FMA Protocol AQUATIC MACROPHYTES

Aim To monitor change in the aquatic macrophytes of rivers and lakes

Rationale Macrophytes are an important component of the aquatic ecosystem and broad changes in the abundance of individual species and community composition provide valuable information on how and why an ecosystem might be changing. Macrophytes are also becoming increasingly valued as a means of indirectly monitoring water quality as, for instance, eutrophication can produce a progressive change in species composition and a loss of species diversity.

Since the emphasis of the freshwater monitoring programme is on the aquatic environment, the macrophyte survey covers plants growing in the water body but not the adjacent banksides. "Bank species" occurring above the level of the river or lake are not recorded because the influence of the river or lake substrate and water chemistry are likely to be less important than local edaphic and climatic influences. The river channel (and by analogy, the lake) is defined in accordance with Holmes (1983): "The 'River' is defined as those parts of the substrata which are likely to be submerged for 85% of the time, whilst 'Bank' is that part of the side of the river (or islands) which is submerged for more than 50% but less than 85% of the time."

Macrophytes include any plant observable by the naked eye and nearly always identifiable when observed (Holmes & Whitton 1977). This includes all aquatic vascular plants and bryophytes, together with groups of algae which can be seen to be composed predominantly of a single species.

It will, however, rarely be possible to survey whole rivers and lakes and in most cases macrophyte surveys will be undertaken at selected sampling points. The main requirement is that the methods employed should be consistent so that information can be used to compare change both within and between sampling points at different sites and times. Common procedures have been recommended for lakes and rivers wherever possible.

This protocol aims to provide data on the following:

- i. Species present and their relative abundance. Although some groups, eg charophytes, are often identified only to family level it is recommended that all macrophytes are identified to species level. Details of the check list of aquatic macrophytes used in ECN are provided in Chapter 3 of this volume (page 106).
- ii. Species distribution along a river length and, in lakes, zonation at selected sample points.
- iii. Physical characteristics of the sampling location.

Wherever possible the recommended methods are close adaptations of existing, widely practised methods in order to ensure continuity with historic data and to reduce the need for training. Although a number of techniques have been developed for survey and monitoring of aquatic macrophytes in rivers (eg Patrick et al. 1991; Environment Agency 1996) and lakes (Wolfe-Murphy et al. 1991), and for characterising waterside habitats (Boon et al. 1997), none of these alone meets the requirements of ECN, particularly in relation to its need for detailed data for detecting change at individual sites. This protocol takes into account the rationale and methods adopted in vegetation monitoring at ECN's terrestrial sites (Rodwell et al. 1996) which is based on recording presence and absence of species in a large number of small quadrats. Some elements of this approach have been used in the methods described below but the use of fixed, small quadrats for recording presence and absence is a less practical and familiar technique in aquatic macrophyte surveys; thus the more common approach of estimating cover in larger areas has also been used.

Method STANDING WATERS

Since in most cases it is impossible to sample thoroughly a whole lake, a transect approach will be used to monitor specific locations which are generally representative of the whole lake. In addition, depending on the availability of resources, site operators are encouraged to carry out a more general, qualitative survey, in order to establish a species list for the whole lake. However, the methodology for such an additional survey should be determined by the site operator and is not included within this protocol.

The main steps in the survey procedure are:

- i. general site survey and mapping of lake margin zones to identify representative sampling locations;
- ii. selection of sampling points in the representative locations around the lake;
- iiii. shoreline surveys around the edge of the lake, centred on the sampling points;
- iv. deep water transects across the littoral zone, starting from the same sampling points.

Data gathered from the surveys will provide information on the presence/ absence of species along sections of shoreline and along gradients of increasing water depth. The point on the shoreline chosen as the starting point of each transect survey will be referred to as a sampling point. Decisions on the location and number of sampling points should be made following an initial appraisal of the lake as described below.

