Waikato Regional Council Technical Report 2014/03

Regional guidelines for ecological assessments of freshwater environments

Aquatic plant cover in wadeable streams – version 2

www.waikatoregion.govt.nz
ISSN 2230-4355 (Print)
ISSN 2230-4363 (Online)

Waikato
REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

Prepared by:
Kevin Collier; Mark Hamer (Waikato Regional Council)
Paul Champion (National Institute of Water and Atmospheric Research (NIWA))

For:
Waikato Regional Council
PO Box 4010
HAMILTON EAST

10 June 2014

Document #: 2938322

Peer reviewed by:
Bruno David Date June 2014

Approved for release by:
Dominique Noiton Date June 2014

Disclaimer

This technical report has been prepared for the use of Waikato Regional Council as a reference document and as such does not constitute Council's policy.

Council requests that if excerpts or inferences are drawn from this document for further use by individuals or organisations, due care should be taken to ensure that the appropriate context has been preserved, and is accurately reflected and referenced in any subsequent spoken or written communication.

While Waikato Regional Council has exercised all reasonable skill and care in controlling the contents of this report, Council accepts no liability in contract, tort or otherwise, for any loss, damage, injury or expense (whether direct, indirect or consequential) arising out of the provision of this information or its use by you or any other party.

Acknowledgements

Rohan Wells, John Clayton, Aleki Taumoepeau and Tracey Edwards at NIWA kindly provided many photos for the field identification guide. Cathy Kilroy kindly assisted with clarifying calculations of the PEI. This revision is based on the original methods developed in association with Johlene Kelly. Several current and former WRC staff have contributed to data collection, in particular Nathan Singleton.

Table of contents

List of figures

List of tables

Executive summary

Aquatic plants (macrophytes) and algae (periphyton) play an important role in stream and river ecology. They provide a food source and habitat for living creatures such as fish and invertebrates and can also influence instream habitats by reducing water velocities and increasing sediment deposition. Aquatic plants can exacerbate flooding in nutrient rich waters by taking up space in confined channels and blocking culverts during flood events. They also play a major role in the diurnal changes in dissolved oxygen levels within waterways by producing oxygen during the day and using it up at night. In turn aquatic plants and algae are influenced by waterway nutrient levels, temperature, flow stability and light. This report outlines the methods the Waikato Regional Council recommends for rapidly assessing plant and algal cover in the field. A demonstration is given on how to produce indices relating to both algal cover and aquatic plants. These indices can then be used to explain differences between invertebrate samples, compare differing sites, and present this information to the public or to council in assessments of environmental effects (AEE).

The periphyton assessment protocol is based on that developed by NIWA in 2002. The aquatic plant rapid assessment method was developed by the Waikato Regional Council in conjunction with NIWA. These methods were originally outlined in; *Collier, Kelly and Champion (2007) Regional guidelines for ecological assessments of freshwater environments. Aquatic plant cover in wadeable streams. Environment Waikato technical report 2006/47*. This report replaces and updates the 2007 version mentioned above to clarify and revise some of the index equations. It also provides some examples of the relationships between macro-invertebrate indices and the aquatic plant and periphyton indices demonstrated in this report. The plant identification photo guide has also been updated to include more of the plants now found regularly in the Waikato region. This report is intended to be used as a guide to the methods for the rapid assessment of aquatic plants and algal cover in wadeable streams.

1 Introduction

This report should be used as the minimum level of assessment expected by the Waikato Regional Council for plant cover in wadeable streams in the Waikato Region. It provides an update of the original report:

- Collier K, Kelly J, Champion P 2007. Regional guidelines for ecological assessments of freshwater environments. Aquatic plant cover in wadeable streams. Environment Waikato technical report 2006/47.

The following changes/additions to the original report have been made:

- Regional statistics for periphyton and macrophyte indices for perennial non-tidal wadeable streams on developed land
- Revised equation for the Periphyton Enrichment Index
- Updated relationships with macroinvertebrate metrics
- Updated pictorial macrophyte identification sheets

Macrophytes can be particularly important as habitat over spring-summer in streams dominated by fine sediments where other stable substrates are uncommon, but few invertebrates eat macrophytes directly (with the exception of the koura *Paranephrops* and the moth larva *Hygraula nitens*). Algae growing on stones, wood, macrophytes or any other stable surfaces can be an important food source for invertebrates, especially in more open streams. Some invertebrates pierce the cells of algal filaments and suck out their contents (e.g., *Oxyethira albiceps*), whereas other invertebrates can scrape (e.g., *Potamopyrgus antipodarum*) or sweep (leptophlebiid mayflies) algae such as diatoms from substrate surfaces. Although some plant cover increases habitat diversity (especially where streambeds are dominated by fine sediments) and can provide food, too much can cause ecological problems by impeding water flow, trapping more fine sediments, smothering benthic habitats, and causing wide fluctuations in dissolved oxygen and pH due to plant respiration and photosynthesis.

This set of guidelines describes the procedures used in Waikato Regional Council's Regional Ecological Monitoring of Streams (REMS) State of the Environment (SOE) monitoring programme to assess cover by aquatic plants (typically algae and rooted macrophytes) in wadeable streams. These methods should be used in association with reach-scale cover assessments (e.g., as described in the REMS Field Assessment Cover Form) to enable comparisons with the transect methods which capture more detailed information at a few locations within the reach. An expanded algal assessment protocol for the REMS programme was introduced for streams dominated by stony substrates in 2002 using an adaptation of Rapid Assessment Method 2 (RAM-2) from the Stream Periphyton Monitoring Manual (Biggs & Kilroy 2000). Waikato Regional Council's initial application of this method involved selecting five stones per reach, but this was altered in 2005 to bring the method in line with the RAM-2 approach of selecting five stones at each of several transects (although some modifications to the RAM-2 method exist; see Section 2). A new rapid macrophyte assessment protocol (RMAP), developed for Environment Waikato by NIWA, was introduced to the REMS programme in 2004 (see Section 3). Both the modified RAM-2 method and the RMAP method allow indices to be calculated, as well as providing information that assists with the interpretation of patterns in invertebrate community structure. Indices reflect nutrient enrichment (periphyton), proliferation (periphyton and macrophytes) and naturalness (macrophytes). The revised equation for the Periphyton Enrichment Index (PEI) should be used to re-calculate historical PEI values.

Both macrophyte and periphyton assessments for the REMS programme are carried out over January to March. Rivers should not be surveyed for aquatic plants if visibility is insufficient to enable a reliable assessment. In slightly-moderately turbid streams, a viewer may assist with assessments. Surveys should be conducted at baseflow as water levels much higher than this could affect assessments of macrophyte height and

may lead to inclusion of terrestrial grasses in assessments by inexperienced observers. A stand down period of two weeks is applied by Waikato Regional Council once flood flows exceed a level considered likely to mobilise bed sediments at representative flow monitoring sites. This stand down period is intended to allow some recovery of macroinvertebrate communities, but may not be sufficient to enable recovery of macrophytes. Some factors that may constrain macrophyte growth at certain sites are recorded on the Field Assessment Cover Form (e.g., shade, turbidity), but additional constraining factors should also be noted (e.g., evidence of macrophyte removal or recent drain clearance, artificial bed substrates).

