% Confidence Interval* >From	To
1 /	2	-0.818	0.046	0.000	-0.909	-0.726
1 /	3	-0.692	0.089	0.000	-0.868	-0.517
1 /	4	-0.634	0.088	0.000	-0.807	-0.461
2 /	3	0.125	0.096	0.203	-0.063	0.313
2 /	4	0.184	0.094	0.481	-0.001	0.368
3 /	4	0.058	0.008	0.000	0.043	0.074

Test for effect called: TREATMENT$

Univariate F Tests

Source	SS	df	MS	F	P
LPPI	52.431	3	17.477	14.195	0.000
Error	368.136	299	1.231		
LPSI	107.761	3	35.920	33.503	0.000
Error	320.578	299	1.072		
LMTC	400.886	3	133.629	97.196	0.000
Error	411.074	299	1.375		
LMCC	390.090	3	130.030	99.953	0.000
Error	388.971	299	1.301		

Multivariate Test Statistics

Statistic	Value	F-Statistic	df	Prob
Wilks' Lambda	0.364	30.417	12, 783	0.000
Pillai Trace	0.774	25.883	12, 894	0.000
Hotelling-Lawley Trace	1.378	33.846	12, 884	0.000

THETA	S	M	N	Prob
0.506	3	0.0	147.0	0.000

Appendix 8: Relationships between trends at REMS sites (stable, increase, decrease) and catchment and site variables.

Table A: Average and median changes in number of consents (waters takes and discharges) and change in stock unit density over 2001–2004 (01–04) and 2001–2007 (01–07) based on Agribase data for sites considered stable or showing evidence of increasing or decreasing trends in macroinvertebrate metrics (excluding site 1055_3 where conflicting trends were detected).

	Consents		**2001 to 2004**					**2001 to 2007**				
	01-04	01-07	Dairy	Beef	Deer	Sheep	**Total**	Dairy	Beef	Deer	Sheep	**Total**
Average												
Stable	-0.8	-1.0	5.1	5.6	0.6	6.0	**17.3**	4.0	5.7	0.1	6.6	**16.5**
Increase	-3.0	-5.6	5.3	-1.5	0.0	-5.0	**-1.3**	4.7	-1.5	0.0	-5.0	**-1.6**
Decrease	-1.7	-1.9	4.5	7.8	0.1	10.1	**22.5**	5.3	8.5	0.1	10.2	**23.9**
Median												
Stable	0.0	0.0	3.0	1.2	0.0	1.1	**14.2**	0.5	1.8	0.0	1.6	**13.0**
Increase	0.0	0.0	6.2	-0.3	0.0	0.0	**-1.3**	3.7	-0.3	0.0	0.0	**-1.3**
Decrease	0.0	0.0	2.2	3.2	0.0	0.3	**13.9**	5.2	2.5	0.0	0.1	**14.0**

Table B: Changes in catchment appearance around sampling locations interpreted from aerial photos (Appendix 9), site visits and local knowledge.

Site		%EPT trend	MCI trend	ASPM trend	Catchment changes from 2002 to 2007 (WRAPS imagery)	Site visit observations
1055_3	Torehape Stm@Torehape West Rd		Decrease	Increase	No change evident	Signs of erosion
1172_6	Wainui Stm (Raglan)@Res. Bridge		Decrease	Decrease	Lifestyle development	Increased residential development; local noted channel widening
1174_10	Waiomou Stm@Waiomou Rd		Decrease	Decrease	No change evident	
1252_3	Waitoki Stm@Rawhiti Rd		Decrease		Riparian planting?	
1257_4	Waiwawa River@U/S Toranoho Stm		Decrease		No change evident	High pest numbers upstream?
1284_1	Whakarautawa Stm@Mangati Rd			Increase	Some pine harvesting	
195_1	Huriwai Stm@Waikaretu Rd		Decrease		No change evident	
256_2	Kiritihere Stm@Mangatoa Rd	Decrease	Decrease		No change evident	Signs of erosion
4_2	5 Mile Stm@Off Tapu Coroglen Rd	Increase			No change evident	
407_1	Mangamingi Stm@Paraonui Rd Br	Increase		Increase	No change evident	Increased shade from willow growth
433_2	Mangapapa Stm@Henry Watson Rd		Decrease		Some pine harvesting	
539_1	Maunurima Stm@SH22			Increase	No change evident	Stock damage in stream
749_10	Piako River@Kiwitahi		Decrease	Decrease	No change evident	
786_2	Pokaiwhenua Stm@Arapuni-Putaruru Rd	Increase		Increase	No change evident	Fenced and planted one side
976_2	Tawarau River@Speedies Rd		Decrease		No change evident	

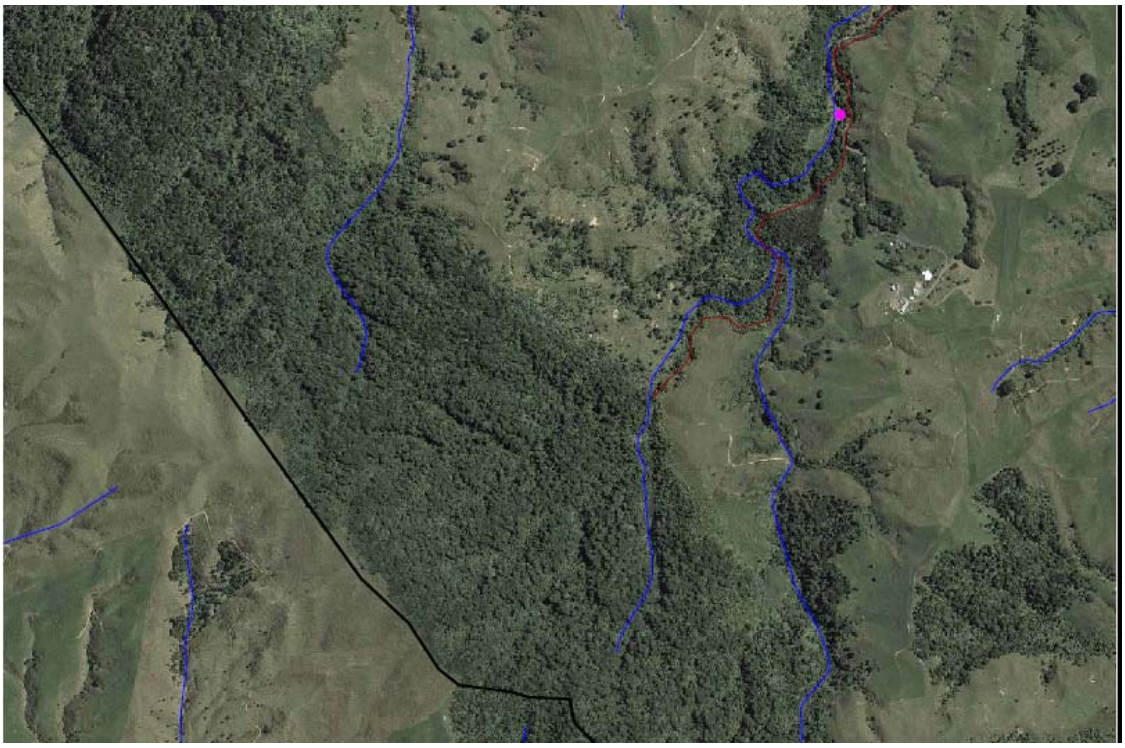
Table C: Trends in water quality parameters at long-term REMS sites. Single arrows indicate water quality trends significant at P <0.05 and double arrows indicate trends significant at P <0.0005 (see Vant 2008 for further details). Upward pointing arrows indicate increase and downward arrows indicate decrease over time, with red and green indicating negative or positive directions of change for ecological values (for REMS trend, + = increase, - = decrease).