Equipment

- · Wading boots.
- Metre rule calibrated in 0.01 m intervals.
- Boat large enough for two/three people plus equipment (see Health & Safety, page 78).
- Ekman grab on rope calibrated in 0.1 m intervals.
- Bathyscope (see Appendix I, page 80) or camera.
- Hand-held echo sounder (optional see Appendix I, page 80)
- Plastic bags.
- Waterproof note book or paper with entry table prepared.
- Bucket.
- Floating transect rope mounted on rope winder (eg a monkey ladder). The rope should be calibrated in 2.5 m intervals to 10 m, then every 5 m. Allow approximately 5 m of "free" rope before the first calibration mark for attachment to the shore.
- Anchor rope attached to heavy anchor (eg a large boulder).
 - Marker buoy (the size of a football or larger).

Location

The number of sampling points will depend on the resources available and on the heterogeneity of the vegetation. Macrophyte surveys at each sampling point are likely to take approximately three to four hours. Wherever possible, sampling points should be located within examples of each of the main vegetation types characteristic of the lake.

An initial appraisal of the whole lake should be made to ascertain which locations within it are most suitable for transect surveys. This is achieved by carrying out a general site survey supplemented, where possible, by advice from aquatic macrophyte experts familiar with the lake, or by reference to existing habitat/vegetation maps. The shoreline is traversed either by wading or by boat, employing a combination of grapnel and grab techniques to identify the major stands of emergent, floating-leafed and submerged macrophytes which are then mapped on a plan of the shore outline. The aim at this stage is not to identify all plants to species level, but to obtain a generalised view of

macrophyte cover and zonation. A plumbline or hand-held echo sounder should be used to assess the degree of offshore slope in locations of potential sample points.

The following guidelines should be followed when selecting sampling points.

- i. Locations close to inflows or potential pollution point sources, which are likely to exert significant local influence on the lake, are to be avoided.
- ii. Each sampling point should be situated in a location where macrophyte cover and species richness are representative of one of the main macrophyte communities of the lake littoral zone, both along the shoreline and along the deep water gradient. These locations will usually be situated in more sheltered parts of the lake where disturbance by wave action and wind is minimal.
- iii. Ideally, the lake basin morphometry adjacent to the survey point should be simple and contours of lake depth should be approximately parallel to the lake shoreline.
- iv. Ideally, aquatic macrophyte species should show some zonation with increasing depth, and should show relative homogeneity along any depth contour, for at least 20 m on either side of the intended deep water transect line.
- v. Ideally, sites should be located where the deep water transect slope is gradual, so that the maximum depth at which macrophytes occur lies at least 30 m offshore. If there are no suitable locations where the macrophyte zone extends more than 5 m from the lake shore, due to extreme slope or very poor water transparency, only shoreline transects are needed. If it is possible only to identify sites in which the macrophyte zone lies 5–30 m offshore it may be necessary to decrease the deep water transect sampling interval, (eg from 5 m to 2.5 m).

Each sampling point should be marked in such a way as to enable its precise relocation on future visits. A unique code and NGR for each point should be recorded. The shoreline survey will always cover the same area 50 m on either side of the sampling point. However, due to the destructive nature of sampling, the origin of the deep water transect should be varied between visits by up to 5 m along the shoreline on either side of the sampling point.

Shoreline survey

Location

At lakes where there is evidence of variability in water level, the high water mark should be used as the upper limit of the shoreline. Lakes which show regular and large fluctuations (>0.3 m) in water level are unsuitable for the application of this protocol. The shoreline survey should be undertaken on foot by a surveyor wearing wading boots. The distance from the shore may be limited by the maximum depth (D_{max}) in which wading is considered safe and practicable. The value of D_{max} should be fixed for a particular lake and used on all future surveys.

The survey should cover an area with a shoreline length of 100 m, centred on the sampling point, and a width (W) of either 5 m or the distance at which the depth equals D_{max} , which ever is less. A record should be made of i) width (W) and ii) sampling depth (D) at distance (W) from the shore, where either:

- i. width = 5 m, maximum sampling depth = D_{max} ; record width (W) as 5 m and sampling depth (D) ±0.1 m), or;
- ii. width <5 m; record actual width (W) ±0.5 m and maximum sampling depth (D_{max}).

These variables will be recorded on all future surveys at the sampling site.