These are rapid assessment approaches, and are therefore recommended for broadscale surveys of wadeable streams with adequate clarity, such as for SOE monitoring, but may not be appropriate for targeted assessments aimed at addressing specific questions, such as compliance monitoring where more detailed analyses may be required (e.g., chlorophyll *a* concentration, biomass in replicate samples). It is recognised that each study will have its own set of questions and requirements, and that variations to any guidelines or recommended methods may be necessary to address specific questions. These guidelines should not constrain the scope of work that is carried out but should be used to ensure that, where appropriate, the approaches applied are consistent with recommended methods and meet or exceed the minimum level of effort.

2 Periphyton cover rapid assessment protocol

As noted earlier, the periphyton protocol is based on the RAM-2 approach described by Biggs & Kilroy (2000). The main points of difference in the approach used by Waikato Regional Council are:

- The use of five transects along 100 m long reaches instead of the four transects in the original method to keep consistency with the macrophyte protocol (Section 3).

- The substrates assessed along a transect include not only sediments but also wood and macrophytes where they occur at sampling points in all types of stream.

- There is no distinction between the different types/colours of (i) “thin” (<0.5 mm thick) periphyton mats or films as we found the colour of thin algal coverings difficult to distinguish from the background rock colour, or (ii) “short-filament” periphyton as they have the same enrichment indicator score (Biggs & Kilroy 2000).

- The enrichment scores used in Biggs & Kilroy (2000) was subtracted from 10 so that colour/thickness categories more indicative of enriched conditions score more highly than those less typical of enriched conditions, to maintain consistency with the other periphyton metrics used here.

2.1 Protocol

The purpose of this protocol is to describe the procedures used in Waikato Regional Council’s REMS programme and to enable consultants conducting similar studies to employ complementary methodologies.

- Select five evenly-spaced transects along the sampling reach (100 m long). Do not start at 0 m because this point has been selected to define the bottom of the

reach and may be biased in some way (e.g., tributary confluence, availability of a post or tree to attach tape).

- Working from the downstream end of the sample reach, move across each transect and randomly remove or assess substrates within a 10 cm diameter circle centred on sampling points at 10%, 30%, 50%, 70% and 90% across the wetted width.

- Assess periphyton on whatever substrate occurs at the sampling point – periphyton adheres to surfaces so if in doubt give the substrate a gentle shake to remove non-adhering material such as detritus or flocculants. In stony streams, aim for stones bigger than around 4 cm across. Place stones on a white tray or similar. If stones are not available, make an *in-situ* assessment on large substrate elements (e.g., boulder, bedrock) or finer sediments (a viewer may be useful), or remove a scoop of sediment from the stream. A tea strainer is recommended by Biggs & Kilroy (2000) for removing scoops of fine sediments.

- If inorganic sediments are not available around the sampling point but macrophytes or wood occur there, make an assessment of periphyton cover on the habitat that is available in an area of around 10 cm diameter.

- Record average percentage cover of upper surfaces at the 5 points across each transect by the different periphyton categories described in Table 1 (see Appendix 1 for data sheet). If cover is patchy for some categories (e.g., nodules which are classified under mats), make an estimate of the average amount of surface area covered as if they all occurred together. Include senescing algae and record it as the colour that it most likely was (look at fresh algal growths nearby for clues); if the original colour isn't apparent record the colour you see.

- Repeat the process at the remaining transects.

- Calculate the mean percent cover for each transect and then the average for all transects for each periphyton thickness and colour category to provide an average for the reach. Calculate indices as described in Section 2.2.

As a general rule, if the periphyton is <0.5 mm thick but can be scraped by a fingernail, we consider it to be "thin". If a stone feels rough we record it as not present. Sometimes mineral particles will be removed by a fingernail scrape from soft rocks and can be mistaken for periphyton. If the particles feel gritty they are probably mineral, although scrapes from soft clay rocks can feel slippery. The length of filaments is best determined by covering the rock with water. A field identification sheet is provided to assist with colour and biomass assessments in the Stream Periphyton Monitoring Manual (Biggs & Kilroy 2000).

For convenience, the periphyton data sheet (Appendix 1) also provides fields to record cover by bryophytes (mosses and liverworts) and iron bacterial growths. These are not algae and so are not used in the calculation of the indices below, although prolific iron bacteria may have implications for aesthetics and ecology. Iron bacteria form orange-coloured growths that resemble jelly-like slime and filaments, and occur where there are high concentrations of dissolved iron in the water. Waikato Regional Council do not record iron-flocs as they do not adhere to stones, or orange precipitates (not slimy) which may form in association with iron bacteria because they are not organic.

Table 1: Enrichment indicator scores for different thickness and colour categories for periphyton. NA = not applicable

Thickness category	Colour category	Enrichment indicator score[1]
Thin mat/film (<0.5 mm thick)	NA	1
Medium mat (0.5-3 mm thick)	Green	5
	Light brown	3
	Black/dark brown	1
Thick mat (>3 mm thick)	Green/light brown	6
	Black/dark brown	3
Short filaments (<2 cm long)	NA	5
Long filaments (>2 cm long)	Green	9
	Brown/reddish	6

[1] Higher scores indicate categories more indicative of enrichment (note these differ from the scores in Biggs & Kilroy (2000) because they have been subtracted from 10 so that higher PEI values indicate greater enrichment).

2.2 Indices

2.2.1 Nutrient enrichment index

Table 1 provides indicator scores for various periphyton biomass and colour categories to reflect enrichment. These scores differ from those in Biggs & Kilroy (2000) so that higher values of the **Periphyton Enrichment Index (PEI)** indicate greater algal cover by periphyton categories indicative of enrichment to maintain consistency with other indices. Biggs & Kilroy (2000) indicate that their scores provided were preliminary, but there has been no subsequent work that suggests they should be modified in terms of their relative sensitivity to enrichment (B. Biggs, NIWA, personal communication). As we do not discriminate colour of thin periphyton films/mats, we give this category a score of 1 to reflect the average of all scores in that thickness category.

To derive PEI you need to do the following:

- Sum all values per transect to provide total periphyton % cover (*a*);
- Multiply % cover for each category in each transect by the enrichment score to produce *b*;
- Sum *b* for each transect to provide *c*;
- Divide *c* by *a* to provide *d* (average cover).
- Sum the values for *d* to provide total weighted coverage (*e*);
- Divide *e* by total number of transects with periphyton cover (i.e., maximum value of 5) (*h*) to provide *f*.
- Multiply by 11 (*g*) as a scaling factor (so that the values range up to 100) to yield PEI.

Thus:

PEI = {[∑(% cover in each category per transect * Indicator score) / Total % cover per transect] / No. transects with periphyton} * 11
Or following the notation below

PEI = {[∑(c / a)] / h} * 11

A worked example is provided in section 2.3 of this report. The PEI is adapted from Biggs & Kilroy (2000) to provide values on a similar scale to other periphyton indices with higher scores reflecting higher enrichment. Note that the equation for (f) in the bottom table on p. 44 of Biggs & Kilroy should read "total average periphyton scores (e)/no. transects with periphyton". It is important to note that transects without periphyton are ignored in the calculation.

The PEI was originally developed for stony streams so caution needs to be exercised in interpreting this index if the substrates assessed were sandy or wood and macrophytes. The PEI is not recommended if a large proportion of the periphyton recorded is senescing and the original colour is not apparent.