	REMS trend	D.O.	pH	Cond.	Turb.	Clarity	Colour	TN	Nitrate	Ammonia	TP	DRP	E.coli	Enterococci
619_20	Stable							↓↓	↓	↓		↓↓		
1249_15	Stable		↑	↑										
1293_8	Stable	↓↓	↑		↓			↓↓	↓↓			↑		
240_5	Stable	↓↓		↑↑				↑↑	↑↑	↑↑	↑↑	↑↑		
1253_9	Stable	↓↓						↑↑	↑↑	↓↓		↑		
428_3	Stable							↑↑	↑↑	↓	↑↑	↑↑		
556_9	Stable	↓↓		↑		↑	↓	↑↑	↑↑		↑	↑		
407_1	%EPT +*, ASPM +;								↑↑	↓↓	↓↓	↓↓		
786_2	%EPT* +; ASPM +			↑↑	↑↑	↓	↑	↑↑	↑↑			↓↓		
976_2	MCI -	↓↓						↑↑		↓↓	↑↑	↑		
749_10	MCI -; ASPM -	↓↓			↓↓	↑↑	↓	↓	↓	↓↓			↑	↑

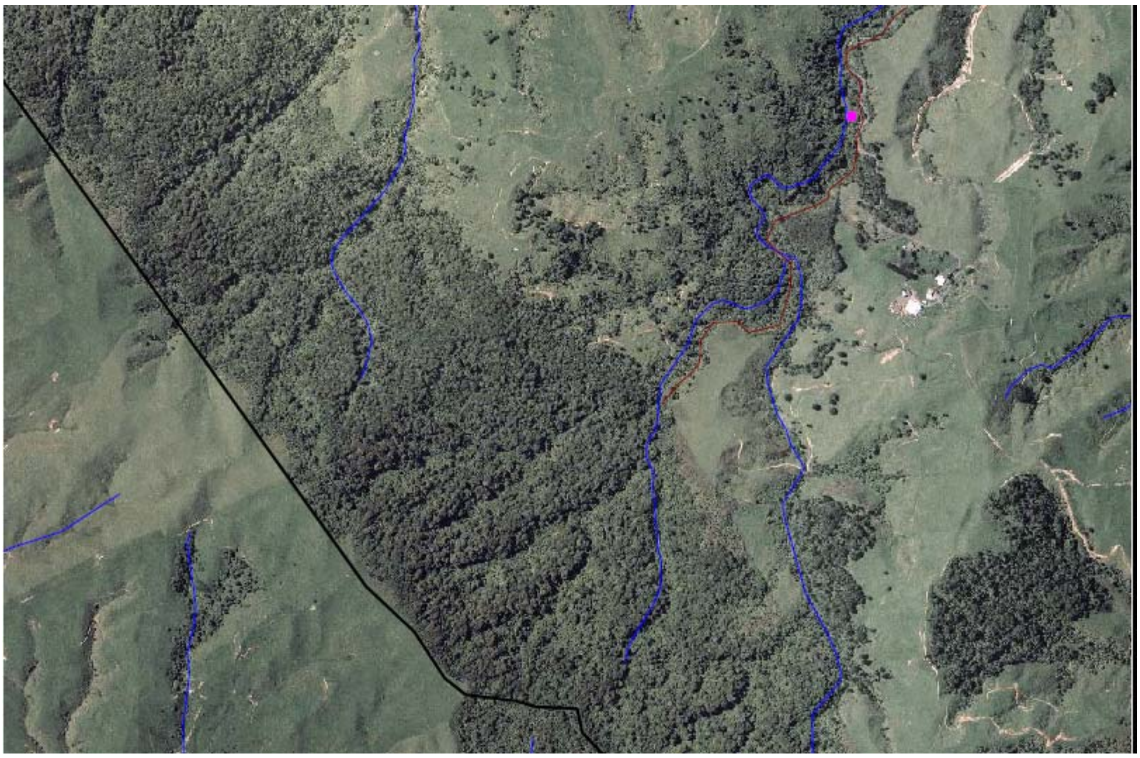
Appendix 9: Aerial photos taken in 2002 and 2007 of sampling locations (dots) showing trends.