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The 100 m length should be divided into ten sections of 10 m using canes (non-permanent) to mark the shoreline limits of each section. The width limit

can be marked temporarily using one or more marker buoys to provide the surveyor with reference points.

• Sampling

Surveys should be repeated every two years from the same sampling points. Ideally all surveys should be undertaken in July/August but the date of the first survey should determine the date of subsequent surveys.

The lake level should be recorded against a standard benchmark at the time of sampling.

Starting at the section to the far left looking towards the lake (Section #1) the surveyor should walk the section, using a bathyscope if this is necessary to detect submerged species, and record the presence of all emergent, floating and submerged macrophytes on a standard form. For each sampling point the data collected will therefore comprise a species list for each section numbered 1–10. Where it is impossible to wade, the surveyor may walk along the shore or use a boat (with appropriate safety procedures), using a grapnel to retrieve plants for identification. A record should be made of the technique adopted.

In the event of a species being detected which cannot be identified by the surveyor, a sample should be taken (providing this is unlikely to affect the lake population of the species) and sealed in a labelled polythene bag for subsequent identification.

A sketch map should be made of the 100 m length of shoreline showing in the broadest terms the general physical character of the surveyed section in relation to prominent physical features of the site. The purpose of the map is to enable future relocation of the survey and to provide an annotated record of specific features related to the site, which may assist in the interpretation of the quantitative data. It is not necessary to make a detailed map on each survey occasion.

Main features to be marked on the sketch map are:

- NGR for both ends of the surveyed 100 m length;
- Grid north;
- relocation features, (eg distances to bridges, trees, boulders);
- points from which photographs are taken;
- shading position and type broken shade (using stippled shading pattern) or dense (solid shading);
- main macrophyte stands (shown with cross-hatched shading);
- adjacent land use (eg arable, pasture, forest, factory, houses/gardens).

On each survey occasion the general physical character of the site is recorded. The following attributes should be recorded in each 10 m section as an aid in the interpretation of macrophyte data (see Chapter 3, pages 103–107, for details of attributes and their categories):

- *i. Substrata*: Estimates should be based on a birds-eye view and should include only surface particles which are directly visible or hidden under macrophytes. If shapes of underlying larger particles are distinct under a layer of fine particles such as silt or clay then the larger particles should be recorded. Record the percentage cover of each substrate category in the appropriate box on the recording sheet.
- *ii. Shading*: Record the percentage of the shoreline section shaded (not the length of bank affected), in each shading category, when the sun is overhead (ie at 12 noon).

Photographs should be taken of the main emergent and floating-leafed macrophyte beds covered by the survey. The use of a polarising filter to reduce surface reflection is recommended. The location of the point $(\pm 2 \text{ m})$ from which each photograph is taken and the direction of the shot should be recorded on the sketch map. Points should be referenced by means of an obvious and permanent land feature, or by the use of global positioning satellite instrumentation. Copies of all photographs should be labelled with site, date and location within site and sent to the CCU for long-term storage. The photographs should also be annotated to highlight any key features.

Deep water survey

Location

It is recommended that three people are used to locate a deep water transect, though two people may be sufficient if a boat with a small outboard engine is used. The following guidelines are recommended.

- i. Secure the free end of the floating transect rope on the shoreline within 5 m of the sampling point, attaching it either to a stake or to available supports such as a fence post or large boulder. The precise location should be varied between visits.
- ii. Manoeuvre the boat on a course approximately perpendicular to the lake shore, releasing the transect rope under light tension. If an outboard engine is used the boat can be reversed from the shore so that the rope is paid out from the bow. It may be helpful to position a pair of surveyor's ranging poles about 10 m apart and behind the shore along the intended line of the transect to provide a sight line.
- iii. Once the full length of the transect rope has been released it should be tightened by continuing to head the boat outwards, and if necessary the angle from the shore should be adjusted. With the transect rope under tension, the anchor should be lowered, and the anchor rope tied off at the water surface to a buoy and then fastened to the transect rope.
- iv. The last 5 m section of the transect should extend just beyond the limit of macrophyte growth.
- Sampling

The survey should be repeated every two years. Ideally all surveys should be undertaken in July/August but the date of the first survey should determine the date of subsequent surveys.