The revised equation (included here) for the Periphyton Enrichment Index (PEI) should be used to re-calculate historical PEI values.

2.2.2 Biomass indices

Calculate a **Periphyton Filamentous Index (PFI)** as percent of total cover by long filaments, and **Periphyton Mat Index (PMI)** as percent cover by thick mats. The periphyton guidelines (Biggs 2000) recommend an upper level 30% cover by long filamentous algae or 60% cover by thick mats of diatoms and cyanobacteria for aesthetic and recreational purposes. These thresholds were originally developed for stony streams and should be applied to these streams as cover of the visible streambed.

Calculate a **Periphyton Proliferation Index (PPI)** as a percent of total cover by long filaments and thick mats.

Calculate a **Periphyton Slimyness Index (PSI**) using the following formula based on percent cover for each thickness category (i.e., all colour categories combined):

PSI = {(%Thin mat/film) + (%Short filaments * 2) + (%Medium mat * 3) + (%Long filaments * 4) + (%Thick mat * 5)} / 5

Regional statistics for periphyton indices are shown in Table 2 and relationships with macroinvertebrate indices are shown in Figure 2. The regional statistics were derived from a probability sampling network of 180 non-tidal perennial wadeable streams on developed land sampled on a 3-year rotating panel (60 per year; see Collier & Hamer 2012; Collier & Olsen 2013). The statistics presented therefore represent this population of wadeable streams and can be used to benchmark results from other perennial, non-tidal wadeable streams on developed land (e.g., the 50th percentile represents the median or 'typical" state).

Table 2: Regional statistics (percentiles and mean) for periphyton biomass indices in perennial, non-tidal wadeable streams on developed land. 50Pct = median. Statistics not available for PEI.

	N	Estimate	StdError	LCB95Pct	UCB95Pct
Peripyhton Proliferation Index					
5Pct	73	0.00		0.00	0.00
10Pct	73	0.00		0.00	0.00
25Pct	73	0.00		0.00	0.00
50Pct	**85**	**1.44**		**0.00**	**2.81**
75Pct	128	9.96		7.53	14.22
90Pct	163	26.42		23.04	31.89
95Pct	171	44.47		27.51	56.04
Mean	**180**	**8.25**	**1.03**	**6.24**	**10.27**
Periphyton Slimyness Index					
5Pct	37	0.00		0.00	0.00
10Pct	37	0.00		0.00	0.00
25Pct	37	0.00		0.00	1.49
50Pct	**84**	**5.84**		**4.44**	**8.64**
75Pct	128	16.02		13.06	20.74
90Pct	158	28.08		24.94	34.90
95Pct	171	40.42		31.09	44.90
Mean	**180**	**10.75**	**0.89**	**9.01**	**12.49**

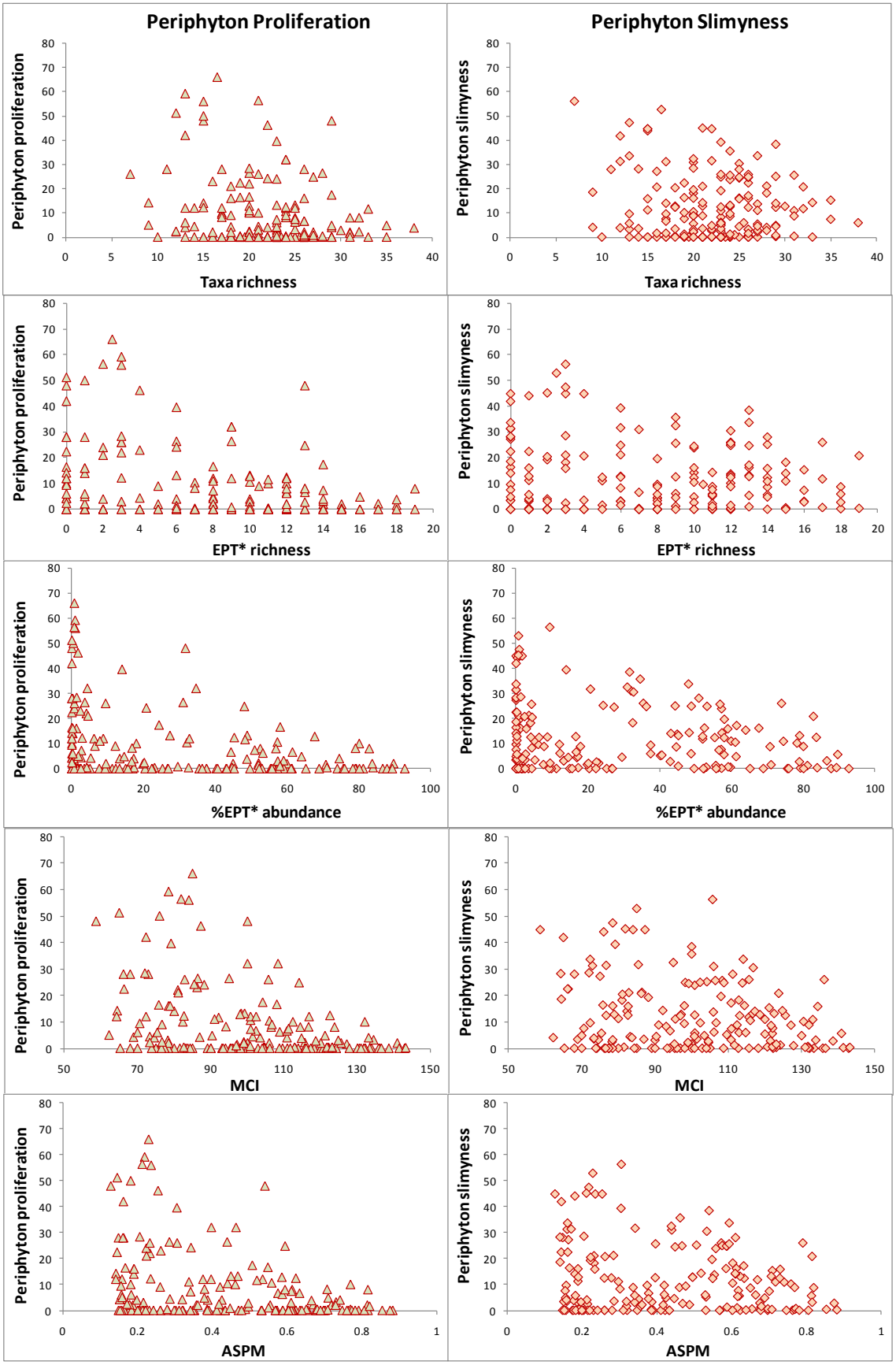


Figure 1: **Relationships between 5 macroinvertebrate indices and periphyton biomass indices from perennial, non-tidal wadeable sites on developed land sampled over 2009-2011. n = 180. EPT = Ephemeroptera, Plecoptera and Trichoptera (excluding Hydroptilidae), MCI = Macroinvertebrate Community Index, ASPM = Average Score per Metric.**

2.3 Example

Figure 2 shows the first of five transects established 20 m upstream of the downstream end of a 100 m stream reach. The substrate across this transect is a mixture of sand and stones with patches of filamentous green algae present, as well as macrophytes (see Section 3.3). Periphyton cover is assessed at 5 evenly-spaced points across each transect (total of 25 points per site). Stones are removed from the water for assessment; where fine sediment or organic material is present, cover is assessed in situ using a viewer where necessary or from scooped up material. Periphyton cover assessed at this transect and four other hypothetical transects upstream is shown in Table 3.