Site 1055_3

2002

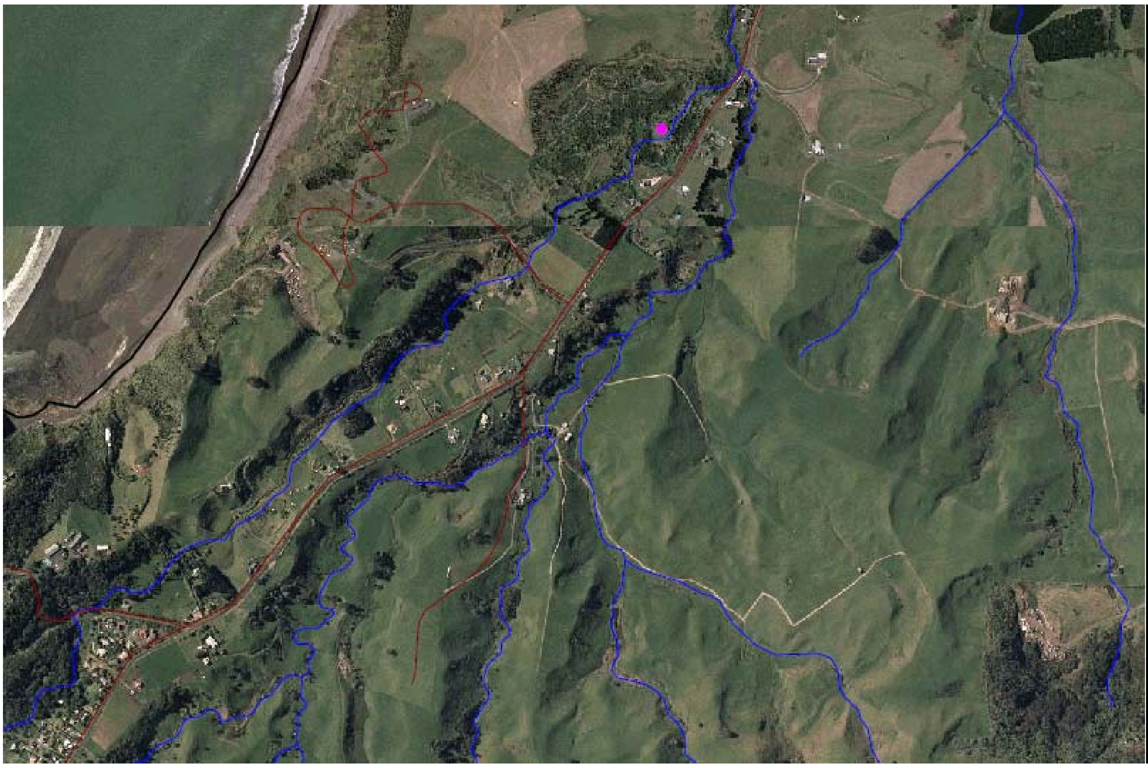


2007

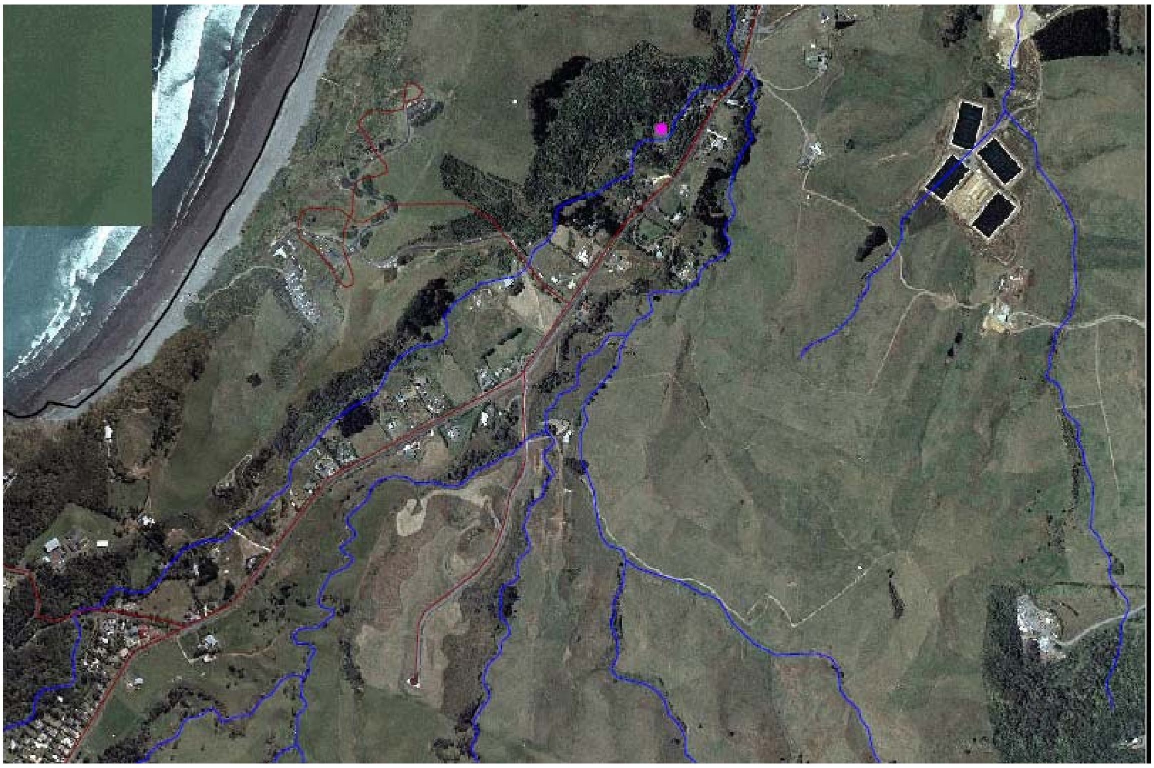


Site 1172_6

2002

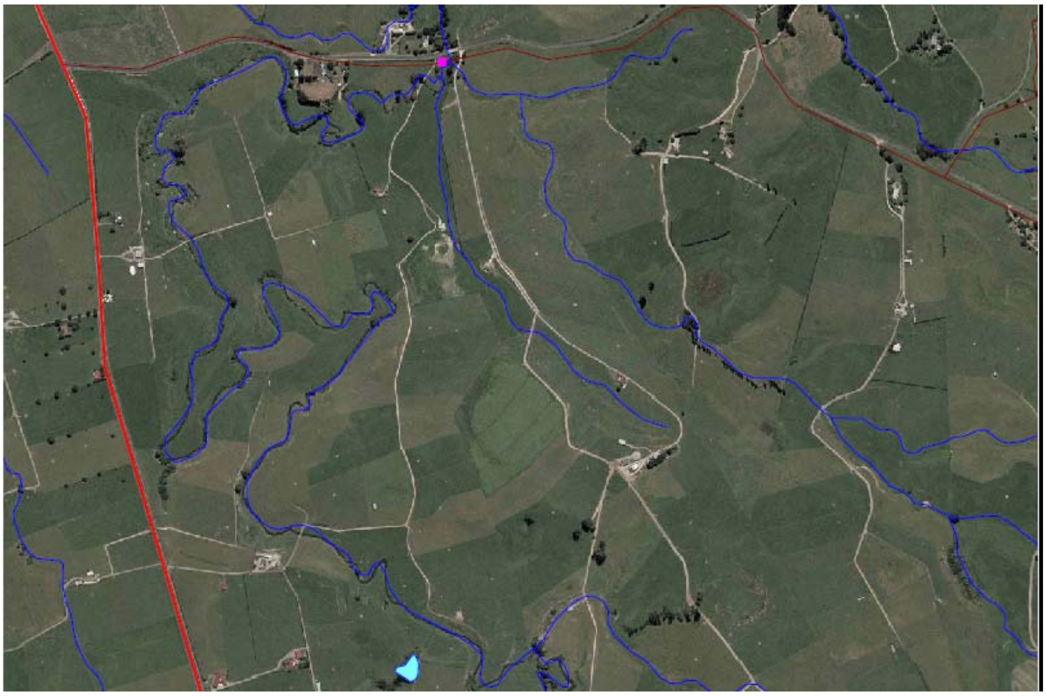