A compass bearing on the position of the deep water transect buoy should be taken from the sampling point; this bearing will be used to help relocate the direction of the transect in future years.

Samples will be taken at 5 m intervals from the shore; each 5 m mark on the transect rope will be referred to as a transect point (see Figure 3, page 80). Starting from the shoreline end, the boat should be moved to the first transect point. The boat should be attached to the transect rope at the bow and stern. At each transect point separate port and starboard measurements are taken using at least one but preferably all three of the following techniques. Selection of the appropriate techniques will depend on the nature of the macrophyte community structure, (eg an Ekmann grab may be sufficient in oligotrophic lakes dominated by isoetids). Advice on the choice of techniques will be combined eventually within the data base to produce species lists for the port and starboard locations, data from each measurement should be recorded separately as an aid to interpretation.

- i. An Ekman grab sample is taken with its rope held immediately adjacent to the side of the boat. All species retrieved are recorded.
- ii. While the Ekman grab is still in place, record all species present in a 1 m² circular plot (radius = 560 mm) around the grab using a bathyscope or underwater camera to scan the area. A standard Ekman grab has a width of 140 mm and the plot radius is therefore equivalent to four Ekman grab widths; it may be helpful, therefore, to use this to judge whether macrophytes fall within the prescribed area. All species within this area which are identifiable to species level remotely (ie without being retrieved) are recorded. Utmost care must be taken to avoid misidentification. If there is in any doubt over the identification of a plant, it should not be included within the final species list for the transect point.
- iii. Allowing enough slack rope to permit free-fall to the lake bed, a macrophyte grapnel (eg double-headed rake) is lobbed into the water approximately 2 m out from the side of the boat in a direction perpendicular to the transect line. Having allowed time for the grapnel to reach the bottom, it is then retrieved at a rate slow enough for it to drag over the lake bed until its rope is approximately vertical, before hauling it to the surface. All species retrieved are recorded.

The following additional data should be collected for the port and starboard locations at each transect point.

- *i.* Sample depth: Measured using the calibrated Ekman grab rope or, with more accuracy, with a hand held echo sounder.
- *ii. Substrate*: The predominant substrate type using the categories listed in Chapter 3, pages 105–106.
- *iii. Total plant cover.* A visual estimate of the percentage cover of live vegetation within the area described in paragraph 2 above, to the nearest 10%. Any cover deemed to be less than 5% should be recorded as a +.

The following should be recorded for each transect.

- *i. Maximum depth of vascular plant growth:* The maximum depth at which vascular aquatic macrophyte species will grow is often controlled by water transparency. It is usually possible to observe their depth limit from the lake surface if a suitable underwater viewing device such as a bathyscope is employed.
- *ii.* Secchi disc depth. A reading should be taken at the deepest point of the transect or, if at this point the disc is visible on the bed of the lake, in deeper water.
- *iii. Limit of macrophyte growth*: The limit of macrophyte growth should be recorded, (ie the distance along the transect from the shore, ± 0.5 m).

A sketch of the deep water transect profile should be made incorporating information gathered from the Ekman grab samples, grapnel hauls and from visual observations made using the bathyscope.

Photographs should be taken of the main emergent and floating-leafed macrophyte beds covered by the survey. The use of a polarising filter to reduce surface reflection is recommended. The location of the point $(\pm 2 \text{ m})$ from which each photograph is taken and the direction of the shot should be recorded on the sketch map. Points should be referenced by means of an obvious and permanent land feature, or by the use of global positioning satellite instrumentation. Copies of all photographs should be labelled with

site, date and location within site and sent to the CCU for long-term storage. The photographs should also be annotated to highlight any key features.

Method RUNNING WATERS

Equipment

- Wading boots.
- Metre rule calibrated in 0.01 m intervals.
- Bathyscope (see Appendix I, page 80) or camera.
- Plastic bags.
- Waterproof note book or paper with entry table prepared.
- Grapnel with depth markings on rope.
- Tape measure, stakes, canes or other marking devices to mark section lengths.
- Optical range finder (optional).
- Boat, large enough for two people and equipment (see Health & Safety, page 78).
- Life jackets, dry suit.