For the example shown in Table 3, these indices equate to:

PEI = {[(420 / 70) + (600 / 100) + (150 / 50) + (110 / 60)] / 4 } *11 = 46

PFI = (60 + 100) / 5 = 32

PMI = (10 + 10) / 5 = 4

PPI = 4 + 32 = 36

PSI = {(20/5) + (0 * 2) + ((80/5) * 3) + ((160/5) * 4) + ((20/5 * 5)} / 5 = 40

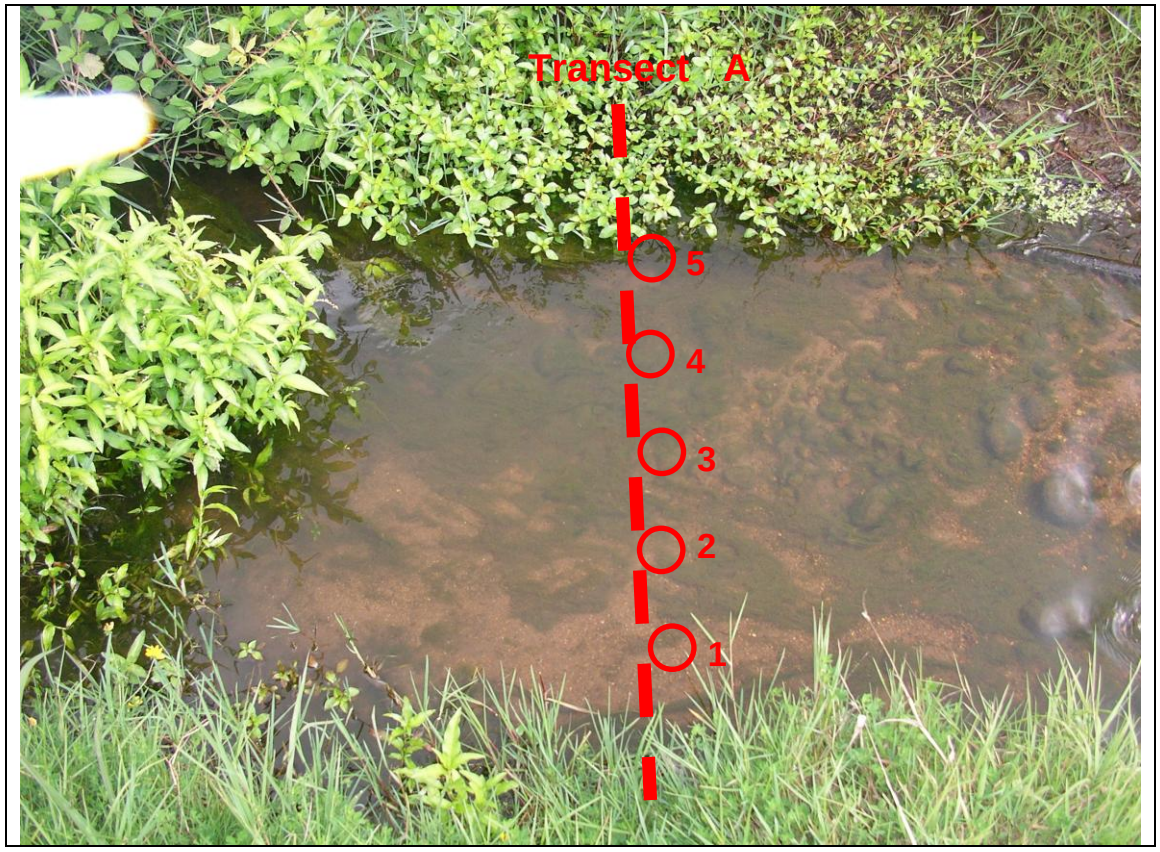


Figure 2: Hypothetical transect (one of five) for assessing periphyton cover in a wadeable stream.

Table 3: **Results of a hypothetical assessment of periphyton cover based on an adaptation of RAM-2 (Biggs & Kilroy 2000) at five transects (A-E) on a wadeable stream.**

	Score	Transect A	Transect B	Transect C	Transect D	Transect E	Transect A	Transect B	Transect C	Transect D	Transect E
Thin film (any colour)	**1**	0	0	20	0	0	0	0	20	0	0
Medium green mat	**5**	0	0	20	0	0	0	0	100	0	0
Medium brown mat	**3**	0	0	10	0	0	0	0	30	0	0
Medium black mat	**1**	0	0	0	50	0	0	0	0	50	0
Thick green/light brown mat	**6**	10	0	0	10	0	60	0	0	60	0
Thick black/dark brown mat	**3**	0	0	0	0	0	0	0	0	0	0
Short filaments	**5**	0	0	0	0	0	0	0	0	0	0
Long green filaments	**9**	0	0	0	0	0	0	0	0	0	0
Long brown filaments	**6**	60	100	0	0	0	360	600	0	0	0
TOTAL		**70**	**100**	**50**	**60**	**-**	**420**	**600**	**150**	**110**	**-**
		No. transects with periphyton = 4					6	6	3	1.8	-
											16.8
											4.2
											X 11
										PEI	**46**

For PEI calculation

	A	total % of transect covered by periphyton
	B	[list of] all % cover * score
	C	sum of all multiplied % scores
	D	average score per stone (or transect) or *c*/*a*=*d*
	E	total of all scores in line *d*
	F	total average periphyton scores (*e*) / no. transects with periphyton (*h*)
	G	multiply by a scaling factor of 11
	H	number of transects with periphyton

3 Macrophyte cover rapid assessment protocol

This protocol is designed to give only a general picture of reach-scale cover and composition by rooted macrophytes as only 5% of a 100 m reach is assessed. It assesses macrophytes growing in or emerging from the wetted channel only; floating macrophytes are not used in the calculation of indices because their impact on 'clogginess' is minimal and a high density of floating plants would skew measures of total cover and %native cover. Generally, free-floating macrophytes only accumulate on top of surface reaching submerged vegetation or amongst emergent plants, although they can build up enough to completely smother slower flowing streams. Include senescing or dying macrophytes in estimates of cover if they can be identified (although surveys should be done before the onset macrophyte senescence).

The protocol requires some training or experience in macrophyte identification; an annual refresher is recommended. If an unknown plant is found and it is of interest or it represents more than 5% of the cover present, a sample (preferably including flowers) should be retained for identification or a photo should be taken. Plants allocated to the "other" category should not exceed 5% without further identification.

3.1 Protocol

- Select five evenly-spaced transects along the sampling reach (100 m long). Do not start at 0 m because this point has been selected to define the bottom of the reach and may be biased in some way (e.g., tributary confluence, availability of a post or tree to attach tape).

- Facing upstream, estimate aquatic vegetation cover from a plan view (i.e., looking down) occupying a 1 m wide belt upstream of the transect and across the entire wetted width of the stream, and record this figure (see Appendix 2 for datasheet).