2007

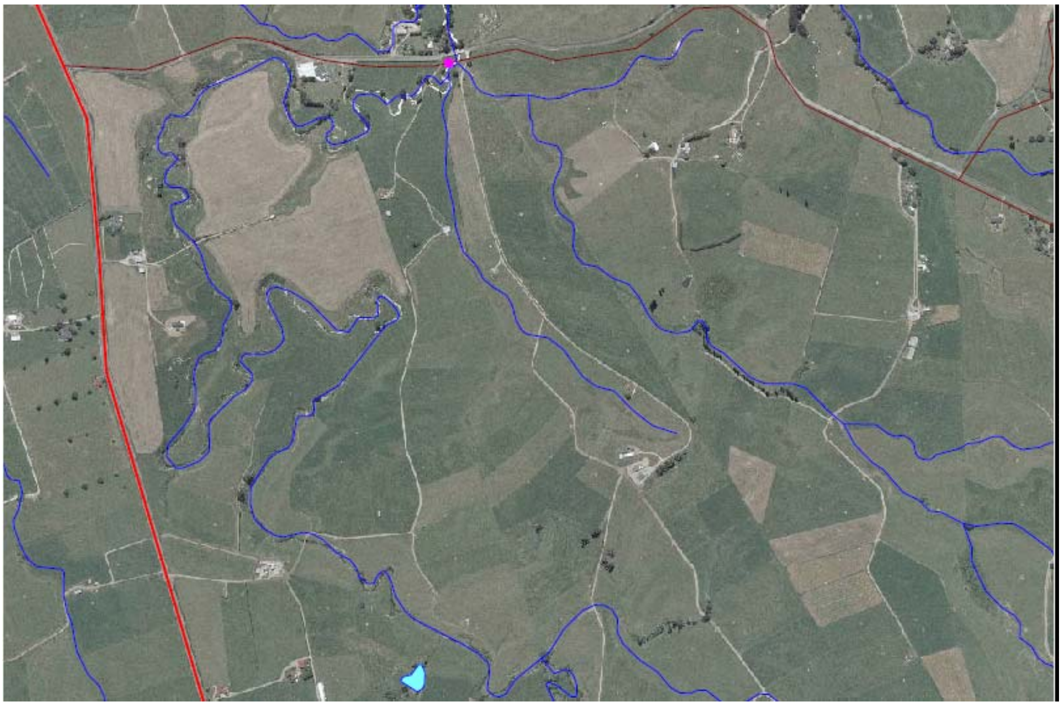


Site 1174_10

2002

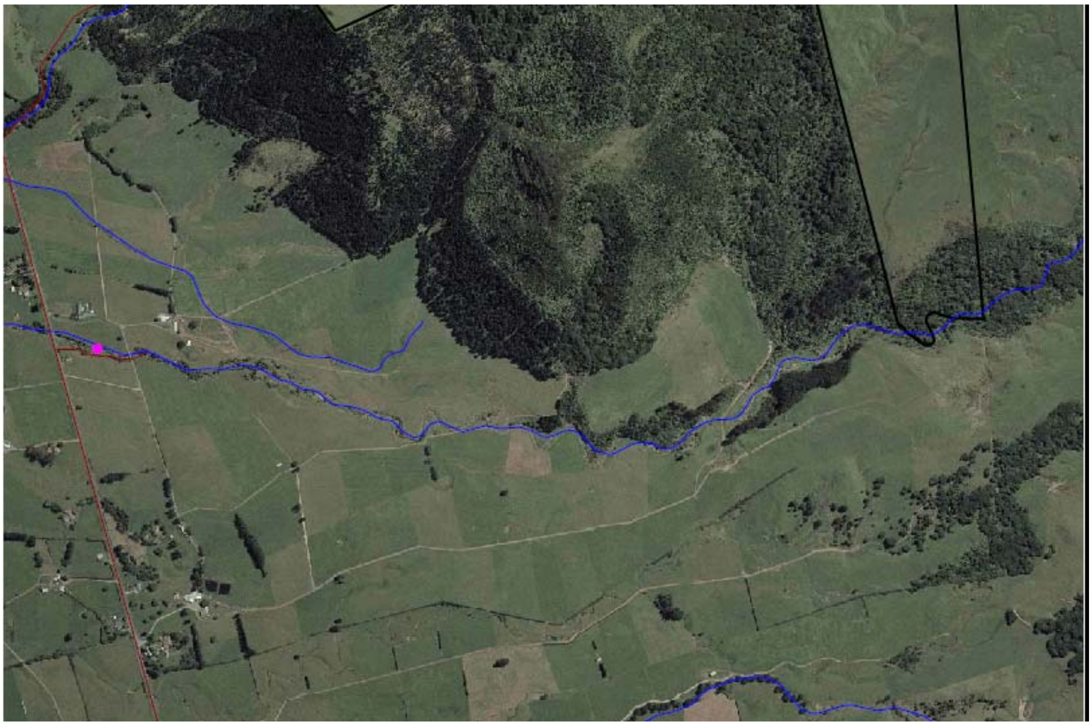


2007

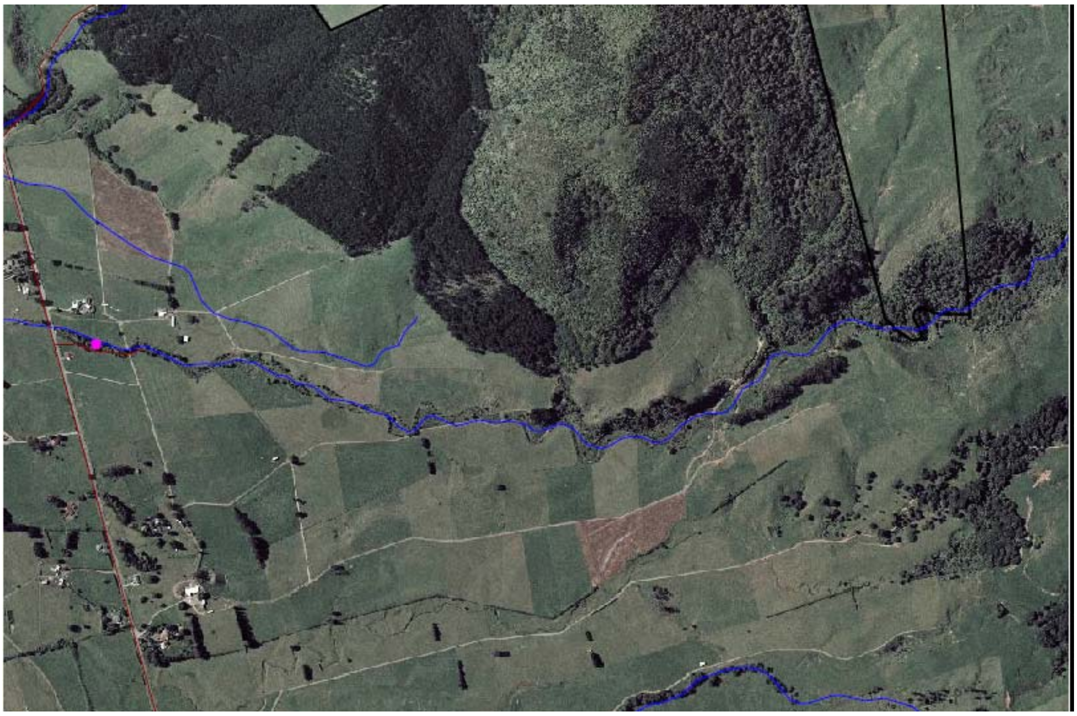