Location

The macrophyte survey should cover a 100 m length of the river immediately upstream of the ECN chemical sample point (see FSP protocol, page 49). If this is not practical, the nearest suitable 100 m length upstream of the sample point should be used. The downstream and upstream limits should be defined by reference to suitable landmarks and Grid References and should be permanently marked and precisely relocatable (±0.5 m).

The 100 m length should be divided into ten sections of 10 m using stakes or canes, or any other suitable method, to mark the end points of each section.

Sampling

FMA Protocol

The technique is based on "Methodology for the Assessment of Freshwater Riverine Macrophytes for the purposes of the Urban Waste Water Treatment Directive" (UWWTD) (Environment Agency 1996) which is itself based on the "Blue Book Method B" (Standing Committee of Analysts 1987). It is designed to exploit the value of macrophytes as a water quality monitoring tool and aims to observe, identify and record, over a standard survey river length (usually 100 m), the macrophyte species present in the river channel, and to provide a semiquantitative estimate of the overall percentage cover of plants.

This approach has been adopted for ECN sites so that results can be directly compared with other surveys using the same technique. Additionally, in order to provide more detailed data on macrophyte distribution as an aid in the detection of long-term change, each site is divided into smaller sections in which measurements of the cover of each species present are made.

Sampling should be undertaken annually at the same location in July or August, ideally when the river has been at a normal low flow for several days and when it is not discoloured. A survey carried out when a river is in flood or is highly discoloured is unlikely to provide useful information. Timing of weed cuts should also be taken into account since they frequently occur between June and September. Once the timing of a survey has been fixed, subsequent surveys should be undertaken at the same time each year, being changed only when necessary to avoid the effects of weed cuts, high flows or discolouration.

All species of floating and submerged macrophytes should be recorded. The survey method covers those 'river macrophytes' contained within the river channel area. All such macrophytes seen submerged or partly submerged at low flow levels are recorded. At the sides of the river all macrophytes growing

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on parts of the substrata which are likely to be submerged for more than 85% of the time are also included. As it is best to survey macrophytes when the river has been in low flow for several days this is fairly easy to interpret consistently. 'Bank species' and macrophytes overhanging the river channel but not rooted in the channel should not be recorded.

Percentage cover of all species in the river channel should be estimated for each species in each 10 m section of the 100 m length. As an aid to estimating percentage cover of individual species it is useful, before starting the survey, to calculate what a 1 m^2 patch of macrophyte represents for each 10 m section, (eg it may be 0.1% or 0.5%).

In the event of a species being detected which cannot be identified by the surveyor, a sample should be taken (providing this is unlikely to affect the population of the species), sealed in a labelled polythene bag and retained for subsequent identification.

Different techniques are required, depending on whether a site is sufficiently shallow to be waded in safety.

- i. At sites where it is safe for the surveyor to enter the watercourse, the survey can be carried out by wading. At most sites this will mean that a second person will be required for safety reasons. Wading should be done in an upstream direction. Where some (<20%) of the length cannot be waded then it is acceptable to walk for a short distance along both banks, using a grapnel to retrieve submerged macrophytes for identification. The surveyor should wade in a zig-zag manner across the channel, investigating all types of habitat present. All species present in each 10 m section are recorded. The operator should cross the channel at least twice in each 10 m section.
- ii. At sites where the channel is narrow (<5 m) and it is not possible to use a boat, if the macrophytes can be seen clearly it is sufficient to walk along both banks and use a grapnel to retrieve material for identification. At other sites, where flow is slow, a small boat should be used, provided that recognised safety guidelines are followed. Each 10 m section is traversed and species presence recorded in the same way as for wadeable rivers. An underwater TV camera or a bathyscope must be used to observe any macrophytes which cannot be seen clearly from the surface. A grapnel should be used to retrieve submerged plants for identification.</p>

On each survey occasion the general physical character of the site is recorded. The following attributes should be recorded in each 10 m section as an aid in the interpretation of macrophyte data (see Chapter 3, pages 103–107, for details of the attributes and their categories):