- Divide the 1 m swathe into emergent macrophytes and submerged macrophytes. Emergent macrophytes are those with parts clearly rising above the water. Submerged macrophytes are those that occur beneath the water surface or extend to the surface. Write down total submerged and total emergent percent cover in appropriate columns on the datasheet. The sum of percent emergent and submerged cover should add up to the total cover figure if floating species are not present. Note floating taxa (i.e. Azolla and duckweed) as present but do not include them in any formula.

- Identify emergent species using the guide in Appendix 3, and allocate a percent cover to each. The total of these should add up to the total emergent cover.

- Divide the submerged macrophytes into "Below surface" and "Surface reaching". "Below surface" is defined as anything growing beneath the top of the water. "Surface reaching" is defined as breaking the surface of the water column. Write down percent cover for each – the sum of these should add up to the total submerged figure.

- Identify surface-reaching submerged species using the identification guide in Appendix 3, and allocate a percent cover to each. Enter these figures in the appropriate column. Repeat for below-surface submerged species. The total of these should add up to the total submerged cover.

- Repeat the process at the remaining transects. Remember you are looking at a plan view so if emergent macrophytes are growing at the edge but cover the whole stream it is 100% cover. If a species has two forms (e.g., some is surface reaching and some is below surface) record this separately in the appropriate column.

- Calculate indices as described below.

3.2 Indices

The macrophyte indices described below reflect the extent of cover over the bottom (**MTC**) and through the water column (**MCC**), as well as the naturalness (**MNC**) of the rooted macrophyte community.

Macrophyte Total Cover (MTC) = {∑(%emergent + %submerged)} / 5

Macrophyte Channel Clogginess (MCC) = {∑ (%emergent + %surface-reaching) + (% below surface * 0.5)} / 5

Macrophyte Native Cover (MNC) = (∑% native species) / 5

Although the **MTC** and **MCC** indices had similar distributions in the sites sampled in 2006 and their rank order was highly correlated (r_s = 0.99), a stream could conceivably have a high **MTC** score and a low **MCC** score. For example, if 100% of all transects are covered by "below surface" macrophytes **MTC** will be 100 but **MCC** will be 50.

Regional statistics for macrophyte indices are shown in Table 4 and relationships with macroinvertebrate indices are shown in Figure 3. The regional statistics were derived from a probability sampling network of 180 non-tidal perennial wadeable streams on developed land sampled on a 3-year rotating panel (60 per year; see Collier & Hamer 2012; Collier & Olsen 2013). The statistics presented therefore represent this population of wadeable streams and can be used to benchmark results from other perennial, non-tidal wadeable streams on developed land (e.g., the 50th percentile represents the median or 'typical" state).

Table 4: Regional statistics (percentiles and mean) for three macrophyte indices in perennial, non-tidal wadeable streams on developed land. 50Pct = median.

Statistic	N	Estimate	StdError	LCB95Pct	UCB95Pct
Macrophyte total cover					
5Pct	43	0.00		0.00	0.00
10Pct	43	0.00		0.00	0.00
25Pct	48	0.20		0.00	1.23
50Pct	**99**	**9.07**		**5.29**	**18.54**
75Pct	145	54.74		40.09	73.51
90Pct	165	85.56		80.96	97.24
95Pct	172	97.64		87.72	99.79
Mean	**180**	**29.14**	**2.63**	**23.99**	**34.28**
SD	180	34.34	1.52	31.35	37.32
Macrophyte channel clogginess					
5Pct	45	0.00		0.00	0.00
10Pct	45	0.00		0.00	0.00
25Pct	46	0.17		0.00	0.89
50Pct	**96**	**9.33**		**5.30**	**16.98**
75Pct	144	55.82		35.90	73.88
90Pct	163	85.81		81.00	93.26
95Pct	171	93.30		85.95	99.51
Mean	**180**	**28.83**	**2.57**	**23.80**	**33.86**
Macrophyte native community					
5Pct	130	0.00		0.00	0.00
10Pct	130	0.00		0.00	0.00
25Pct	130	0.00		0.00	0.00
50Pct	**130**	**0.00**		**0.00**	**0.00**
75Pct	130	0.00		0.00	1.60
90Pct	157	6.95		4.12	15.54
95Pct	168	18.23		9.25	36.99
Mean	**180**	**2.74**	**0.56**	**1.65**	**3.84**