Site 1252_3

2002



2007



Site 1257_4

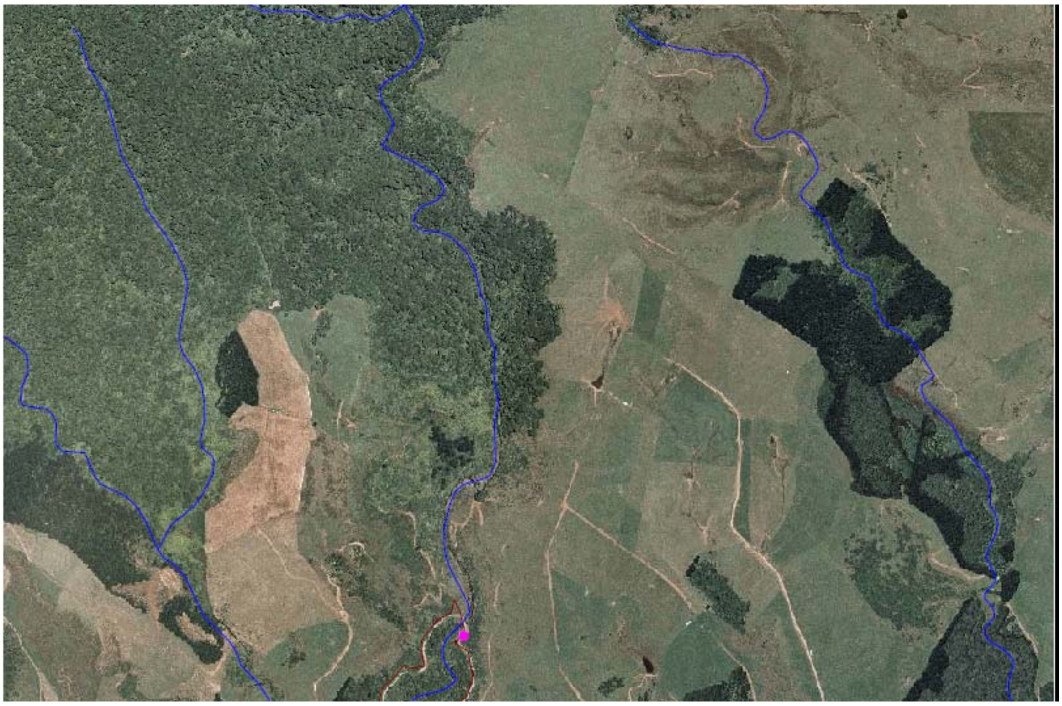
2002

2007

Site 1284_1

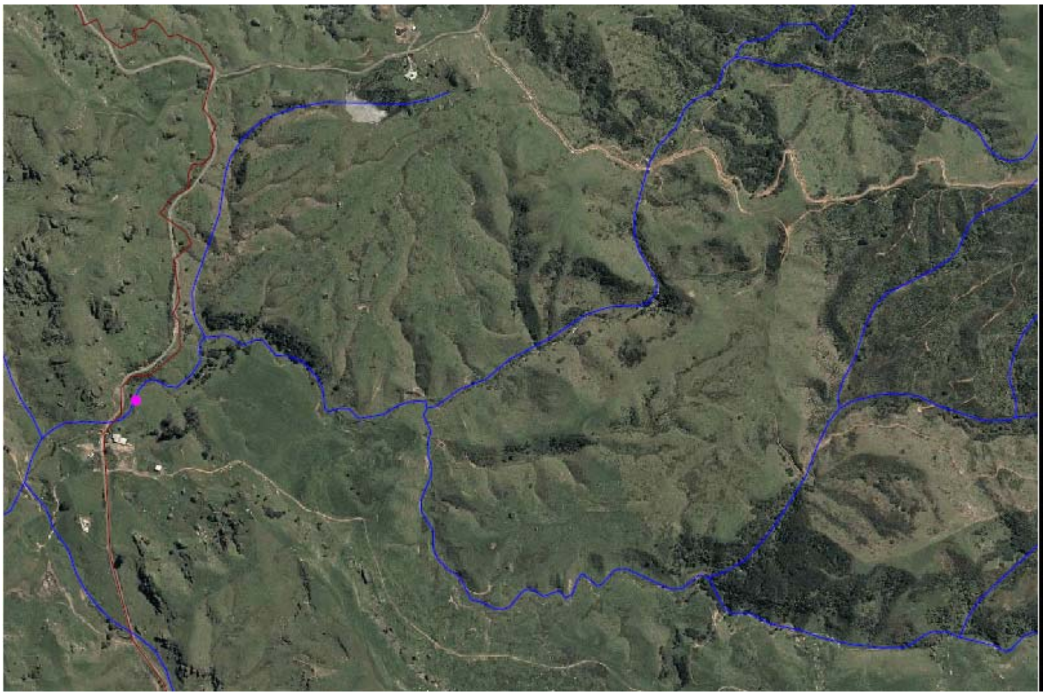
2002

2007