- *i. Width:* This is the average width of the channel across which macrophytes have been recorded. Usually it will be sufficient to measure the width of the channel at the mid-point of each 10 m section using tape measures or ropes with 0.5 m divisions, or an optical range-finder. If the channel width varies irregularly, then the average of three measurements made at the centre and two ends of the section should be used.
- *ii.* Depth: Measure the depth at various points in the section; the number and exact location of the measurement points should depend on the variability of depths encountered when surveying the macrophytes. Record the depth by entering the percentages in each depth category.
- *iii. Substrate:* Estimates should be based on a birds-eye view and should only include surface particles which are directly visible or hidden under macrophytes. If shapes of underlying larger particles are distinctly visible under a layer of fine particles such as silt or clay then the larger particles

should be recorded. Record the percentage of the section in each substrate category.

- *iv. Habitats:* Record the percentage of the section in each habitat category.
- *v. Shading:* Record the percentage of the section in each shading category when the sun is overhead (ie at 12 noon) by summing estimates made from both banks to the centre of the channel.
- *vi. Water clarity:* Estimate the percentage of the section in each category. This is necessary because a survey length may be clear in the shallow margins and progress through cloudy to turbid as the water depth increases.
- vii. Bed stability. Record the percentage of the section in each category.

A sketch map should be made of the 100 m length showing, in the broadest terms, the general physical character of the site. The purpose of the map is to enable future relocation of the survey and to provide an annotated record of specific features related to the site which may assist in the interpretation of the quantitative data. It is not necessary to make a detailed map on each survey occasion. The map should be drawn so that the direction of flow is from the bottom to the top of the paper.

Main features to be marked on the sketch map are:

- NGR for both ends of the surveyed 100 m length;
- Grid north;
- width of the channel (as included in the survey);
- relocation features, (eg distances to bridges, trees, boulders);
- · points from which photographs are taken;
- shading position and type broken shade (using stippled shading pattern) or dense (solid shading);
- main macrophyte stands (shown with cross-hatched shading);
- extent of riverbanks riverbank is defined as the area before an adjacent land use starts;
- adjacent land use (eg arable, pasture, forest, factory, houses/gardens);
- direction of flow.

More extensive habitat mapping for the site may be completed as part of the River Habitat Survey (RHS) (Environment Agency 1997, Raven *et al.* 1997). The RHS is an optional protocol for ECN freshwater sites; it covers a 500 m stretch and should be chosen to include the 100 m length used for the macrophyte survey.

Photographs should be taken of the main emergent and floating-leafed macrophyte beds covered by the survey. The use of a polarising filter to reduce surface reflection is recommended. The location of the point $(\pm 2 \text{ m})$ from which each photograph is taken and the direction of the shot should be recorded on the sketch map. Points should be referenced by means of an obvious and permanent land feature, or by the use of global positioning satellite instrumentation. Copies of all photographs should be labelled with site, date and location within site and sent to the CCU for long-term storage. The photographs should also be annotated to highlight any key features.

QUALITY ASSURANCE IN MACROPHYTE SURVEYS

Quality assurance is an important part of the recording process, particularly where species exhibit a plastic morphology and/or where hybrids frequently form (eg *Potamogeton* species and Charophytes).

It should be achieved by ensuring the following:

	i. Collection and preservation of voucher specimens and the exchange of specimens with botanical experts, such as those based at the Natural History Museum and the Biological Records Centre (BRC) at ITE Monks Wood. Plants are best kept by preserving between newspaper sheets or blotting paper, or by preserving in formalin or alcohol. The latter is preferred, particularly for fine-leafed small species since macrophytes become brittle when dried out. Soak the plants in 5% formalin overnight then transfer them to well labelled air-tight polythene bags.	
	ii. Use of trained surveyors.	
	iii. Use of aerial photographs of an appropriate scale as a means of clarifying the extent of the main macrophyte stands of the river or lake.	
	HEALTH AND SAFETY	
	Field workers should follow their employer's regulations regarding health and safety, risk assessments and COSHH (Control of Substances Hazardous to Health). General guidance on health and safety precautions are given in National Rivers Authority (1996); this covers precautions associated with: i. chemical hazards associated with collection and laboratory identification; ii. physical hazards in the river and water channel; iii. clothing and equipment; iv. working procedures; v. use of boats.	
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Appendix I

Suppliers

Details of suppliers of hand-held echo sounder, bathyscope, and Ekman Grab are obtainable from the CCU.