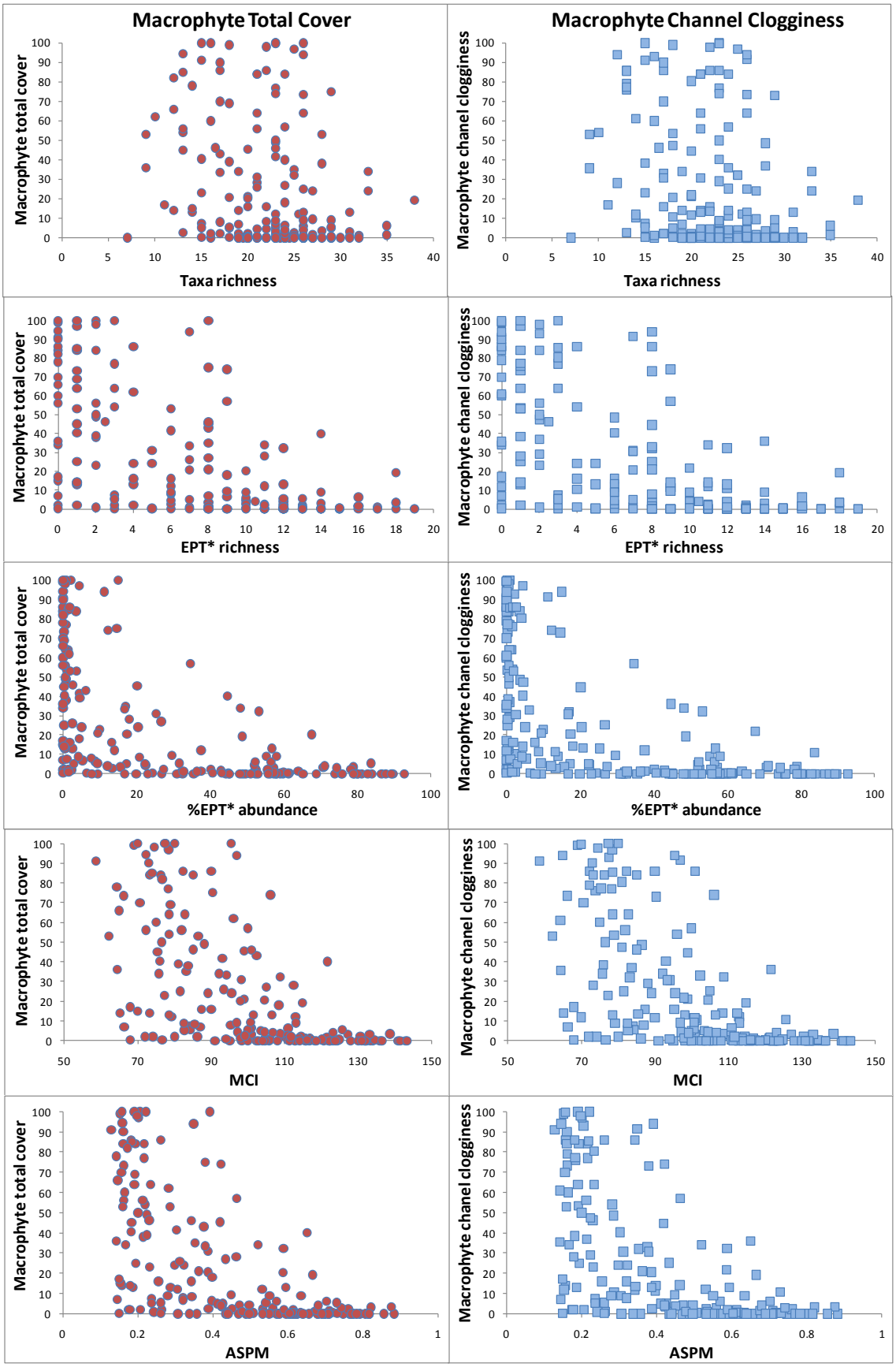


Figure 3: **Relationships between 5 macroinvertebrate indices and two macrophyte indices from perennial, non-tidal wadeable sites on developed land sampled over 2009-2011. n = 180. EPT = Ephemeroptera, Plecoptera and Trichoptera (excluding Hydroptilidae), MCI = Macroinvertebrate Community Index, ASPM = Average Score per Metric.**

3.3 Example

In Figure 4 below, the rectangle indicates the 1 m wide band upstream of one of five evenly-spaced transects in which macrophyte cover is assessed. Macrophytes cover around 35% of the area (plan view). The dashed lines show emergent macrophytes which are estimated to cover around 25% of the area looking down. These comprise around 12% starwort, 10% *Persicaria hydropiper*, and 3% *Ludwigia palustris*. Submerged macrophytes, indicated by the dotted line, cover around 10% of the area, and all are classed as surface-reaching. These comprise 5% *Ludwigia* and 5% *Persicaria*. None of these species are native. Macrophyte cover assessed at this transect and four hypothetical transects upstream is shown in Table 5.

For the example shown in Table 5 these indices equate to:

MTC = (35 + 100 + 60 + 20 + 70) / 5 = 57

MCC = {(135 + 105) + (45 * 0.5)} / 5 = 53

MNC = (5 + 10 + 15 + 10 + 5) / 5 = 9

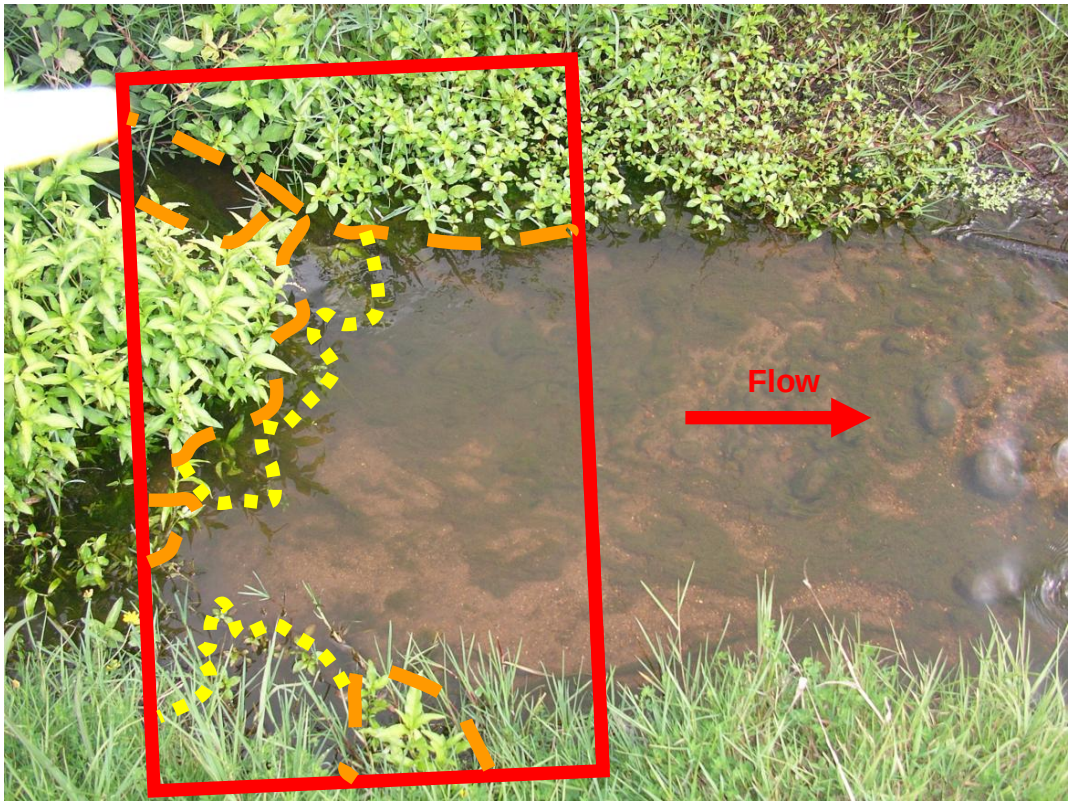


Figure 4: Hypothetical transect (one of five) for assessing macrophyte cover in a wadeable stream.

Table 5: Results of a hypothetical assessment of macrophyte cover at five transects (A-E) on a wadeable stream

(See Appendix 3 for species codes – those underlined are native species). No floating macrophytes were present.

Transect	Vegetation cover (% wetted area)							
		Submerged plants					Emergent plants	
	Total cover	Total submerged	Surface-reaching		Below surface			
			Sub-total	Species	Sub-total	Species	Total emergent	Species
A	35%	10%	10%	Lp 5% Ph 5%	0	-	25%	St 12% Ph 10% Lp 3%
B	100%	20%	10%	Ed 5% Pk 5%	10%	Nh 10%	80%	Ph 70% Ps 10%
C	60%	60%	50%	Ed 50%	10%	Pk 10%	0%	-
D	20%	15%	0	-	15%	Nh 15%	5%	St 5%
E	70%	45%	35%	Ed 25% Lp 2% Ps 5% Other 3%	10%	Pk 10%	25%	Mp 5% Lp 3% Mg 15% Other 2%

References

Biggs BJF 2000. New Zealand periphyton guideline: Detecting, monitoring and managing enrichment of streams. Wellington, Ministry for the Environment.

Biggs BJF, Kilroy C 2000. Stream periphyton monitoring manual. Published by NIWA for the Ministry for the Environment. Christchurch, National Institute of Water and Atmospheric Research Ltd (NIWA).

Collier KJ, Kelly J 2005. Regional guidelines for ecological assessments of freshwater environments: Macroinvertebrate sampling in wadeable streams. Environment Waikato Technical Report 2005/02. Hamilton, Waikato Regional Council (Environment Waikato).

Collier K, Hamer M 2012. The ecological condition of Waikato wadeable streams based on the Regional Ecological Monitoring of Streams (REMS) programme. Waikato Regional Council Technical Report 2012/27. Hamilton, Waikato Regional Council.

Collier KJ, Olsen AR 2013. Monitoring network-design influence on assessment of ecological condition in wadeable streams. Marine and Freshwater Research 64: 146–156

Appendix 1: Datasheet for periphyton rapid assessment.