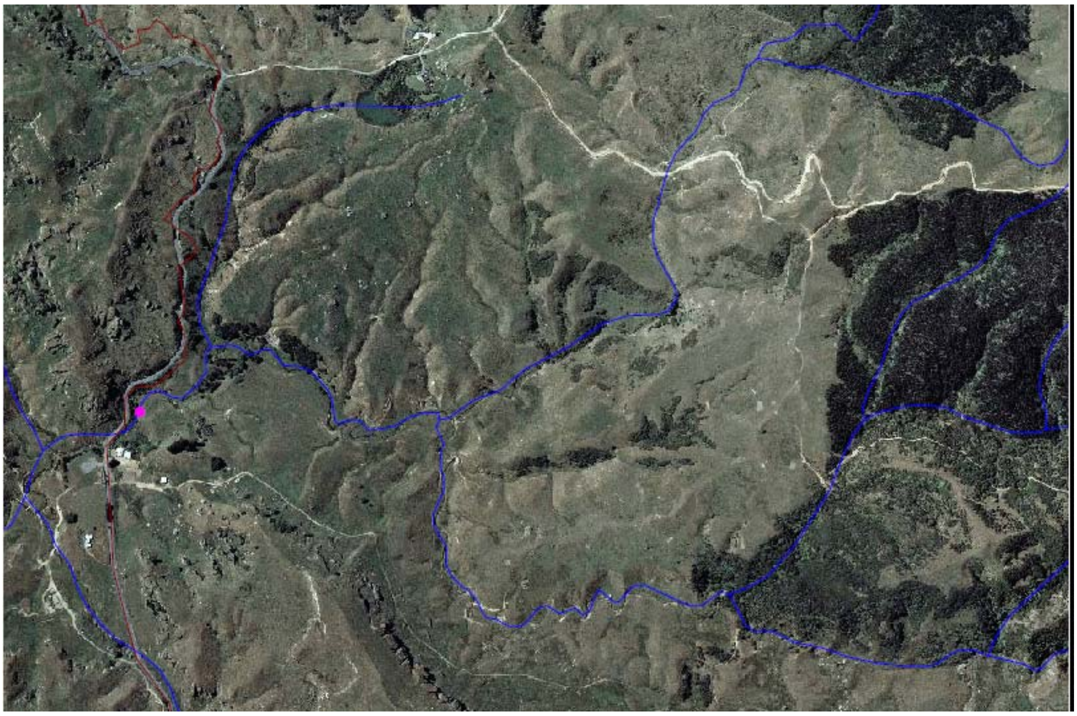


Site 195_1

2002



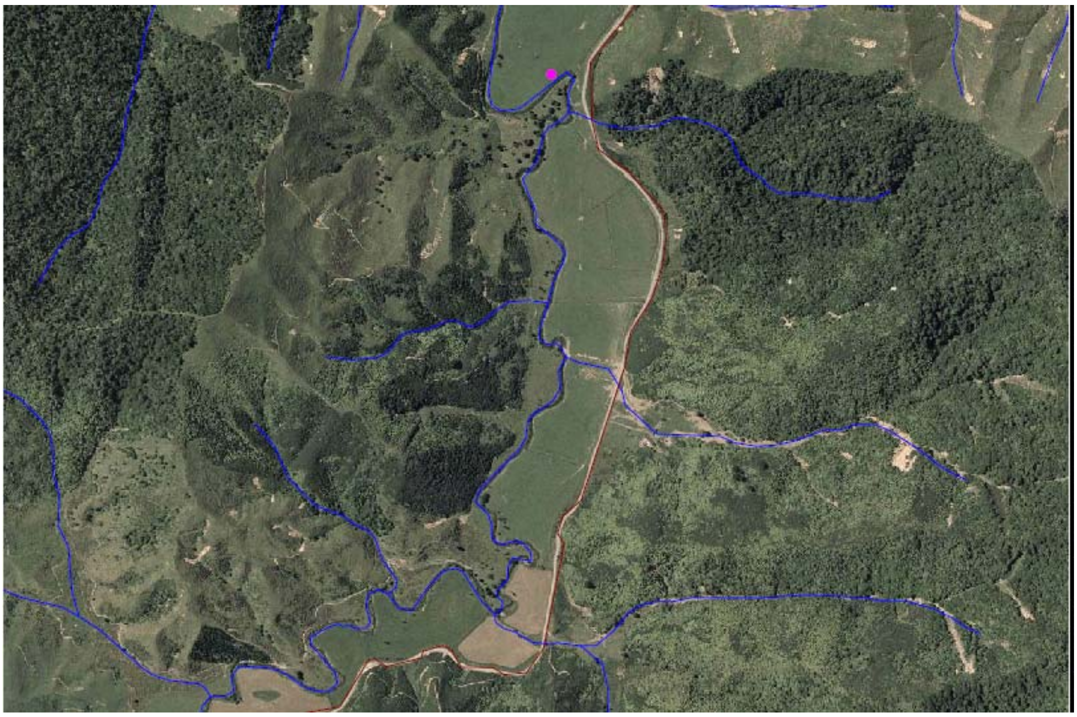
2007



Site 256_2

2002

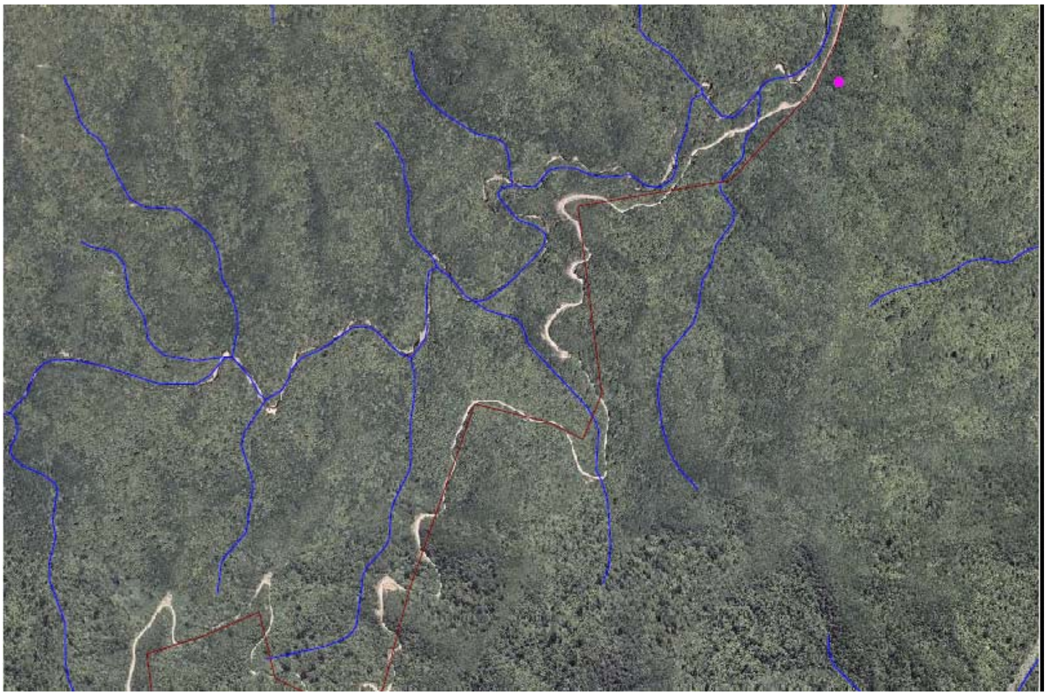
2007