Figure 3. Relationship between transect point and the shoreline and trawl surveys .

Specification of results and recording conventions

The measurement variables listed below are those required for each FMA sampling location at an ECN Site. Sites submitting data to the ECNCCU should refer to the accompanying Data Transfer documentation for the specification of ECN dataset formats, available on the restricted access Site Managers' extranet. Contact <u>ecnccu@ceh.ac.uk</u> if you need access to this documentation.

The first 4 key parameters uniquely identify a sample or recording occasion in space and time, and must be included within all datasets:

Unique code for each ECN Site

where sampling is more frequent than daily

- <u>Site Identification Code</u> (e.g. R10)
- <u>Core Measurement Code</u> (e.g. FWC) Unique code for each ECN 'core
- Location Code (e.g. 01)
 Each ECN Site allocates its own code to replicate sampling locations for each core measurement (e.g. FWC 01, FWC 02 for different surface water collection points)
 Sampling Date (/time)
 Date on which sample was collected or data recorded. This will include a time element

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Core measurement: Aquatic macrophytes (FMA protocol)

The following variables are recorded at a recommended frequency of annually for rivers and once every two years for lakes:

1.5.1 Lakes

According to the protocol, the survey should be repeated at a number of sampling locations (centred on 'sampling points') around the lake. Each of these locations should be allocated a different FMA Location Code (eg FMA 01, FMA 02, FMW 03, etc) as described in the introduction to this chapter.

i. Shoreline Survey

Verieble	l lucita	Precision		
	Units	of recording		
Site identification code				
Core measurement code				
Location code				
Sampling date				
Width (W) of survey area	m	0.1		
Sampling depth (at distance W	m	0.1		
from the shore)				
Lake level	m	0.1		
For each 10 m shoreline section	r:			
Section ID	2-character code S1 to S10			
Survey method	1-character code:			
	W = Wading			
	B = Boat			
	E = Estimated from shore			
Substrate categories ⁽²⁾	% in each category	1		
Shading categories ⁽⁴⁾	% in each category	1		
enaanig eategenee	, e each ealegely	•		
and then for each species present:				
Species code	6-digit code ⁽⁷⁾	(eg 382901)		
Species name	genus species	(eq Iris pseudacorus)		

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ii. Transect Survey

		Precision			
Variable	Units	of recording			
Site identification code		Ŭ			
Core measurement code					
Location code					
Sampling date					
Compass bearing	degrees	1			
Max depth of vegetation growth	m	0.1			
Secchi disc depth (at deepest point	m	0.1			
of transect)					
Limit of macrophyte growth	m	0.1			
(distance from shore)					
For each transect point:					
Transect Point ID	2-character code 11 to 1h				
and then for hoth Devision of Otenhannel					
Transact side (Port or Starboard)	1 obstactor codo: D or S				
Sample Denth	m	0.1			
Substrate (dominant category)	2-character code ⁽²⁾	0.1			
Total plant cover	%	10			
	, o				
and then for each sampling method (Ekman grab, circular Plot, and Rake grappel).					
Method code 1-character code: F P or R					
and then for each species present:					
Species code	6-digit code ⁽⁷⁾ (eg 36	4701)			
Species name	genus species (eg Me	enyanthes trifoliata)			

1.5.2 Rivers

		Precision			
Variable	Units	of recording			
Site identification code					
Core measurement code					
Location code					
Sampling date					
For each 10 m river section:					
Section ID	2-character code S1-S10				
Survey method	1-character code:				
	W = Wading				
	B = Boat				
	E = Estimated from bank				
Average width of channel	m	0.1			
Depth categories (1)	% in each category	1			
Substrate categories ⁽²⁾	% in each category	1			
Habitat categories ⁽³⁾	% in each category	1			
Shading categories ⁽⁴⁾	% in each category	1			
Water clarity categories ⁽⁵⁾	% in each category	1			
Bed stability categories ⁽⁶⁾	% in each category	1			
Ded stability categories	/o in cach category	•			
and then for each species present:					
Species code	6-digit code ⁽⁷⁾	(eg 362701)			
Species name	genus species	(eg Filipendula ulmaria)			
Cover estimate	%	1			

Standard recording forms for macrophyte surveys are available from the CCU.