Bryophytes and iron bacterial growths are recorded here for convenience (NA = not applicable)

Stream:_____ **Located number:**_____

Sample Number:_____ **Date**:_____

		Transect					
Thickness category	**Colour category**	**A**	**B**	**C**	**D**	**E**	**Mean cover**
Thin mat/film (<0.5 mm thick)	NA						
Medium mat (0.5-3 mm thick)	Green						
	Light brown						
	Black/dark brown						
Thick mat (>3 mm thick)	Green/light brown						
	Black/dark brown						
Short filaments (≤2 mm long)	NA						
Long filaments (>2 cm long)	Green						
	Brown/reddish						
Submerged bryophytes	NA						
Iron bacteria growths	NA						

Appendix 2: Datasheet for macrophyte rapid assessment.

Channel and wetted widths and depths are recorded here for convenience but are not used in the calculation of indices.

Stream:_____ **Located number:**_____ **Sample Number**:_____

Date:_____

Transect	Wetted width (m)	Channel width (m)	Thalweg depth (m)	Vegetation cover (% wetted area)							
				Total cover	Submerged plants					Emergent plants	
					Total submerged	Surface-reaching		Below surface		Total emergent	Species
						Sub-total	Species	Sub-total	Species		
1											
2											
3											
4											
5											

		SUBMERGED SPECIES
	Cd	*Ceratophyllum demersum* - HORNWORT
Native	Ec	*Elodea canadensis* - CANADIAN PONDWEED
Introduced	Ed	*Egeria densa*
	St	*Callitriche stagnalis* - STARWORT
	Lm	*Lagarosiphon major*
	Mp	*Myriophyllum propinquum*
	Mt	*Myriophyllum triphyllum*
	Nh	*Nitella hookeri/cristata*
	Pc	*Potamogeton cheesemanii* – RED PONDWEED
	Pk	*Potamogeton crispus* - CURLED PONDWEED
	Po	*Potamogeton ochreatus* -BLUNT PONDWEED
	PoS	*Potamogeton subolongus* – MUD PONDWEED
	Rt	*Ranunculus tricophyllus* – WATER BUTTERCUP
	Uid	Unidentified Other species

	EMERGENT SPECIES
As	*Agrostis stolonifera* – CREEPING BENT
An	*Apium nodiflorum* - WATER CELERY
Apa	*Alisma plantago-aquatica* – WATER PLANTAIN
Ap	*Alternanthera philoxeroides* – ALLIGATOR WEED
Eg	*Erythranthe guttata* - MONKEY MUSK
Gd	*Glyceria declinata* – FLOATINGSWEET GRASS
Gm	*Glyceria maxima* - REED SWEET GRASS
Ip	*Iris pseudacorus* – YELLOW FLAG
Ipr	*Isolepis prolifera* – JUMPING RUSH
Ja	*Juncus articulatus* – JOINTED RUSH
Lop	*Lotus pedunculatus* - LOTUS
Lp	*Ludwigia palustris* - WATER PURSLANE
Lup	*Ludwigia peploides* – PIMROSE WILLOW
Le	*Lycopus europaeus* - GYPSYWORT

	EMERGENT SPECIES
Me	*Mentha spp.* – WILD MINT
Mep	*Mentha pulegium* – PENNYROYAL
Mpc	*Mentha x piperita var. citrata* - BERGAMOT MINT
Ml	*Myosotis laxa – WATER FORGET-ME-NOT*
Ma	*Myriophyllum aquaticum* - PARROTS FEATHER
Na	*Nasturtium officinale/microphyllum* - WATERCRESS
Gr	Other grass spp
Pd	*Paspalum distichum* – MERCER GRASS
Ps	*Persicaria decipiens* - SWAMP WILLOW WEED
Ph	*Persicaria hydropiper* - WATER PEPPER
Rf	*Ranunculus flamula* – LESSER SPEARWORT
Ve	*Veronica anagallis-aquatica/Americana* - WATER SPEEDWELL
Uid	Unidentified Other species

Appendix 3: Pictorial guide to some macrophyte species found in Waikato streams and rivers.

Stems leafy – oxygen weeds

Lagarosiphon major (Lm)
EXOTIC

Leaves not in whorls
Usually bend downwards

SUBMERGED SPECIES

Canadian pondweed *(Ec)*
Elodea canadensis
EXOTIC

Leaves in whorls of 3
Usually < 1 cm long
Much smaller than *Egeria*

Leaves in whorls of 4+
Usually > 1 cm long
White flowers

Egeria densa (Eg)
EXOTIC

Stems of single cells – charophytes

Branches in whorls
Green or black
Easily crushed

Nitella sp. aff. *cristata (Nh)*
NATIVE

Starwort *(St)*
Callitriche stagnalis
EXOTIC

Leaves opposite,
Upper leaves a rosette

SUBMERGED SPECIES

Leaves alternate

Leaves crimped, red veined, short
Stems flattened

Curled pondweed (Pk)

Potamogeton crispus

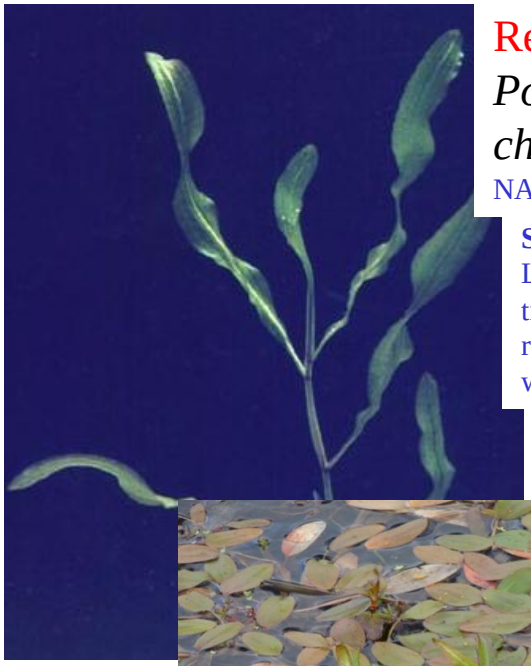
EXOTIC

Leaves flat, veins not red, leaves long
Stems round

Blunt pondweed (Po)

Potamogeton ochreatus

NATIVE



Red pondweed (Pc)

Potamogeton cheesemanii

NATIVE

Submerged form: Leaves wavy almost transparent, veins not red, leaves broader with leaf stalk

Surface-reaching form: Leaves alternate, blunt-ended, 5-11 veins

Leaves alternate, pointed at tip, 13-21 veins

Mud pondweed (PoS)