Site 4_2

2002

2007



Site 407_1

2002

2007

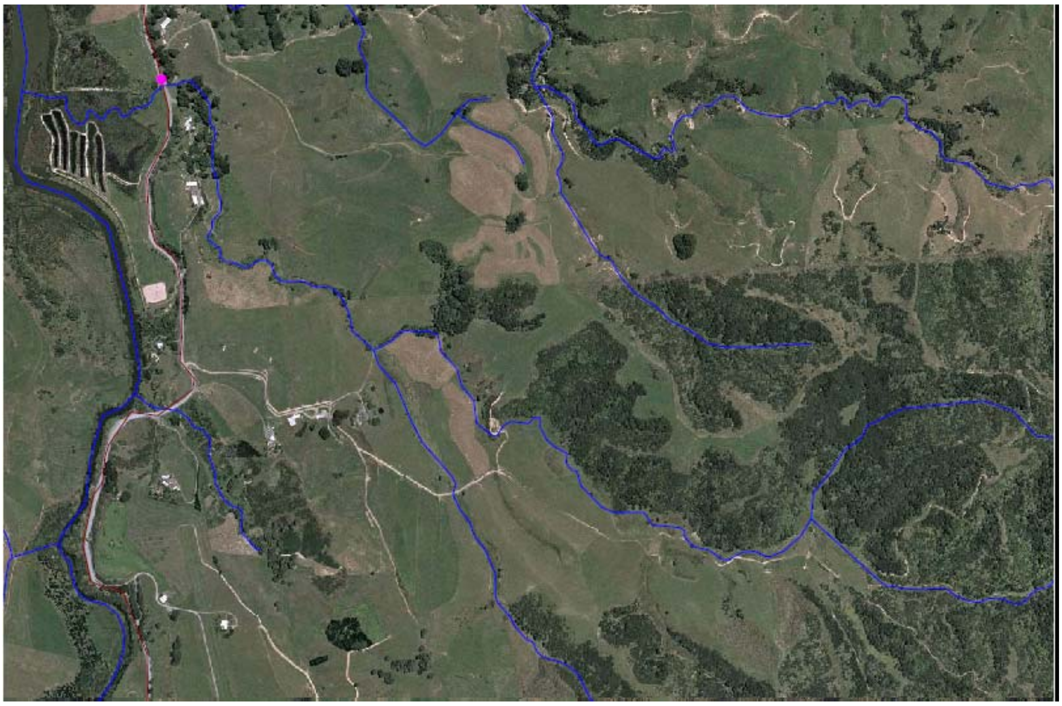
Site 433_2

2002

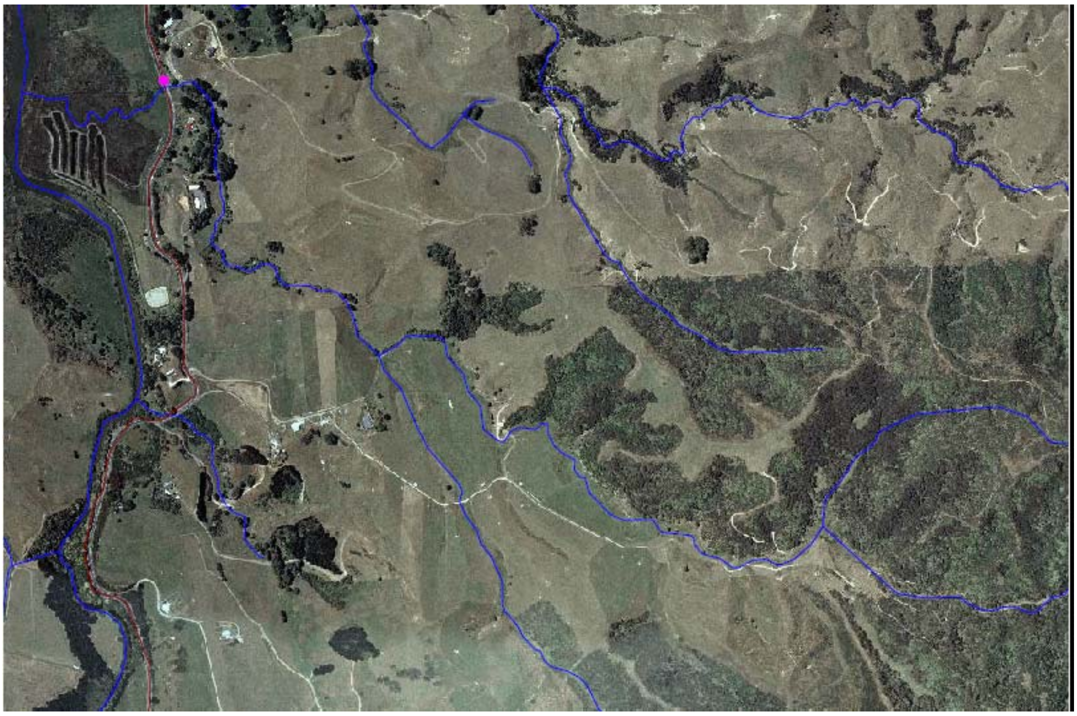
2007

Site 539_1

2002