Recording forms Notes Depth categories are as follows: 1 <0.25 m 2 0.25 m-0.5 m 3 >0.5 m-1 m 4 >1 m (2) Substrate categories are as follows: В BEDROCK exposure of underlying rock not covered by alluvial deposits BC BOULDERS/COBBLES >64 mm: half-fist or larger PG PEBBLES/GRAVEL > 2-64 mm; half-fist to coffee granule size >0.0625-2 mm; smaller than coffee granules and S SAND unlike silt/clay, abrasive to hands SC SILT/CLAY <0.0625 mm - have a soft texture. PEAT dead vegetation undergoing bacterial decay in Р stagnant deoxygenated water. Strictly pure peat, not fine peaty deposits over more substantial substrate. (3) Habitat categories are as follows: Р POOL A discrete area of slow flowing water, usually relatively deeper than surrounding water, between faster flowing stretches, as in a sequence of rifflepool-riffle. Pools are deep and often turbulent, scoured during spate flows. RI RIFFLE Fast flowing, shallow water whose surface is distinctly disturbed. RU RUN Fast or moderate flowing, often deeper water whose surface is rarely broken or disturbed except for occasional swirls and eddies. S SLACK Deep, slow flowing water, uniform in character. (4) Shading categories are as follows: Ν NONE No shading в BROKEN Some direct sunlight hits the water surface in the shade-affected area when sun is directly overhead. D DENSE 5% or less of the shade affected area receives direct sunlight when the sun is directly overhead. (5) Water Clarity categories are as follows: CR CLEAR Channel substrate is clearly visible at all depths, as are macrophyte species. CY CLOUDY Slightly discoloured with a moderate suspended solids load and partially reduced light penetration. All clumps of macrophyte species can be located on the substrate of the river channel but the view of them is partially distorted. A small piece/single shoot of a macrophyte species may be missed. т TURBID Strongly discoloured, carry a heavy suspended solids

load and greatly restrict light penetration. The channel bed is obscured and submerged macrophyte species are indistinguishable from substrate and water. This will lead to a reduction in accuracy and efficiency of the method. Bed Stability categories are as follows:

SF SOLÍD/ (eg bedrock/compacted clay), increased flow has little FIRMLY BEDDED effect. ST STABLE (eg boulders/pebbles/gravel), unlikely to be

significantly affected by increased flows. U UNSTABLE (eg gravel/sand/silt/mud), likely to be dislodged by increased flows. SS SOFT/SINKING (eg deep silt/mud), making channel unwadeable. Bank stick penetrates easily into substrate.

⁽⁷⁾ ECN currently uses the list of macrophyte species and coding system given in Holmes *et al.* (1978), with the addition of some large algal species from Whitton *et al.* (1998) as follows:

Batrachospermum spp Cladophora spp Enteromorpha spp Hildenbrandia rivularis Lemanea fluviatilis Vaucheria spp Chara aspera Chara baltica Chara braunii Chara canescens Chara connivens Chara contraria Chara curta Chara denudata Chara fragilifera Chara globularis Chara hispida Chara intermedia Chara muscosa Chara pedunculata Chara rudis Chara tomentosa Chara virgata Chara vulgaris Lamprothamnium papulosum Nitella capillaris Nitella confervacea Nitella flexilis Nitella gracilis Nitella hvalina Nitella mucronata Nitella spanioclema Nitella tenuissima Nitella translucens Nitellopsis obtusa Tolypella glomerata Tolypella intricata Tolypella nidifica Tolypella prolifera

A machine-readable version of the coded macrophyte list can be obtained from the CCU.