Potamogeton suboblongus

NATIVE

Leaves divided

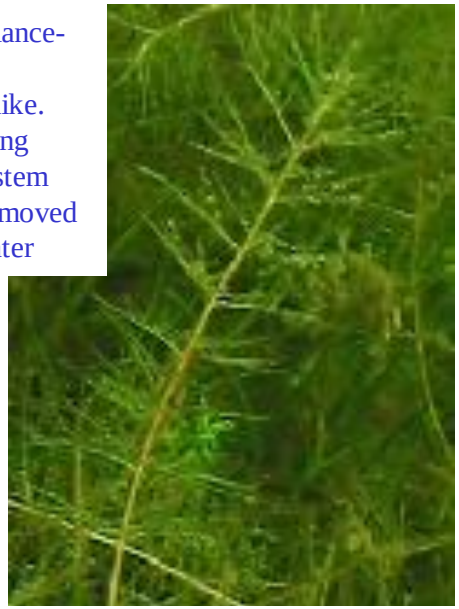
Leaves toothed
Rough to touch
No roots

Hornwort (Cd)
Ceratophyllum demersum
EXOTIC

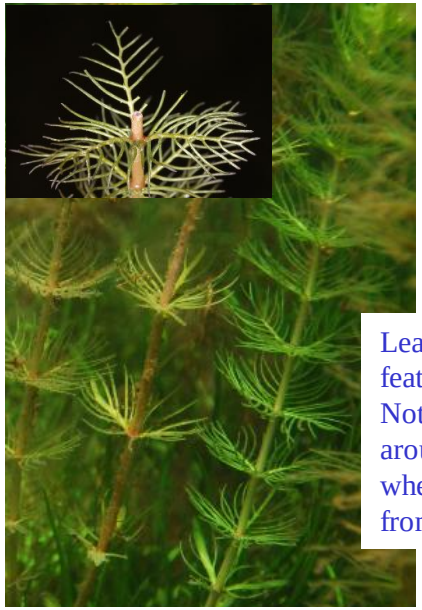
Water buttercup (Rt)
Ranunculus trichophyllus
EXOTIC

Leaves divided into soft linear segments

Leaves lance-shaped feather-like. Collapsing around stem when removed from water



Water milfoil (Mp) NATIVE
Myriophyllum propinquum



Leaves oval feather-like. Not collapsing around stem when removed from water

Water milfoil (Mt) NATIVE
Myriophyllum triphyllum

SUBMERGED SPECIES

EMERGENT SPECIES

Leaves divided

Water celery (An)
Apium nodiflorum
EXOTIC

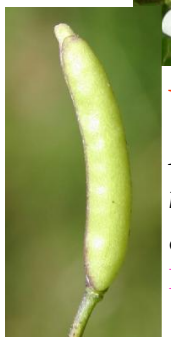
Leaflets toothed
Carroty smell

Leaves feathery
Pale green
EXOTIC

Parrot's feather (Ma)
Myriophyllum aquaticum
See other sheet for native species

Leaflets mostly untoothed
Peppery smell

N. microphyllum



N. officinale

Water cress (Na)
Nasturtium microphyllum & N. officinale
EXOTIC

Five leaflets
Not scented

Lotus (Lop)
Lotus pedunculatus
EXOTIC

EMERGENT SPECIES

Leaves alternate, undivided

Leaves wrinkled, not shiny
Veins obvious

Water pepper (Ph)
Persicaria hydropiper
EXOTIC

Swamp willow weed (Ps)
Persicaria decipiens - NATIVE

Stem with a black or dark green scale beneath each leaf

Primrose willow (Lup)
Ludwigia peploides EXOTIC

Water forget-me-not (Ml) *Myosotis laxa* EXOTIC

Spearwort (Rf)
Ranunculus flammula
EXOTIC

Leaves lance-shaped, plants fleshy

Leaves undivided opposite

Leaves toothed,
lance-shaped
Short stalks

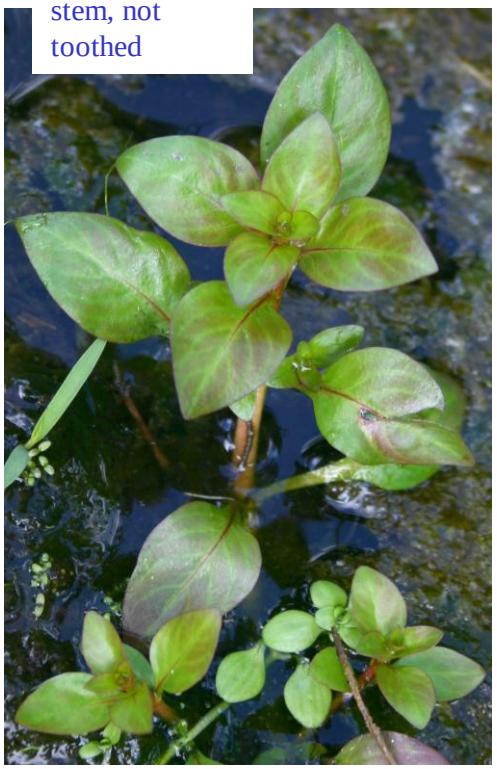
V. anagallis-aquatica

Veronica americana

Water speedwell (Ve)

Veronica americana/
anagallis-aquatica
EXOTIC

Leaves not
joined across
stem, not
toothed



Water purslane (Lp)
(can also be submerged)
Ludwigia palustris – EXOTIC

Almost
circular,
toothed

Monkey musk (Mg)
Erythanthe guttata - EXOTIC
(formerly *Mimulus guttatus)*

EMERGENT SPECIES

Leaves grass-like (true grasses)

EMERGENT SPECIES

Reed sweet grass (Gm)

Glyceria maxima

EXOTIC

Leaves over 1 cm across
Plants ~ 1m tall
Leaf tips like prow of boat

Creeping bent (As)
Agrostis stolonifera

Leaves <1 cm across
Leaf tips pointed, bases not hairy

Floating sweet grass (Gd)

Glyceria declinata EXOTIC

Leaves <1 cm across
Leaf tips like prow of boat

Mercer grass (Pd)

Paspalum distichum EXOTIC

Leaves <1 cm across
Leaf tips pointed, bases hairy

Leaves opposite, undivided stem square (mint family)

Gypsywort (Le)
Lycopus europaeus EXOTIC
Leaves coarsely toothed
Plant not scented

Leaves basal, grass-like

Pennyroyal (Mep)
Mentha pulegium
EXOTIC

Leaves finely toothed
Plant highly scented

Bergamot mint (Mpc)
Mentha x *piperita* var. *citrata*
EXOTIC

Leaves coarsely toothed
Plant highly scented

EMERGENT SPECIES

Leaves grass or rush-like (other plants)

EMERGENT

SPECIES

Water plantain (Apa)
Alisma plantago-aquatica
EXOTIC

Leaves upright, basal, broad lance-shaped

Jumping rush (Ipr)
Isolepis prolifera NATIVE

Leaves reduced to sheaths, stems
arch to form tangled mats

Jointed rush (Ja)
Juncus articulatus
EXOTIC

Leaves tubular with cross-walls

Appendix 4: Pictorial guide to some macrophyte species that are considered biosecurity threats and may be found in Waikato streams and rivers (report these to the Biosecurity officer).

NASTIES – KEEP AN EYE OUT FOR – REPORT SIGHTINGS!!

Water poppy
Flowers Nov-April
NATIONALLY BANNED

Marshwort
Flowers Nov-April
NATIONALLY BANNED

Fringed waterlily
Flowers Oct-April
NATIONALLY BANNED

Water hyacinth
NOTIFIABLE ORGANISM

Salvinia
NOTIFIABLE ORGANISM

NASTIES – KEEP AN EYE OUT FOR – REPORT SIGHTINGS!!

Yellow flag
Flowers Oct-Dec
NATIONALLY BANNED
Present in Lower Waikato

Purple loosestrife
Flowers during summer
NATIONALLY BANNED

Arrowhead
Flowers Oct-April
NATIONALLY BANNED

Sagittaria
Flowers Nov-March
NATIONALLY BANNED

Senegal tea
Flowers Nov-April
NATIONALLY BANNED

Alligator weed
NATIONALLY BANNED