2007



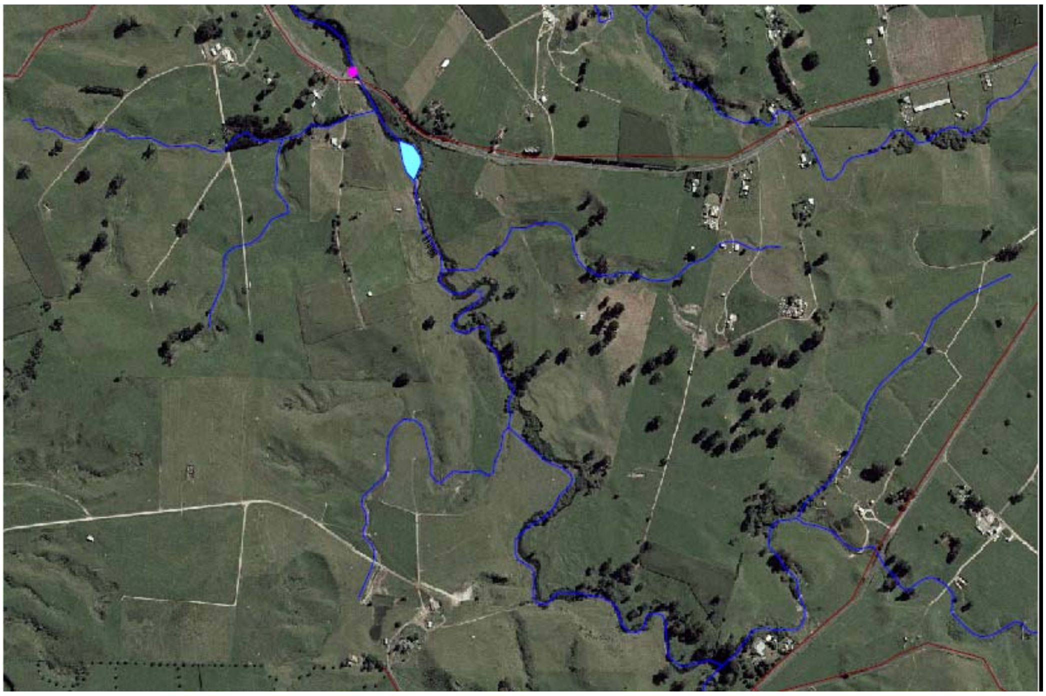
Site 749_10

2002

2007

Site 786_2

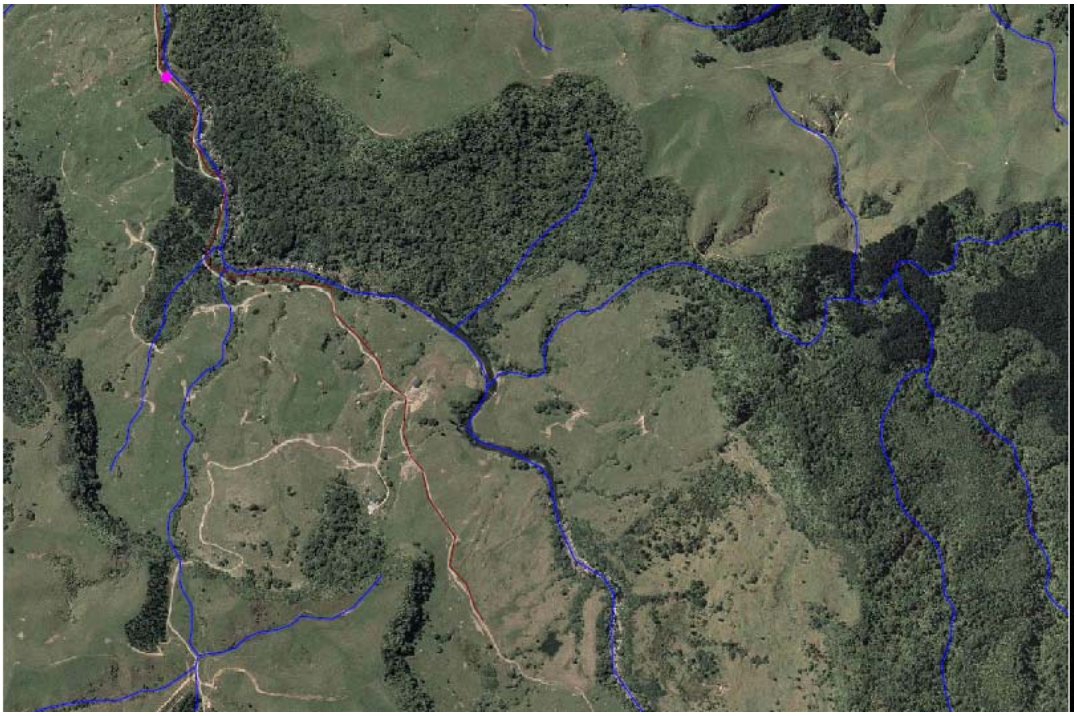
2002



2007

Site 976_2

2002



2007